Australian Government

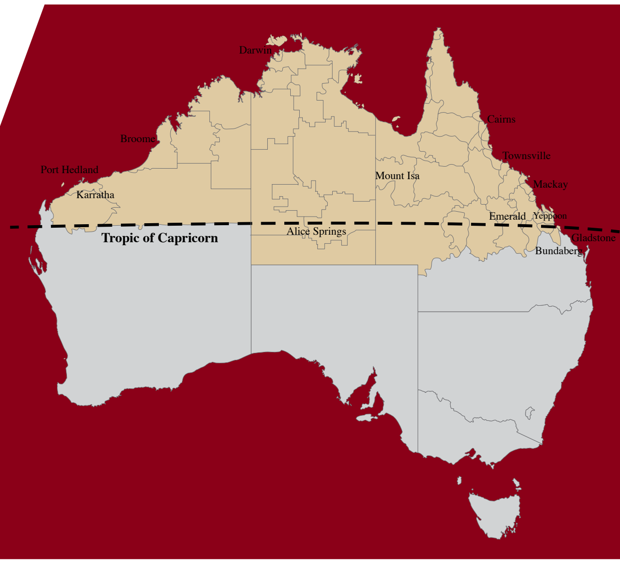
Infrastructure Australia

Northern Australia Audit

Infrastructure for a Developing North

Report

January 2015



Acknowledgement

Infrastructure Australia recognises the contribution of PricewaterhouseCoopers and GHD in preparing this report. The information, statements, statistics and commentary contained in this report have been sourced by PwC and GHD from publicly available material and from discussions held with Infrastructure Australia and other stakeholders.

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Chairman's introduction

Mark Birrell, Chairman Infrastructure Australia

Northern Australia is an integral and growing part of the Australian economy and it offers major development and employment opportunities for the nation. Infrastructure must be a key element in realising this potential, particularly where a sparse population base tends to rely on transport, energy, water and communications to an even greater extent than those in the more populated south of the country.

This audit report is the first major output under Infrastructure Australia's new legislative and operating arrangements. It represents the Infrastructure Australia board's approach to providing a detailed factual base that will guide decisions of governments, seeking to strike the right balance between risk and long-term value creation for all Australians.

The audit analysis highlights that there are significant challenges to further development of Northern Australia, concludes that there are infrastructure inadequacies but notes, without being prescriptive, that there are positive responses that will provide economic and social benefit. The report also emphasises that infrastructure development and maintenance requirements are best achieved by collaboration between government and the private sector and, wherever possible, progress on the basis of analysis of costs and benefits.

The work on this report has also proved valuable to our ongoing task in our development of the Australian Infrastructure Plan, which will be completed and publicly released in late 2015.

Key conclusions of the Northern Australia infrastructure audit are:

- **Evaluation processes and policy need to improve** to avoid unwanted or stranded infrastructure investment. Cost-benefit analysis is essential to investment evaluation and prioritisation. While it is sometimes difficult to find hard data, the exercise of attempting to identify costs and benefits is always valuable.
- In **cases where it is not clear that benefits exceed the costs**, there may be merit in considering multi-user investment with some social amenity (e.g. transport and communications) that broaden the economic and social contribution that infrastructure can make.
- In **prioritising infrastructure investment**, maximising the efficiency of existing infrastructure is critical to the development of Northern Australia and, in many cases, equal to or of greater importance than new infrastructure. Key areas for attention include addressing maintenance backlogs (roads sector) and introducing more cost-reflective pricing where feasible (especially in the water sector).
- In **infrastructure provision**, the community and the private sector should drive provision of infrastructure to ensure that it meets the needs of users. Government's role should seek to create an environment where this can be achieved. Government investment will be necessary in some cases but should only proceed where there is a clearly defined value to the taxpayer. Public sector investment should seek to maximise the role of the private sector to achieve innovation, service quality and, where feasible, competition.
- **Strengthened infrastructure network planning and coordination** merits consideration as a means to help lower the costs of infrastructure service and improve reliability of supply. The issue is particularly important in the electricity sector, with as many as four significant networks in the north and numerous isolated systems. Network planning and coordination, however, also has a role to play in all sectors, in order to further: comprehensive service where this is applicable; network security and resilience (e.g. alternative route access and increased market depth and supply); and improved connectivity (e.g. 'missing' road and communications backhaul links).

- There are **sources of market failure** in the infrastructure industries in general and in Northern Australia in particular, which could call in principle for a government response. These include: limited economic scale in many infrastructure settings, resulting in a high cost and/or poor quality of service, or an absence of competition in service provision; 'first mover disadvantage'; coordination externalities that preclude more extensive networks, which would provide more reliable and lower cost service; and low socio-economic circumstances, with resulting weak capacity to pay for infrastructure services.
- **The private sector has a central role to play as do local communities** in providing and supporting infrastructure development and maintenance – leaving the role for government to provide a supportive regulatory and policy framework. However there are circumstances where this is likely to be insufficient and government funding will be necessary (including in times of constrained government budgets). This presents often unique challenges, requiring actions that encourage careful prioritisation and innovation in infrastructure delivery and provision, to ensure quality outcomes at least cost.

Mark Birrell

CHAIRMAN

January 2015

"The audit highlights significant challenges to further development of Northern Australia... but there are positive responses that will provide economic and social benefit."

Key findings

The audit has assessed critical economic infrastructure gaps and requirements to meet projected Northern Australia population and economic growth through to FY31. Infrastructure gaps have been identified in terms of unmet demand, missed opportunity, excessive pricing or poor service standard. This report is about broader infrastructure gaps and requirements not a detailed project by project analysis.

Northern Australia is mostly sparsely populated with 1.2 million people spread across 45 per cent of Australia's land mass. These 1.2 million people represented 5.6 per cent of Australia's 22.7 million residents in the audit base year of FY11. Northern Australia's population has grown faster (at 1.7 per cent year on year) than the Australian average over the past decade (1.4 per cent year on year). Under a baseline projection, Northern Australia's population would grow at 1.8 per cent year on year, compared to 1.6 per cent year on year for Australia as a whole, from 1.23 million in FY11 to 1.77 million residents in FY31.

The Northern Australia economy made up 11.7 per cent or $178 billion of Australia's FY13 Gross Domestic Product, compared with some nine to 10 per cent during the 2000s.

Infrastructure in Northern Australia faces cost and service challenges. With limited population and often small industry sizes (albeit with exceptions, most notably in the resources sector), it can be difficult to capture the infrastructure economies of scale that allow commercially viable infrastructure services at competitive prices. Distance, remoteness and conditions of extreme heat and high rainfall during four months of the year in much of the region add to the challenges.

'National network' infrastructure improvement can benefit both northern and southern Australia. By reducing economic distance, improved links between north and south and between jurisdictions can offer wide benefits. This infrastructure encompasses: capital city and major northern airports; the major 'north-south' and inter-jurisdictional highways; the North Coast Line; the Adelaide-Darwin Railway; and the National Broadband Network that is currently being rolled out. Road and rail links face capacity and/or reliability pressures, while additional peak period capacity at Perth and Brisbane airports will be important for the longer term.

> The Northern Australia economy made up 11.7 per cent –$178 billion – of Australia's FY13 Gross Domestic Product."

Transport infrastructure for resource development hinges on major customer demand. As the 'first mover' generally funds new port and rail supply chain infrastructure, the size and certainty of resulting revenue are key considerations in infrastructure planning. Rail and port expansions are under way in the Pilbara region, are planned for the Queensland coal regions and are possible in the North West Queensland Minerals Province. In contrast, the absence of major customer demand in the Northern Territory and other yet to be developed areas leads to reliance on existing smaller ports which lack the specialised facilities (e.g. ship handling equipment, deep water channel access) that can support large tonnages at reduced unit cost. Any government role in infrastructure investment in such circumstances needs to balance cost against overall expected benefits.

Roads servicing the dispersed cattle industry can benefit from better flooding resilience in all three jurisdictions, to link with ports and markets in the north and also in southern Australia. The Port of Darwin, the largest livestock export port in the region, faces capacity pressure and lacks specialist infrastructure to service the industry.

Road maintenance is critical to facilitate heavier vehicles and renew ageing pavements in a demanding climatic environment. Funding for pavement maintenance may sometimes compete with funding for specific safety improvements (e.g. lane widening). Maintenance backlogs are a feature of the northern road system, with attendant risks of load restrictions and road closures, particularly during high rainfall periods.

Major centres can benefit from both road upgrades and public transport planning. Improved port and / or airport road access in centres including Mackay, Darwin, Karratha and Port Hedland, together with rail access to the Port of Townsville, can both facilitate trade efficiently and improve community access, amenity and safety. Bus priority measures, to improve peak service reliability, manage congestion and limit the need to widen roads and bridges will also be important within 10 to 15 years in Cairns and Townsville.

Network planning and coordination can often offer reliable electricity at lower cost, while major resource producers frequently opt to meet their own power (and water) requirements. This paradox reflects the difficulties of implementing coordinated arrangements. Lower cost energy is especially important in enabling marginal resource projects to proceed. This issue has been in play in the Pilbara and the Mount-Isa Cloncurry regions and is emerging in the Galilee Basin.

Northern Queensland power prices for industrial use are comparatively high, relative to other northern locations and despite connection to the National Electricity Market. This limits resource, agricultural and other economic opportunities. Long transmission lines from southern-located generators and marginal losses result in higher prices. The extent to which prices are also a function of market cost allocation rules and whether there could be an economic efficiency case for altering these rules, including the concept of splitting Queensland into two or more market regions, are matters for review.

Photo courtesy of Aurizon Holdings Ltd

> As the 'first mover' generally funds new port and rail supply chain infrastructure, the size and certainty of resulting revenue are key considerations in infrastructure planning."

Linking northern and eastern gas markets could create significant benefits. A gas pipeline from Alice Springs to Moomba, or from Tennant Creek to Mount Isa, would enable gas flows in either direction, for both export and domestic markets. It could also drive development of potential new sources of gas from the Amadeus Basin and increase resilience to failures of supply in both northern and eastern gas markets.

Many northern centres will need water supply upgrade or operational improvement. This includes Townsville, Cairns, Mackay and Rockhampton, as each grows, while bore system renewal is important for Alice Springs, Tennant Creek and the Kimberley region. Darwin, with an abundant catchment, is planning for an additional water source before 2020, which current demand management measures could work to delay for a period.

Irrigated agricultural development will call for additional water supplies, as well as supporting power and transport infrastructure. Water supply options include use of currently unallocated water reserves, recommissioning of mothballed mining dams, expansion of existing dams and development of both new dams and groundwater resources. On past experience, it may be difficult for agriculture projects to bear the full capital and operating costs of a new dam and water distribution infrastructure. However, without this, private investment could be difficult to attract.

With distance, remoteness and the reliance on communications, broadband is critical. 70 per cent of premises in Northern Australia received the lowest broadband quality rating in 2013, in a Department of Communications assessment, compared with 45 per cent in the south. Service levels will improve with the current roll-out of the National Broadband Network.

Mobile broadband services lag those in southern Australia. 21 per cent of Northern Australia premises had good mobile availability in 2013, according to the Department of Communications, compared with 91 per cent in southern Australia.

The audit also assessed infrastructure gaps to meet specific FY31 growth scenarios. Growth scenarios involve high and medium agriculture, tourism and energy export growth targets, as outlined in the 2030 Vision for Developing Northern Australia (Liberal Party 2013).

Achieving higher-value agricultural production from irrigation is a scenario focus. An estimated 700,000 hectares of production, nearly nine times current irrigated production across the north and more than the total of all currently identified irrigation opportunities, would be needed to meet the (lower) scenario target. While market viability should be demonstrated on an individual project basis, the scenario indicates the importance of innovative and least cost approaches to meeting the infrastructure needs of agricultural expansion.

Airport, road and communications infrastructure underpin visitor growth, to meet a scenario target of two million international tourist stopovers annually in Northern Australia. Excepting Kununurra, tourism airports have adequate runway capacity. Upgrade of a number of regional roads would benefit accessibility for tourists and mobile and Wi-Fi communications may also be important.

Infrastructure plans are largely in place to meet a scenario doubling in energy exports (to $150 billion). These plans include liquefied natural gas supply base support infrastructure (Darwin and northern Western Australia) and coal terminal infrastructure in northern Queensland, together with associated rail infrastructure. Regional airport, road and water infrastructure (e.g. Galilee Basin) is also important. Evolving commodity market conditions will mostly drive timing and implementation of these plans.

A further scenario involves a northern shift in population, to reach 2.14 million in FY31, a total that is 21 per cent higher than the baseline FY31 population estimate and consistent with the Queensland Plan and the Pilbara Cities Vision. Higher scenario populations in major centres would be likely to bring forward the timing of infrastructure requirements in all sectors.

"70 per cent of premises in Northern Australia received the lowest broadband quality rating in 2013."

Photo courtesy of Aurizon Holdings Ltd

Executive summary

The Australian Government has committed to help realise the potential of Northern Australia. This began with the release of the *2030 Vision for Developing Northern Australia* policy paper in June 2013, followed by the release of the *Green Paper on Developing Northern Australia* in June 2014. The Joint Parliamentary Select Committee on Northern Australia has also released the final report of its inquiry (tabled 4 September 2014).

Infrastructure Australia has been requested to conduct a Northern Australia infrastructure audit, aimed at informing a white paper on Northern Australia development currently being prepared by the Australian Government. The White Paper will set out a clear, well defined and timely policy platform for realising the potential of Northern Australia. It will define policies for developing the north to 2030, capitalising on the region's strengths, removing barriers to investment and bringing Australia's broader strengths to Northern Australia.

Undertaken alongside the Australian Infrastructure Audit, the scope of the audit was to:

- Collect and evaluate data for critical infrastructure assets and networks in the economic infrastructure (transport, energy, water and communications) sectors
- Undertake demographic and economic modelling of Northern Australia against various population growth scenarios (for the years FY16 short-term, FY21 medium-term and FY31 long-term)
- Provide a critical infrastructure gap analysis against both 'baseline' projections and the various population growth scenarios
- Generate a list of critical infrastructure requirements.

The audit focuses primarily on infrastructure connecting to larger northern population centres (3,000 persons or more), as well as to areas of significant existing or prospective economic activity. In consequence, the essential infrastructure needs of the many smaller remote Indigenous communities fall outside the scope of the audit. These matters are addressed in the concurrent Northern Territory Regional Infrastructure Study and in a Council of Australian Governments Remote and Regional Transport Infrastructure Study, being led by the Northern Territory Government.

Audit methodology (Section 2)

The audit's methodology involves a number of key concepts and definitions, addressed in Box ES 1, in particular: the boundary of 'Northern Australia'; criteria for identifying 'critical infrastructure' in the context of the audit; the notion of an 'infrastructure gap'; and the relationship between infrastructure gaps, sources of market failure and potential government response.

The audit involved a number of core methodological steps:

- **Analysis of population and industry drivers of economic growth,** involving developing baseline population projections, regional economic growth projections and identification of key growth regions
- **Identification of critical infrastructure in Northern Australia,** involving developing a definition of 'critical infrastructure' (see Box ES 1) and applying it, in conjunction with jurisdiction infrastructure planning information, to a candidate set of infrastructure assets and networks to identify the 'in scope' infrastructure for the audit. There are eight sub-sectors, each of which has a separate section in this report: transport – airports; transport – ports; transport – rail; transport – road; energy – electricity; energy – gas pipelines; water; and communications
- **Audit of critical infrastructure:** Using public sources and information from infrastructure managers and other parties, information was assembled on existing critical infrastructure assets and networks covering configuration, capacity, capacity usage (demand), planned capacity increases/upgrades and relevant service quality information, together with available future demand projections
- **Identification of future critical infrastructure gaps:** Using the study's baseline population projections for Northern Australia and future industry and infrastructure demand information, the audit identified critical infrastructure gaps across the four sectors over the period to FY31. The FY31 date, together with a FY11 common base year, coincides with the horizon for the Australian Infrastructure Audit and the associated 15 year Australian Infrastructure Plan
- **Development of future growth scenarios for Northern Australia development,** including analysing the regional population impacts of the scenarios
- **Identification of critical infrastructure gaps** against the growth scenarios in similar manner to the baseline infrastructure gap assessment
- **Development of a list of critical infrastructure requirements,** involving preparing a list of critical infrastructure requirements to address identified gaps. The main focus is on baseline infrastructure requirements, while additional requirements to meet the scenario targets are also identified.

Northern Australia growth and development (Section 3)

The audit identified population and industry drivers of economic growth, involving development of baseline population projections, baseline economic growth projections and identification of key growth regions.

The **Northern Australia economy** has grown faster than the Australian economy in recent years, driven by expansion of the resources sector. Key characteristics of this sector are its capital intensive nature and concentration in particular regions, notably iron ore in the Pilbara in Western Australia, coal in central Queensland and off-shore gas processed on-shore (currently Darwin, Dampier), presenting both challenges and opportunities. Minerals and fuels, especially iron ore and coal, play a vital role in Australia's economic success, making up around half of the nation's exports ($157 billion in 2013). Northern Australia is a key driver of this export sector – being responsible for over two-thirds of Australia's minerals and fuels exports in 2013.

Northern Australia's demographic profile is younger, faster growing and with a significantly larger number of Indigenous people than that of the country as a whole. The audit has developed population baseline projections, based on Australian Bureau of Statistics' projections distributed to Statistical Area Level 2 (SA2) units – which comprise suburbs, or groups of suburbs in urban areas and larger zones in rural areas – and state/territory projections. Northern Australia is projected to grow at 1.8 per cent year-on-year, compared to 1.6 per cent for Australia as a whole, from 1.23 million in FY11 to 1.77 million residents in FY31.

The **northern Queensland population**, which makes up more than 20 per cent of the Queensland population and almost 75 per cent of the Northern Australia population, is projected to drive population growth in the north with year-on-year growth of 1.9 per cent to FY31.

The audit has also developed **economic baseline projections**, based on applying the economic forecasts established in the Australian Infrastructure Audit to baseline economic activity by industry and SA2 region contained in PwC's Geospatial Economic Model. The Northern Australia economy is projected to expand at a faster rate than the national average over the period FY11 to FY21, with growth easing between FY21 and FY31.

Economic output (as measured by real gross value added) in Northern Australia is forecast to be 143 per cent of FY11 levels by FY21, representing year-on-year growth of 3.7 per cent. Economic output in FY31 is projected to be 181 per cent of FY11 levels (approximately 127 per cent of FY21 levels or year-on-year growth of 2.4 per cent from FY21).

The audit has also taken account of the prospects for **key growth regions**. Regions where there is a combination of economic opportunity, government support, projects that are well advanced and a requirement for economic infrastructure include:

- Queensland – The Galilee Basin (thermal coal), Bowen Basin (metallurgical coal expansion) and North-west minerals province (base metals, other minerals)
- Northern Territory – The Darwin-Katherine/Wolfe basin and Roper River/McArthur River (both base metals and other minerals), the Tennant Creek/Wonarah region (phosphate) and the Amadeus basin (oil, shale gas)
- Western Australia – The Pilbara (iron ore expansion), Canning Basin (oil, shale gas), the Browse Basin (liquefied natural gas), North-West Shelf (oil, gas) and the East Kimberley (Ord irrigated agricultural expansion).

The audit's baseline population and economic projections and key growth regions provide the basis for the **audit and baseline infrastructure gap analysis**, which makes up the larger part of this report. The focus is on the capacity and other pressures on the four infrastructure sectors, in facilitating the economic and social development of the north.

The audit has also developed four future **growth scenarios** for Northern Australia development as a means to provide additional insight into future infrastructure gaps for Northern Australia development.

The audit's scenarios take account of state and territory population growth and other targets. Scenarios 1 and 2 take an industry perspective (e.g. that of the energy export sector) on infrastructure gaps and requirements, while scenarios 3 and 4 focus on population-driven infrastructure – on arguably the social dimension of economic infrastructure. The scenarios are outlined in Table ES 1.

Transport – airports (Section 4)

Airports appear to cope adequately with existing demand in larger regional areas and in fly-in fly-out locations.

The audit identified **40 airports in scope** against the critical infrastructure criteria. While this total includes the overwhelming bulk of Northern Australia's regular public transport passengers, it excludes many smaller airports and airstrips that provide an essential all-weather transport link.

Box ES1: Key audit concepts and definitions

What is Northern Australia?

Northern Australia in this audit captures all Australian Bureau of Statistics' medium-sized areas (Statistical Area Level 2) with boundaries that intersect the Tropic of Capricorn, but with adjustment to reflect stakeholders' understanding of Northern Australia.

This approach provides for the centres of Gladstone (Queensland), a key coal and liquefied natural gas port and Newman (Western Australia), a regional mining centre, to be included, together with the entire Northern Territory. While the Statistical Area Level 2 in which it sits is largely below the Tropic, Exmouth, a growing Western Australian service centre for the offshore oil and gas sector is included.

What is critical infrastructure?

The transport, energy, water and communications sectors all provide essential services to Northern Australia's economy and society. However, not all essential infrastructure has been considered critical for the purposes of the audit. The audit identified 'critical infrastructure' with the aid of selected criteria:

- Whether the infrastructure connects to either a major Northern Australia population centre (population of 3,000 or more at the 2011 Census), or to a current or prospective area of significant economic activity in the resources, agricultural or tourism sectors (i.e. those Statistical Area Level 2s with at least 0.3 per cent of Northern Australia's total gross value added)
- Whether or not it occupies a central or dominant network position.

In addition, critical infrastructure identification takes account of relevant jurisdiction plans and strategies.

What are infrastructure gaps?

The audit identifies four types of infrastructure gap:

- *Demand gaps*, where demand exceeds capacity, or approaches capacity such that the service becomes congested, unreliable, unsafe, or where capacity is inadequate for larger, more efficient services (e.g. a runway widening to support larger aircraft) than the level of demand can support
- *Opportunity gaps*, where the provision of improved or lower cost infrastructure could generate demand that is not currently present, stimulating economic development or population growth: e.g. safer, more weather-resilient roads that promote remote pastoral industry development
- *Cost gaps*, where the cost of providing infrastructure is higher than in other locations or facilities, due to scale differences or other factors, limiting or deterring economic development activity. The high relative cost of delivered power in Northern Australia is an example
- *Service standard gaps*, where the level of infrastructure service falls short of community, policy-based or legislated standards for attributes such as safety, availability and quality.

Infrastructure gaps can be of more than one type. For example, a new water treatment plant could be triggered by rising demand (demand gap) and by more stringent health regulations (service standard gap).

What could infrastructure gaps mean for government response?

Infrastructure gaps respond to both demand pressure and to sources of market failure, the latter calling necessarily for some degree of government response.

Demand gaps involve government response only if the sector (or relevant part of it) is institutionally dependent on government action, as is largely the case with roads.

Infrastructure owners may not capture the full benefits of addressing opportunity gaps, i.e. the economic growth resulting from increased scale in downstream industries. In these circumstances, infrastructure that unlocks economic opportunities will be under-provided if left entirely to the market.

Cost gaps are often linked to low economic scale, a source of market failure if it leads to service that is supplied by a single monopoly provider. 'First mover disadvantage', where a first mover bears all of the capital costs of a new facility that reduces costs, while others receive some of the benefits – may prevent action to address the gap and provides a rationale for government response. So do network coordination externalities, where the costs of cooperation between separate parties preclude lower cost outcomes.

Service standard gaps are similarly linked to the problem of low economic scale, exacerbated in the north by circumstances of distance and remoteness. Government response, whether through direct provision or through incentivising private provision, is pervasive in all infrastructure sectors.

The audit also excludes single use airstrips, such as those located at mine sites.

The region's regular public transport airports moved some **15.6 million passengers** (not including charter flight passengers, who include many fly-in fly-out workers) in FY13. Cairns (4.2 million) and the airports of, in market size order, Darwin, Townsville, Mackay, Karratha, Rockhampton, Alice Springs, Port Hedland, Gladstone, Hamilton Island, Newman and Broome comprised 85 per cent of this total.

Recent growth in the region's traditionally strong **tourism sector** has been slow. This is due to a high Australian dollar, the impact of the global financial crisis as well as some mismatch between tourism products on offer and a changing Asian market. As a consequence many airports have faced limited capacity pressure. Stronger future growth for tourism locations appear unlikely to require any major expansion (other than periodic terminal size increases), with runways at airports such as Ayers Rock, Broome and Cairns – Kununurra is an exception – already capable of supporting short to medium haul aircraft servicing international destinations in Southeast Asia.

In contrast, exceptional **growth in the mining and energy sectors** and associated fly-in fly-out activity over the past decade has resulted in acute capacity pressures at Pilbara region airports (e.g. Karratha, Newman and Port Hedland), particularly regarding terminal size and aircraft parking space. These pressures are expected to continue over the period to 2021. A range of apron, taxiway and terminal expansions are planned or underway at Broome, Derby-Curtin, Exmouth-Learmonth, Gladstone, Karratha, Newman, Paraburdoo and Port Hedland airports.

Major capital city airport infrastructure, especially at Brisbane and Perth, is vital to Northern Australia air transport. As well as linking with fly-in fly-out source markets and providing access to commercial and government service hubs, these airports are also at the centre of the region's air networks, with 'thin' markets precluding direct airline services between many northern locations. With high peak period pressures at both airports, additional runway capacity would appear important to avoiding congested and unreliable service in the future.

Transport – ports (Section 5)

Ports are critical to both mining and export of agricultural products. Defence is also reliant on some Northern Australian ports for its maritime operations.

Trade volumes through port authority' ports[1] in Northern Australia have more than doubled from 317 million tonnes in FY01 to 722 million tonnes in FY13. Nearly 90 per cent of this volume comprises coal and iron ore exports. Coastal freight loaded at Queensland, Western Australian and Northern Territory ports, notably bauxite (Weipa) and iron ore (Port Hedland), with petroleum flows from southern ports also significant, totalled 29 million tonnes in FY12.

The audit covers **23 diverse single and multi-purpose ports** in Northern Australia. The two largest ports in Australia (by total throughput tonnes) are Port Hedland and Dampier. Both are located in the iron rich Pilbara region. In FY13 these two ports had a throughput of 469 million tonnes (of which 91 per cent was iron ore export). Port expansion is ongoing at both ports to meet iron ore export capacity into the future. The next two ports, in terms of throughput size, are Hay Point and Gladstone, in Queensland, which had combined throughput of 182 million tonnes in FY13 (of which 85 per cent was coal export). The Port of Darwin had the highest 10 year growth rate of any port, at 15 per cent per annum, largely attributable to growth in dry bulk exports of iron ore, manganese and copper concentrate.

A significant number of energy and mining companies operate their own ports in the north to serve their nearby resource activity. These ports include Barrow Island, Bing Bong, Gove, Milner Bay, Onslow and Port Walcott.

1. 'Port authority' ports in Northern Australia are members of Ports Australia and governed by relevant port authority acts. This excludes privately owned and operated ports, for which data is often unavailable.

Table ES 1: Northern Australia baseline growth and the four scenarios

Baseline or scenario	Description	Impacts assessed
Baseline – broadly a continuation of current trends	Models the population outcomes through to FY31 of applying a set of assumptions about the future direction of fertility, mortality and migration based on past demographic trends. Economic outcomes are consistent with Australian Infrastructure Audit forecasts.	Infrastructure gaps to meet economic and population growth and expected market opportunities
Scenario 1 – aspirational economic growth against industry opportunities outlined in the 2030 Vision	By FY31, achieve aspirational economic growth adapted from the opportunities identified in the *2030 Vision* (with minor adaptations): • Increasing the real value of Northern Australia's real agricultural output to $14,906 million by FY31, which helps double Northern Australia's contribution to Australia's agricultural output to 24.4 per cent • Increasing international visitor stopovers to 2.8 million per annum by FY31 • Increasing energy exports from Northern Australia to $150 billion by FY31 with all publicly announced energy projects, projects in feasibility stage and committed projects proceeding to completion.	Additional infrastructure gaps, relative to the FY31 baseline, to meet the scenario targets
Scenario 2 – medium economic growth against industry opportunities outlined in the 2030 Vision	By FY31, achieve medium levels of economic growth adapted from the opportunities identified in the *2030 Vision* (with minor adaptations): • Increasing the real value of Northern Australia's real agricultural output to $7,452 million in FY31 (double the FY11 level) • Increasing international visitor stopovers to 2.0 million per annum by FY31 • Increasing energy exports from Northern Australia to $150 billion by FY31 with a weighted probability that publicly announced energy projects, projects in feasibility stage and committed projects proceeding to completion (based on their capital expenditure value and progress to date).	Additional infrastructure gaps, relative to the FY31 baseline, to meet the scenario targets
Scenario 3 – northern population shift in Queensland and Western Australia	Achieve a northern shift in population consistent with: • The target in the Queensland Plan of doubling the Queensland population outside of South East Queensland by 2044 (approximately 1.52 million people in Northern Queensland by FY31) • The Pilbara Cities vision of growing the population in the Pilbara region from 68,000 in FY11 to 140,000 by FY35 (approximately 126,000 by FY31).	Additional population-specific infrastructure gaps, relative to the FY31 baseline
Scenario 4 – Low population growth	Realise lower than baseline population growth due to lower overseas migration and lower net internal migration to Northern Australia (the more volatile components of population growth)	Reduction in population specific infrastructure gaps, relative to the baseline

Northern Australia's rail systems provide dedicated routes from mine to port or to connecting rail corridors."

Almost all **new port development and port expansion**, including dredging and marine infrastructure, is linked to natural resource activity – this includes the possible future ports of Anketell (iron ore) and Ashburton (LNG), both in Western Australia. New projects in the Galilee and Bowen catchment may cause structural changes, in terms of the mix of commodities transported, at the ports of Townsville and Mackay. The specialised coal port in the area, Abbot Point, has proposed a sixfold increase in its capacity, to 300 million tonnes by 2025.

Smaller ports (e.g. Bing Bong, Darwin, Karumba) lack the specialised infrastructure, including high capacity ship handling equipment, deep water channel access and supporting landside infrastructure, to support large tonnages. This adds a 'first mover' constraint in developing smaller iron ore and other mineral deposits.

The Port of Darwin, the largest livestock export port in the region, faces capacity pressure and lacks specialist infrastructure to service the industry.

Cairns, Darwin and Mackay/Whitsundays had over 38 cruise ship visit days each in FY13, reflecting the ability of these ports to serve as **tourism gateways**. The ports of Northern Australia have very limited container activity. Townsville is the largest, handling 50,173 containers in FY13 (in comparison, Brisbane dealt with over 21 times this amount). This is reflective of both the size of the population in Northern Australia and the logistics and economies of scale of using a major capital city port as a hub.

With regard to agricultural exports, the major Queensland sugar export ports of Townsville, Mackay, Lucinda, Mourilyan and Cairns together exported 3.2 million tonnes of sugar in FY13. The largest livestock export port in FY13 was Darwin (118,712 tonnes). The port has experienced congestion on account of a recent surge in livestock exports to Asia. Broome, Karumba, Townsville, Port Hedland and Wyndham all have the ability to export livestock. The current Phase 2 of the Ord Expansion may have infrastructure implications at Darwin and Wyndham (the two nearest ports) in facilitating agricultural exports.

Transport – rail (Section 6)

Rail is critical to mining operations in much of Northern Australia. The private sector provides key rail networks, however there remain third party access issues. Rail freight is a critical element in moving agriculture product.

Northern Australia's rail systems provide dedicated routes from mine to port or to connecting rail corridors for Bowen Basin, Queensland coal (Central Queensland Coal Network), Mount Isa region mineral resources (Mount Isa Line) and Pilbara, Western Australia iron ore (BHP Billiton, Fortescue Metals Group and Rio Tinto railways). In addition, there are two north-south lines, from Brisbane to Cairns (North Coast Line) and Adelaide to Darwin, each carrying passengers, intermodal freight and bulk freight.

Pilbara region vertically integrated railways have seen substantial expansion in recent years, with iron ore production having increased by nine per cent a year over the past decade. With significant further growth expected to 2020, all owners are continuing to expand their networks. A fourth railway (Roy Hill-Hancock Prospecting) is under construction and a potential fifth (Brockman Resources, Atlas Iron and Aurizon) is under consideration. New rail infrastructure, in conjunction with the Anketell Point port development, will be required to develop potential mines in the West Pilbara region. Third party access to existing railways for junior miners offers in principle potential to limit new infrastructure requirements and avoid 'first mover' costs. However, the record to date suggests railway owners may often be unwilling to grant access and applications involve both cost and uncertainty.

The amount of coal carried on the **Central Queensland Coal Network** has grown at around three per cent a year over the past decade. Assuming commencement of the first large-scale thermal coal projects being planned in the Galilee Basin, there should be higher annual growth in


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future years, potentially with new rail lines from the basin and expansion of the Port of Abbot Point required. Growing demand for mining inputs to the Bowen and Galilee Basins provides an opportunity to develop rail terminal handling capability between the ports of Mackay and Gladstone and areas such as Emerald and Alpha.

The **Mount Isa Line** can experience severe weather conditions (heat and flooding) over the summer months, which can impact on reliability. While capacity itself currently appears adequate, demand should increase in the shorter term, with more intermediate mine product traffic and, in the longer term, there is potential for significant upgrade associated with coal supply from Northern Galilee Basin mines, together with a potential rail link to Abbot Point.

On the **North Coast Line** between Brisbane and Cairns, there is a longer-term opportunity to shift more freight from road to rail (reducing congestion on the road network) and to also improve passenger transport options through upgrading of this line (e.g. track straightening, passing loops to facilitate longer trains and speed improvement and including the single track constraint at Beerburrum and Landsborough/ Nambour in Southeast Queensland). In the absence of upgrading, there is a risk that the line may lose freight to a progressively improved Bruce Highway, constraining some of the safety and amenity benefits of the road upgrading.

In contrast, the 1.8 kilometre trains on the **Adelaide-Darwin Railway**, commissioned in 2004, provide a time and cost-competitive freight service that dominates the intermodal market between these cities. Increasing the number of passing loops, maximum axle weights and improving all-weather resilience are the key areas for facilitating mining growth in the corridor and reducing the cost of goods in end-user markets.

Transport – roads (Section 7)

Roads servicing the dispersed cattle industry can benefit from better flooding resilience in all three jurisdictions, to link with ports and markets in the north and also in southern Australia.

Road maintenance is critical to facilitate heavier vehicles and renew ageing pavements in a demanding climatic environment. Funding for pavement maintenance may sometimes compete with funding for specific safety improvements (e.g. lane widening). Maintenance backlogs are a feature of the northern road system, with attendant risks of load restrictions and road closures, particularly during high rainfall periods.

Major centres can benefit from both road upgrades and public transport planning. Improved port and / or airport road access in centres including Mackay, Darwin, Karratha and Port Hedland, together with rail access to the Port of Townsville, can both facilitate trade efficiently and improve community access, amenity and safety. Bus priority measures, to improve peak service reliability, manage congestion and limit the need to widen roads and bridges will also be important within 10 to 15 years in Cairns and Townsville.

Roads in scope include:

- All of the north-south links (Bruce, Stuart, Victoria, Great Northern and North West Coastal Highways)
- Other routes on the currently defined National Land Transport Network (Barkly, Landsborough, Flinders Highways)
- Other major routes including the Capricorn, Landsborough, Peak Downs and Gregory Highways, the Burke, Gregory, Gulf, Kennedy and Peninsula developmental roads in Queensland, the Arnhem, Buntine, Plenty Highways and Tanami Road in the Northern Territory and the Derby Gibb River and Marble Bar roads in Western Australia.

Total **traffic levels** are in some cases low (for example, fewer than 100 vehicles a day on the Buntine Highway and around 200 vehicles a day on the Queensland developmental roads). However, heavy vehicle shares are typically 20 per cent or higher and these roads may offer the sole access route for passengers and freight to these communities. With a mix of two lane bitumen, single lane bitumen (both often with narrow seals) and unsealed roads, roads are subject to closures, load restrictions and safety concerns, particularly during the December to April wet season.

Western Australian roads have seen the **highest traffic growth rates** over the past decade, with several important roads including Onslow Road, Karratha Tom Price Road and Ripon Hills Road (East Pilbara) having experienced double digit annual growth. In the Northern Territory, traffic on the Roper Highway, a key access road for the Roper/Gulf mineral resources rich region, has increased at six per cent a year over the past decade. The Arnhem Highway, which now links the major construction quarries servicing Darwin as well as the Ranger uranium mine (Jabiru), has seen growth at four per cent a year. In Queensland growth rates of around four per cent a year are projected for the Peninsula and Fitzroy developmental roads and the Capricorn Highway, all substantially linked to mining development. Growth at two per cent is projected for Northern Australia's most heavily trafficked road, the Bruce Highway, a growth rate comparable to other more heavily used segments of the National Land Transport Network.

Road capacity, freight productivity, availability and safety pressures are highly present on 'hinterland' roads connecting to major centres, such as the Peak Downs Highway (Mackay), the Arnhem and Roper Highways (Darwin) and Marble Bar Road (Port Hedland). These pressures are also seen, with the compounding impact of greater remoteness, on roads that are important for pastoral producers and for remotely located mines, including the Buntine and Plenty Highways and the Tanami Road. The latter, as an access route from Alice Springs to the Kimberley region is also potentially important for tourists and the tourism sector. Productivity, capacity and safety issues are also key to urban and port access routes in Western Australia (e.g. Port Hedland, Karratha, Kununurra), Queensland (e.g. Mackay, Townsville) and the Northern Territory (Darwin).

Development of new **mining regions** (e.g. the Galilee Basin) and expansion of existing ones will trigger new road capacity requirements, particularly for mining inputs, even in those locations where the scale of development may justify rail transport for commodity export. Development of rail intermodal terminals, in line with Queensland Government policy, can mitigate this trend.

Timely pavement rehabilitation and strengthening are critical to ensuring level of service for both heavy and light vehicles, while road re-sealing prevents moisture ingress and reduces the risk of pavement failure – and of the imposition of temporary load restrictions during wet weather to prevent pavement failure. **Maintenance backlogs**, linked to factors including safety (road widening) prioritisation and a reported tendency for heavy vehicles to operate more intensively during the northern wet season than previously, are characteristic of Northern Australia road networks. Over half of the North Queensland network exceeds the theoretical design life and an increasing proportion, currently one third, of network seals are older than the target optimum.

Energy – electricity (Section 8)

Electricity availability and higher cost remains a major issue to both residents and business in Northern Australia. Consideration of network extensions, additional generation closer to the user and off-grid developments are all options which merit further study.

Four major electricity networks (the National Electricity Market, Mount Isa, the Darwin-Katherine Integrated System and the North-West Integrated System) together supplied 3,558 MW to major centres in Northern Australia in FY11. Beyond these networks a small number of separate, localised distribution systems supplied

80 MW to major centres including Alice Springs, Tennant Creek, and Kununurra-Wyndham-Lake Argyle. Around 80 per cent of northern electricity demand came from Queensland, with a single customer (the Boyne Island aluminium smelter) accounting for around 25 per cent of Northern Australian electricity demand.

Northern Australia **investment in electricity generation and network assets** is primarily driven by expansion of mining and mineral resource processing as well as other industrial development. Possible reductions in industrial loads, such as the recent closure of the Gove alumina refinery, will conversely produce sudden and significant step changes down in electricity demand. Residential demand growth is less significant and driven to some extent by population growth, but equally by technological changes and social trends such as the take-up of home air-conditioning, increasing appliance efficiency and/or self-generation.

Future resource developments are likely to include major new locations such as the Galilee Basin coal fields, expanded minerals provinces in Queensland and the Northern Territory, new mine sites for iron ore in Western Australia and exploitation of conventional and unconventional gas resources in the Northern Territory and Western Australia. Resource development sites tend to coincide with remote locations that may also generally be suitable for the generation of renewable energy.

Access to sources of electricity in itself is unlikely to change the technical feasibility of new resource projects, since on-site generation is always possible. However, the **cost of access to electricity** may be a major factor in determining the economic feasibility of marginal resource projects, as well as of irrigated agriculture developments. The Government has recently consulted on electricity pricing and reliability as part of the Energy Green Paper released on 23 September 2014. Options to deliver a lower (but unsubsidised) cost of electricity in specific locations, such as north-east Queensland, Mount Isa, remote Northern Territory and the Pilbara region, could be considered. These could include:

- Reviewing the commercial incentives for generator location in North Queensland, including the cost of connection assets and the application of the National Electricity Market Rules
- Reviewing future supply options for the wider Mount Isa area, including National Electricity Market connection, local generation expansion and new gas supply options
- Moving towards more coordinated planning and integrated infrastructure development in the Pilbara region to respond to future load growth, with a focus on the advantages of multi-user open access networks and interconnecting transmission gas hubs and load centres.

To address growing demand and asset replacement and updating in smaller locations with **isolated systems** in Northern Australia, local development plans are important to ensure timely additional or replacement generation capacity, incorporating renewable energy sources where it is efficient to do so.

Energy – gas pipelines (Section 9)

Gas is increasingly both a major export opportunity and a potential domestic shortage issue. Extension of gas pipelines to link the east and west networks may offer some relief to anticipated rises in domestic gas prices, however more investigation is needed.

In FY11 around half of **Australia's gas production** of 2,030 petajoules was sourced from offshore basins in Western Australia and the Northern Territory and exported as liquefied natural gas (LNG). The export proportion is likely to rise significantly with newly developed sources of coal seam gas production in Queensland and expansion of LNG exports from both Queensland and Western Australia/Northern Territory. At the same time, around half the electricity generated in Northern Australia and a large majority of the electricity generated in Northern Territory and Western Australia is powered by natural gas supplied by pipeline. As a result of the Western Australian Government's 15 per cent reservation policy, a significant quantity of gas sourced in the north of Western Australia is consumed by domestic and business customers in southern population centres. The policy is to be reviewed in FY15.

Existing pipelines in Northern Australia include:

- The Carpentaria Gas Pipeline, which allows gas to flow northward from the South West Queensland Pipeline to supply the Mount Isa region
- The North Queensland Gas Pipeline, which allows coal seam gas to flow north from the Bowen Basin to Townsville

- The Queensland Gas Pipeline, which begins in south-east Queensland and ends at Gladstone, supplying large industrial users and gas distribution networks in Gladstone and Rockhampton, as well as a gas distribution network in Wide Bay
- The Amadeus Gas Pipeline and connected Bonaparte and McArthur River branches, which transports gas to Darwin, Katherine and other Northern Territory locations principally to fuel electricity generation
- The Dampier to Bunbury natural gas pipeline, which transports gas from the North West Shelf gas fields to customers in the south-west of Western Australia
- The Goldfields gas pipeline, which transports gas from gas fields in the Carnarvon Basin and the North West Shelf to mining customers in the Pilbara, Murchison and Goldfields regions of Western Australia for industrial use and power generation, via the Karratha to Cape Lambert Pipeline, the Pilbara Pipeline System and the Telfer gas pipeline.

Notwithstanding high export prices and the widespread use of gas for power generation and industrial uses in the north, significant quantities of gas sourced in Northern Australia find their way to domestic markets in the south via one or other of the limited routes that exist.

While complete data on existing and forecast pipeline utilisation are unavailable, forecasts of pipelines in north Queensland by the Australian Energy Market Operator do not point to any demand-based capacity limitations. Any **new gas transmission pipelines** built in the next twenty years would likely be built in response to the location of new LNG export facilities, new sources of gas production (such as the Canning Basin in Western Australia and the Amadeus Basin in the Northern Territory), the location of new resource development sites and whether significant new electricity loads are supplied by network extension or by isolated generators.

With much of Australia's gas resources located in Northern Australia and most of the demand in the south, domestic demand for gas may also drive pipeline development. Growth in domestic demand is likely to be heavily influenced by the extent of convergence between the domestic and international price of gas. A new **pipeline linking the Northern Territory with eastern gas markets** would facilitate the supply of both domestic and export gas markets, as has been proposed by the Northern Territory Government in its response to the 2014 Green Paper on Developing Northern Australia.

Water (Section 10)

Water availability varies dramatically in Northern Australia. Water is abundant in some areas at certain times of the year, but there are catchment issues. It is not available at all in other parts, where there may be some opportunities for agricultural development. Water availability will be a key factor in urban growth, mining and agriculture.

Northern Australia has **significant sources of surface water and ground water**. North Queensland has some 26 dams and other major water storages. These storages supply the major centres and other smaller centres and are also the principal source for existing bulk water industrial and agricultural users. Groundwater is the main water source for other Queensland locations including Longreach and Weipa and in the Northern Territory, with the exception of Darwin (Darwin River Dam) and in Western Australia, with exceptions of Kununurra, Wyndham and Karratha.

Against a background of widespread drought across Queensland, three of the four largest Northern Australia population centres – Townsville, Cairns and Mackay – recently implemented water restrictions. Investigation of **least cost supply expansion options** is important in each centre to support population and economic growth. Rockhampton, the fifth largest population centre, has a comparatively small water storage and is likely to require increased storage capacity.

Darwin, the third largest centre in Northern Australia, is planning for an additional water source to be connected by 2019, which may be able to be deferred to 2025 through the current programme of enhanced demand management measures. Tennant Creek will require renewal of old bores. There are no material water supply infrastructure gaps for northern Western Australian centres over and above what has already been identified as part of their current planning framework.

For **prospective agricultural and mining developments** in Northern Australia, there may be a range of potential water supply options, with case-by-case evaluation important. These comprise:

- Indirect and direct potable reuse
- Managed aquifer recharge
- Water trading, particularly trading of registered water allocation titles

- Use of currently unallocated water, with the largest volumes in the Gulf, Burdekin and Fitzroy catchments in Queensland
- Expansion of existing dams such as the Burdekin Falls and Ord River Dams
- Groundwater access, for mining and agricultural precincts situated within the Great Artesian Basin and in the Pilbara region – not available for the North West Queensland Minerals Province
- Re-commissioning of previously mothballed mining dams
- Planning new dams.

New surface water storages and connecting trunk pipelines are likely to be required for Galilee Basin (resource) development and for Upper Burdekin and Gilbert and Flinders catchments (irrigated agriculture) development. In the Pilbara region, additional bore fields, pumps and connecting pipelines will be important.

It would appear from available information that **water pricing in Northern Australia** is generally at, or below, a lower bound of cost-reflective pricing that covers administrative and operational costs, without contribution to capital costs. All Queensland irrigation schemes in Queensland require various levels of community service obligation contribution by the state government to achieve lower bound prices. This situation suggests that future infrastructure may require either investment by government, or an increase in prices, or both.

Similarly, past history with greenfield dam and irrigation projects including the Ord and Burdekin schemes indicates that substantial government investment could be required to implement comparable projects in future. As a partial alternative and in order to **incentivise private investment**, mechanisms to reduce the risk associated with land acquisition and approvals and/or to provide benefit back to the provider in respect of change of land values could be considered.

Communications (Section 11)

Communications services are an integral part of everyday life and are of even greater value where they reduce the challenges of distance. Communications infrastructure in Northern Australia lags well behind that available in southern centres. Improvement in communications infrastructure, particularly mobile, offers major productivity and social amenity benefits.

All **fixed, mobile and satellite communications infrastructur**e is within the scope of the audit. The choice of delivery platform varies across the country because of the economies of scale and market density in telecommunications provision. Northern Australia, because of its smaller population spread over a large land-mass, has poorer coverage, service capacity and lower levels of competition between communications service providers than that experienced by other parts of Australia.

The communications sector is undergoing a **period of fundamental change** with the increasing importance of mobile technology, a step change in the provision of fixed infrastructure through the roll-out of the National Broadband Network (NBN) and significant growth in demand for data based services.

The **traditional fixed network** is the Telstra Public Switched Telephone Network. While the basic copper pair customer access networks have seen little change, the manner of their use has changed substantially. In the past 15 years, Asymmetric Digital Subscriber Line (ADSL) technology has been added to provide data capability over the copper network. This provides voice and data service at speeds up to eight megabits per second downstream and up to 1.3 megabits per second upstream, although speeds can vary for a range of reasons including the distance from the exchange. Fibre to the premise, building or sometimes basement distribution point and node are all now options for the 'last mile' sub-networks, as is fixed and mobile wireless and hybrid fibre coaxial. These technologies offer much higher speeds, for example 100 megabits per second downstream and 50 megabits per seconds upstream for fibre to the node.

Approximately 99 per cent of Australia's population also have **mobile voice (cell phone) coverage** at their normal place of residence and yet this represents coverage of only about one-third of the Australian land-mass, with the largest gaps likely to be in Northern Australia. Fourth generation (4G) mobile networks typically offer speeds between two and 50 Mbps downstream and one and ten Mbps upstream. There are also four satellite networks offering mobile voice solutions at present. Importantly, as for fixed satellite installations, mobile handsets require a clear line of sight with the satellite.

Fixed satellite is likely to be an important medium in the delivery of broadband services to Northern Australia for cost reasons. Regional and remote satellite broadband products over existing Ku-band satellite networks for home and small business users offer speeds up to six Mbps downstream and up to one Mbps upstream. NBN Co's Long Term Satellite Service (LTSS) is designed to bring broadband users in regional and remote Australia download speeds of up to 25 megabits per second and upload speeds of five megabits per second, similar to fixed wireless.

The issues considered in the audit reflect the need to address both a rapidly changing environment and a potentially widening **'digital divide'** between the populated centres of the east coast of Australia and the rural and remote north (noting areas of good service in major centres such as Townsville and Darwin). Some of these issues include:

- Increases in expectations of digital service across a range of sectors
- Increases in digital traffic and the number and range of devices compounding growth in population and the economy
- Increasing demand for mobile technology of various kinds, capable of accessing the cellular network, Wi-Fi and fixed radio
- Lack of competition in providers in the north, particularly for mobile service
- Poor current service quality both for mobile and fixed data service
- A commercial and regulatory environment that does not incentivise shared access to the available or new infrastructure.

Due to the remoteness of much of the region, **the north lags behind the more densely settled areas of Australia** in the quality of its communications services. 70 per cent of premises in Northern Australia Distribution Areas receive the lowest broadband quality rating; for southern Australia this figure is 45 per cent. Much of the demand for communications has occurred as people have become aware of the power of the internet and the data transmission media that facilitate it, together with a growing range of other applications in education, healthcare, commerce and industry, and social interaction. The internet has become almost mandatory in today's competitive business environment. The economics of communications provision in remote areas work against extensive provision of terrestrial links and mobile phone coverage. However the need for high quality communications is exacerbated by remoteness – in e-health and e-education for example.

It follows that the quality of service available to remote Northern Australia will be less than that available to urban Australia, in the absence of some form of **policy response**. There are several possible ways that this may occur, including financial support for provision of necessary infrastructure, funding in the form of 'Universal Service Obligation' payments, and/or incentivising (or requiring) the owners or developers of new infrastructure to include carrier quality communications links in their development. It may be possible to use NBN Co to facilitate this by expanding its remit to that of common infrastructure provider of last resort for mobile services in designated areas of the north.

Critical infrastructure requirements (sections 4 to 11)

The audit has identified **critical infrastructure requirements against the baseline infrastructure gap analysis** in each sector (included at the end of each of the eight sub-sector sections of the report). These are likely infrastructure requirements to support the scale of northern development associated with the baseline economic and demographic projections within the audit timeframe to FY31. The listing, shown in Table ES 2, also has regard to an extensive range of jurisdiction and other strategy and planning documents (included in Section 14, References) and information compiled through consultation.

Jurisdiction planning is ongoing, with, notably, Queensland intending to release a state infrastructure plan (including project pipeline) in 2015, and a Northern Territory Regional Infrastructure Study having proceeded in parallel with this audit.

Infrastructure requirements are identified in the table by type of infrastructure gap, i.e. demand, opportunity, cost and service standard.

Critical infrastructure requirements are 'pre-project' and are specified more generally than would be necessary for project planning, costing and evaluation. While funding sources are not addressed, these are likely to vary both by infrastructure sector and by type of infrastructure gap. Bulk port, rail freight, larger airport and non-remote electricity infrastructure managers are commercially driven, often privately owned and generally not reliant on government infrastructure funding. In contrast road and water infrastructure investment is typically largely or wholly sourced from government. Equally, where an infrastructure gap is based on rising demand, prospects for private financing are likely to be greater than where the gap involves addressing inadequate infrastructure service standards, or capturing uncertain downstream economic opportunities.

Growth scenario infrastructure gaps (Section 12)

Scenarios 1 and 2 – industry growth

Scenario 1 and Scenario 2 involve aspirational and medium levels of **industry growth** respectively, having regard to the 2030 Vision.

Aspirational growth (Scenario 1) would stimulate an **increase in resident population** in Northern Australia from 1.23 million in FY11 to 2.14 million in FY31, which is 21.2 per cent higher than the baseline population in the final year. Medium growth targets would stimulate an increase in resident population from 1.23 million in FY11 to 1.87 million in FY31, 5.6 per cent higher than the baseline population in the final year (Scenario 2).

Under **Scenario 2**, doubling the value of Northern Australia agricultural output over the period to FY31 appears challenging. It follows that the **Scenario 1** aspiration of doubling the relative contribution of northern agriculture to national agricultural output would require significant investment.

To achieve the Scenario 2 target from **irrigated agriculture** would require an irrigated area greater than all of the currently identified irrigation development opportunities (estimated at 470,000 hectares compared with current irrigated production around 80,000 hectares). The cost of development is also a major consideration. In the largest jurisdiction, Queensland, irrigation infrastructure cost recovery from existing schemes is only at the COAG-approved lower bound of pricing (i.e. covering operation, maintenance and administration), which would not incentivise private sector development. However, in approaching the scenario target, water, power and transport infrastructure would be required at locations identified in Table ES 2 (see rows dealing with bulk water requirements) and potentially at other locations as well.

Airport infrastructure is generally adequate to support **increased tourism**, the second strand of the industry scenarios. Key constraints to sector growth are considered to lie beyond the economic infrastructure sphere – recently subdued international economic conditions outside Asia, a high Australian dollar and northern tourism product offerings that may not appeal sufficiently to a growing Asian market. However, major tourism developments, such as the Aquis Great Barrier Reef Resort near Cairns, will require concerted local infrastructure improvement across roads, water, power and communications. In addition, a number of regional roads (in addition to those listed below under critical infrastructure requirements) have been identified that would benefit tourism access to and through key areas in the three jurisdictions.

Port and related infrastructure for **increased energy (LNG and coal) exports** should meet the scenario target of an export value of $150 billion if current and recent proposals are fully implemented. However, the extent of actual development will be subject to industry decision-making in light of market conditions and, in some cases, resolution of environmental and other issues. Accompanying road infrastructure upgrades, as identified in the baseline infrastructure gap assessment, will be important to address freight productivity, safety and access issues with growing mixed traffic on roads that are often narrow and in need of both pavement renewal and strengthening, and targeted flood-proofing. Opportunities to maximise rail transport, for example, through appropriately sited intermodal terminals, are also important.

The scenario would also add some 60 per cent to **Northern Australia's peak electricity capacity requirement**. This would make it even more important to review the commercial incentives for generator location in northern Queensland, with potential to reduce the cost of delivered power by around 20 per cent for wider regional economic benefit.

Scenarios 3 and 4 – population shift

Scenario 3 involves a **shift in the Australian population** from the south to the north, achieved by growing the population in Northern Queensland to 1.52 million people by FY31 (in line with the target to double the Queensland population outside of South East Queensland by 2044) and the population in the Pilbara region to 127,000 by FY31. This would stimulate an increase in resident population in Northern Australia from 1.23 million in FY11 to 2.03 million in FY31, which is 14.7 per cent higher than the baseline population in the final year.

Northern population growth is highest in total in Scenario 3. Higher populations in and near major centres could be sufficient to induce increased liner shipping calls at the Port of Townsville, with landside logistics infrastructure implications. Cairns could possibly see regular rather than the current irregular pattern of ship calls. Higher population growth will also bring forward additional road and related infrastructure requirements to protect and improve urban accessibility, including road capacity upgrades (e.g. lane duplications, safety treatments, dedicated bus lanes, additional bus stops and interchanges).

With industry the main driver of electricity capacity requirements in Northern Australia, which are substantial in Scenarios 1 and 2, Scenario 3 on its own has minimal infrastructure implications. While agricultural and mining requirements are the major drivers of water infrastructure requirements, higher population growth would increase **water supply pressures** in centres including Cairns, Townsville and Mackay and reinforce the importance of identifying least cost solutions for secure increased supply. The scenario also adds to the challenge in providing good quality communications services to northern locations.

Population-related infrastructure requirements apply also in Scenario 1, particularly for the **Northern Territory**, which does not form part of Scenario 3, as within-jurisdiction northern population shift is not relevant. With increased mining and agricultural growth, population would double in the rural Barkly, Petermann-Simpson and Victoria River regions, giving the greatest absolute population effect in the jurisdiction (that is, higher than Darwin). This would involve potentially significant infrastructure requirements in roads, power, water and communications sectors.

The aim of Scenario 4 is to test the sensitivity of critical infrastructure requirements to changes in the more volatile components of population growth, i.e. overseas and internal migration. It **involves lower population growth than in the baseline population projections**, due to low net overseas migration (for all jurisdictions), small net internal migration into Queensland and Western Australia (i.e. small population inflows as net internal migration in these regions has historically been positive) and high net internal migration from the Northern Territory (i.e. high population outflows, as net internal migration in Northern Territory has historically been negative). This would lead to a smaller increase in resident population in Northern Australia from 1.23 million in FY11 to 1.66 million in FY31, which is 6.2 per cent lower than the baseline population in the final year (1.77 million).

In Scenario 4, **urban and community-related infrastructure pressures** in roads, public transport, water, energy and communications, will continue to apply, but to a lesser extent and with a slower ramp-up.

Concluding issues (Section 13)

A number of issues arise from the audit for consideration by governments in furthering development of Northern Australia.

Firstly, **strengthened infrastructure network planning and coordination** merits consideration as a means to help lower the costs of infrastructure service and improve reliability of supply. The issue of extending networks in northern Queensland, the Pilbara and elsewhere – and overcoming the various costs of both transmission and collaboration between different parties in doing so – has been identified in the electricity sector. Conversely, in the same sector in those parts of northern Queensland that are connected to the National Electricity Market, the issue that presents is the absence of commercial incentives under market rules for generators to locate in northern Queensland and resulting high costs of power for industry customers. Network planning and coordination, however, has a role to play in all sectors, in order to further: provision of a comprehensive service where this is applicable; network security and resilience (e.g. alternative route access and increased market depth and supply); and improved connectivity (e.g. 'missing' road and communications backhaul links).

Secondly, with **numerous sources of market failure** in the infrastructure industries in general and in Northern Australia in particular (see Box ES 1, 'What could infrastructure gaps mean for government response?') a long list of critical infrastructure requirements is perhaps to be expected. Not all of these market failure challenges necessarily require a government-funded 'hard infrastructure' response. For example, improved electricity network coordination can involve government facilitation action to bring together different players. However, it is apparent that many do call for such a response, posing difficulties for constrained government budgets. This presents opportunities, firstly, for careful prioritisation and secondly, for, innovation in infrastructure delivery and provision, to ensure quality outcomes at least cost.

With regard to **prioritisation**, maximising the efficiency of existing infrastructure is critical to the development of Northern Australia and arguably equal in importance to new infrastructure, or of greater importance. Key areas for attention in this regard include addressing maintenance backlogs (roads sector) and introducing more cost-reflective pricing where feasible (especially in the water sector).


Photo courtesy of Pilbara Ports Authority

As to **infrastructure provision**, to address pervasive service standard gaps in areas where the cost of service provision is high, maximising the role of the private sector is particularly important, to achieve innovation, quality service and, where feasible, competition.

Finally, **project evaluation processes** could be reviewed to ensure that there is no unintended bias against initiatives that incentivise opportunities in end user markets (in agriculture, tourism or elsewhere). Cost-benefit analysis is essential to investment prioritisation evaluation. However, its central focus on expected or known infrastructure demand can be an inadequate one where future opportunities are central to the business case. Here cost-benefit analysis needs to encompass a wider scope, in order to capture potentially significant impacts in end-user markets.

The following table presents a list of current and potential future pressures on Northern Australia's infrastructure and the likely infrastructure needs in the decades ahead. Importantly, this is not a list of projects that Governments should or could fund. Many are private sector ventures, and all would require further investment and analysis, including to assist with planning. The timeframes for development and the potential sources of funding would be a key part of this analysis.

Strengthened infrastructure network planning and coordination merits consideration as a means to help lower the costs of infrastructure."

Table ES 2: Potential infrastructure requirements

Infrastructure grouping	Location	Primary infrastructure gap(s)	Areas for investigation
Airports			
Airport expansion – resource sector	Broome	Demand	Apron (aircraft parking), taxiway and terminal facilities
		Demand	New airport location to accommodate growing heliport needs
	Galilee Basin	Demand	Airport upgrading to accommodate resource development traffic (possible airports include Alpha, Clermont, Emerald)
	Gladstone	Demand	Apron (aircraft parking) facilities including for helicopter relocation, runway improvements and terminal facilities
	Karratha	Demand	Apron (aircraft parking) facilities, runway extension, taxiway improvements and terminal facilities
	Newman	Demand	Apron (aircraft parking) facilities, runway improvements and terminal facilities
	Port Hedland	Demand	Apron (aircraft parking) facilities, taxiway improvements and terminal facilities
	Townsville	Demand	Apron (aircraft parking) facilities
		Demand	Terminal facilities to accommodate passenger increase
Airport expansion – tourism and/or mixed traffic	Alice Springs	Demand	Runway and taxiway improvements
		Demand	Terminal facilities upgrade to accommodate passenger increase
	Ayers Rock (Yulara)	Demand	Apron (aircraft parking) facilities, runway strengthening, taxiway improvements
		Demand	Terminal facilities upgrade to accommodate passenger increase
	Darwin	Demand	Taxiway improvements
	Katherine	Demand, service standard	Taxiway, apron and fire service upgrade to maintain international alternate airport status for Darwin Airport
	Kununurra	Demand, opportunity	Runway improvements, including extension to accommodate larger aircraft
		Demand	Terminal facilities to accommodate passenger increase
	Milingimbi	Service standard	Runway sealing and extension
	Port Keats	Demand, service standard	Expansion of the length and width of this runway is required to facilitate movement of larger aircraft
	Ramingining	Service standard	Runway needs length and width extensions
	Townsville	Demand	Apron (aircraft parking) and terminal facilities

Infrastructure grouping	Location	Primary infrastructure gap(s)	Areas for investigation
Ports			
Port expansion – resources	Abbot Point	Demand	Expansion (potential for two additional 60 million tonne terminals) for Galilee Basin coal development, with resolution of dredging issue required
	Anketell	Demand	Dry bulk dedicated infrastructure (West Pilbara iron ore)
	Ashburton	Demand	Bulk liquid dedicated infrastructure (North West Shelf and Carnarvon Basin LNG)
	Bing Bong	Demand	Iron ore specialised handling equipment upgrade – possible (alternative to Darwin)
	Broome	Demand	Bulk liquid dedicated infrastructure (North West Shelf, Canning Basin oil and gas) – possible
	Dampier	Demand	Iron ore (Pilbara) and bulk liquid (Carnarvon Basin LNG) upgrade
	Darwin	Demand	Dedicated livestock handling and storage facilities
		Demand, opportunity	Dry bulk berth and handling facilities
		Demand	Rail loop or other rail receival solution to accommodate mining throughput growth
		Demand	Improved cruise vessel facilities and associated infrastructure
	Gladstone	Demand	Coal specialised handling equipment upgrade and channel duplication
	Hay Point	Demand	Coal specialised handling equipment's upgrade (25 million tonne metallurgical coal demand)
	Karumba	Demand	Expansion, including transhipment infrastructure, to accommodate possible future irrigated agricultural exports and North West Queensland mineral exports
	Mackay	Demand	Intermodal facilities and infrastructure and improved land transport access for imports
	Port Hedland	Demand	Outer Harbour development (Pilbara iron ore, Canning Basin oil and gas)
		Demand	Intermodal and logistics facilities
	Port Melville	Demand, opportunity	Development of ancillary port infrastructure to service the oil, gas, mineral sands and agricultural industries
	Townsville	Demand	Additional bulk berth for increased mining output
		Demand	Common user rail receival facility
		Demand	Outer Harbour development for potential large-scale mining export increase
	Wyndham	Demand	Dry bulk dedicated infrastructure (Ord Stage 2 and Canning Basin)
Port expansion-passengers	Cairns	Demand	Cruise vessel facilities, including channel capacity and wharf extension, subject to Queensland Ports Strategy constraints on dredging
Rail upgrading – north-south access, mixed traffic	Adelaide-Darwin Railway	Demand, opportunity	Track drainage improvements, crossing passing loop construction (intermodal freight reliability, mine development opportunity)
		Demand, opportunity	Siding/passing loop at Mataranka to facilitate loading of iron ore
		Demand	Rail spur line for a proposed passenger terminal in the Berrimah Farm, Stuart Highway area to improve accessibility to the central business district
	North Coast Line	Opportunity, service standard	Track capacity and alignment, axle loading, signalling, flood resilience upgrades, including a single track constraint between Beerburrum and Landsborough/Nambour (Southeast Queensland)
		Demand, opportunity	New rail access corridor to port through Townsville

Infrastructure grouping	Location	Primary infrastructure gap(s)	Areas for investigation
Rail			
Rail upgrading and expansion – resources	Central Queensland Coal Network	Demand	Blackwater System – expansion to enable longer trains
		Demand	Newlands System – minor works to achieve capacity of 50 million tonnes per year
	Central West System	Demand	Track and signalling, crossing/passing loop upgrades to accommodate Galilee Basin demand – possible
	Galilee Basin links	Demand	Track construction and extension to the Central Queensland Coal Network (for Galilee Basin thermal coal development)
	Mount Isa Line	Demand, opportunity	Axle load, train length, weather resilience upgrade for new mining development
		Demand, opportunity	New rail access corridor to the port to accommodate future demand and improve city amenity
	Pilbara rail systems	Demand	Expansion of the three existing rail systems
		Demand	Construction of Roy Hill-Hancock Prospecting Railway and a possible fifth East Pilbara railway
	West Pilbara Railway	Demand	New railway construction to Anketell Point
Roads			
North-south and inter-jurisdictional links	Barcaldine to Cloncurry, QLD (Landsborough Highway, NLTN)	Demand, service standard	Upgrades to address ageing and narrow pavements, structures, flooding (reliability) and safety (with vehicle mix including Type 2 road trains and tourist vehicles) and capacity (e.g. overtaking lanes and shoulders)
	Beneraby to Cairns, QLD (Bruce Highway, NLTN)	Demand, service standard	Safety (including seal widening, sealed shoulders), flooding immunity, capacity (including pavement rehabilitation, duplications, Mackay Ring Road (see Queensland Government (2012))
	Townsville to Mount Isa, QLD (Barkly and Flinders highways, NLTN)	Demand, service standard	Upgrades to address ageing and narrow pavements and structures, flooding (reliability) and safety (with vehicle mix including Type 2 road trains and tourist vehicles) and capacity (e.g. overtaking lanes) (See Department of Transport and Main Roads 2014a, for Townsville to Mount Isa)
	Darwin to the South Australian border, NT (Stuart Highway, NLTN)	Demand, service standard	Address safety pavement and structure strength, flood mitigation and industrial/suburban duplications (Hughes near Darwin abattoir and residential development and Alice Springs road to the airport addressing residential and industrial development)
	Darwin, NT to Kununurra, WA (Victoria Highway, NLTN)	Demand, service standard	Address safety, pavement strength and width (e.g. Halls Creek section connecting to Great Northern Highway and Victoria Highway), high level bridges (e.g. bridges such as Big Horse and Little Horse River/Creek and on the Victoria Highway), for flooding resilience (e.g. Kununurra Diversion Dam Bridge route)
	Tennant Creek to Flinders, NT (Barkly Highway, NLTN)	Demand, service standard	Address safety (narrow pavement and structures), pavement and structure strength
	Tobermorey to Stuart Highway, NT (Plenty Highway – Outback Way)	Service standard	Address unsealed pavements and structures, flooding (reliability) and lane capacity upgrade to improve livestock flow efficiency

Infrastructure grouping	Location	Primary infrastructure gap(s)	Areas for investigation
Roads			
North-south and inter-jurisdictional links	Kununurra and Wyndham to Perth, WA (Great Northern Highway, NLTN)	Demand, service standard	Address safety (narrow pavement and vehicle mix conflict e.g. Wyndham Spur, duplication of single lanes, e.g. Erskine – Blina), pavement and bridge strength, culvert rehabilitation and flooding resilience
	North West Coastal Highway, WA	Demand, service standard	Address pavement and steel culvert rehabilitation, seal widening (e.g. Minilya to Barradales), capacity/congestion (Karratha to Roebourne link) and demand linked regional including west Pilbara region growth (e.g. Anketell Port, Cape Preston, and Northern Carnarvon Basin)
	North West Coastal Highway, WA	Demand, service standard	Upgrades to strengthen pavements and ease freight and road users' interaction by providing extra passing lanes and sealed shoulders
Resource, agriculture, tourism and community links	Cairns to Boulia, QLD (NT border) (Kennedy Developmental Road/Hann Highway – Outback Way)	Service standard	Address unsealed sections, narrow pavement (largely single lane near NT border)
	Charters Towers to Cairns, QLD (Gregory, Kennedy Developmental roads, Kennedy Highway	Demand, service standard	Address safety (narrow pavement and structures), pavement and structure strength, flooding resilience, slow traffic movement (Atherton, Mareeba)
	Clermont to Charters Towers, QLD (Gregory Highway, Developmental Road)	Demand, service standard	Address safety (narrow pavement and structures), pavement and structure strength, flooding resilience
	Cloncurry to Dimbulah, QLD (Burke Developmental Road)	Demand, service standard	Address safety (narrow pavement and structures), pavement and structure strength
	Dingo to Mount Flora, QLD (Fitzroy Developmental Road)	Demand, service standard	Address safety (narrow pavement and structures), pavement and structure strength, flooding resilience
	Innisfail to Ravenshoe, QLD (various roads)	Demand, service standard	Address safety and freight efficiency (widen seal)
	Lakeland to Weipa, QLD (Peninsula Developmental Road)	Demand, service standard	Address safety (narrow pavement and structures), road sealing and flooding resilience to alleviate prolonged wet season closures
	Mackay to Clermont, QLD (Peak Downs Highway)	Demand, service standard	Upgrades to strengthen and widen narrow pavements, replace load-limited timber bridges and upgrade the Eton Range winding alignment (west of Walkerston), improve flood resilience (See Department of Transport and Main Roads 2014c)

Infrastructure grouping	Location	Primary infrastructure gap(s)	Areas for investigation
Roads			
Resource, agriculture, tourism and community links	Mareeba to Lakeland, QLD (Mulligan Highway)	Service standard	Address safety and freight efficiency (widen seal) and structure strength
	Normanton to Mount Garnet, QLD (Gulf Developmental Road)	Demand, service standard	Address safety (narrow pavement and structures), pavement and structure strength
	Rockhampton to Barcaldine QLD (Capricorn Highway	Demand, service standard	Safety and capacity upgrades, including extensive seal widening, overtaking lanes, targeted pavements strengthening, bridge and culvert upgrades, duplication (Rockhampton to Gracemere), flood immunity improvements (See Department of Transport and Main Roads (2014b))
	Alice Springs to Yulara, NT (Red Centre Way)	Opportunity, service standard	Seal the Mereenie Loop Road Hermannsburg to King's Canyon) and upgrade Lasseter Highway to King's Canyon spur, assisting tourism development
	Alice Springs, NT to Halls Creek, WA (Tanami Road)	Opportunity, cost, service standard	Address pavement sealing and widening of single lane sections and sealing of unsealed sections
	Barkly Highway to Borroloola, NT (Tablelands Highway)	Demand, service standard	Address single lane and pavement widening
	Daly River to Wadeye, NT (Port Keats Road)	Service standard	Address unsealed road flood resilience for community and resource sector access
	Jabiru to Pine Creek, NT (Kakadu Highway)	Demand, service standard	Address safety (narrow pavement and structures), pavement and structure strength and flooding resilience to cater for the mixed traffic of tourists with caravans and heavy transport
	Katherine to Nhulunbuy, NT (Central Arnhem Highway)	Demand, service standard	Phase pavement sealing through strategic links (i.e. Stuart Highway to Bulman, Bulman to Nhulunbuy and connection to Melville Bay Road) including bridging of river/creek crossings
	Mataranka to Numbulwar, NT (Roper Highway)	Demand, service standard	Address pavement sealing and widening of single lane sections and sealing of unsealed sections and flooding resilience and bridges (e.g. Wilton Crossing)
	Stuart Highway to Borroloola, NT (Carpentaria Highway)	Demand, service standard	Address safety (narrow pavement and structures), single lane pavements and pavement widening and strengthening
	Stuart Highway, NT to the WA border (Lasseter Highway, Tjukaruru Road – Outback Way)	Demand, service standard	Address safety (narrow pavement and structure), pavement and structure strength to cater for the mix of tourists with caravans and heavy transport
	Derby to Broome, WA (Derby Highway)	Demand, service standard	Address safety, improve access to Derby city, pavement sealing and seal widening when connecting to Great Northern Highway
	Derby to Wyndham, WA (Derby Gibb River Road/ Gibb River Road/ Gibb River Wyndham Road)	Demand, service standard	Address pavement sealing, seal widening (Derby to Fairfield-Leopold), flood resilience including remote monitoring to improve information to road users

Infrastructure grouping	Location	Primary infrastructure gap(s)	Areas for investigation
Roads			
Resource, agriculture, tourism and community links	East Pilbara mines to Marble Bar Road, WA (Ripon Hills Road)	Demand, service standard	Address pavement rehabilitation and flooding resilience
	Karratha to Tom Price and Paraburdoo, WA (Karijini Drive)	Demand, service standard	Address freight efficiency (steep alignment)
	Kununurra to Keep River/ Legune Station, WA (Weaber Plains Road extension)	Opportunity	Extend road to support Ord Stage 3 agricultural development
	Nanutarra, WA (on North West Coastal Highway to Munjina, WA (near Paraburdoo)	Demand, service standard	Address safety (road geometry), bridge strengthening and widening, pavement sealing, flood mitigation, (e.g. Oakober River Floodway, Nullagine River Floodway and Shaw River Floodway upgrade/repair)
	Pannawonica to North West Coastal Highway, WA (Pannawonica Road)	Demand, service standard	Address freight efficiency (narrow pavement)
	Paraburdoo to Tom Price, WA (Paraburdoo Tom Price Road)	Demand, service standard	Address narrow pavement and bridge strength
	Strelley, WA (on Great Northern Highway) to near Newman, WA (Marble Bar Road)	Demand, service standard	Address pavement sealing, road geometry, bridge strength, flood resilience
	Victoria Highway to Nicholson, WA (Buntine Highway)	Demand, service standard	Address unsealed sections and single lane pavements (Kalkarindji to Victoria Highway)
Access to ports, airports and tourism locations	El Arish to Mission Beach Road, QLD	Service standard	Address safety (narrow pavement)
	Gladstone to Mount Larcom, QLD (Gladstone Mt Larcom Road)	Demand, service standard	Address safety (narrow pavement, limited overtaking)
	Halifax to Lucinda Point Road, QLD	Service standard	Address safety (narrow pavement)
	Ingham to Halifax-Bemerside Road, QLD	Demand, service standard	Address safety (narrow pavement)
	Mackay-Slade Point Road, QLD	Demand, service standard	Address safety (mixing of heavy vehicle and passenger traffic)
	Tully – Mission Beach Road, QLD	Service standard	Address safety (narrow pavement)
	Berrimah to East Arm Port Access, NT (Berrimah Road)	Demand, service standard	Address duplication to port access infrastructure and mixed traffic through urban links (e.g. Export Drive)

Infrastructure grouping	Location	Primary infrastructure gap(s)	Areas for investigation
Roads			
Access to ports, airports and tourism locations	Borroloola to Bing Bong Port, NT (Carpentaria Highway, Robinson Road)	Demand, service standard	Address safety, seal width, pavement design and strengthen for heavy vehicles traffic
	Humpty Doo to Jabiru, NT(Arnhem Highway)	Demand, service standard	Address bridge repairs and maintenance (e.g., Mary River, Wildman River, and East Alligator Rivers), safety (narrow pavement and structures, vehicle mix conflicts), pavement and structure strength, rehabilitation and flooding resilience (e.g. Adelaide River)
	Dampier – Burrup Road, WA	Demand, service standard	Address safety and capacity through duplication to Dampier Port facilities and intermodal access (e.g. Burrup Peninsula Logistics Hub)
	Port Hedland, WA (Gilbert Street/ Wilson Street)	Demand, service standard	Address safety (narrow pavement and structures, vehicle mix conflicts), pavement and structure strength and rehabilitation)
	Robe River loading facility to Roebourne, WA (Point Samson Roebourne Road)	Demand, service standard	Address safety (shoulder width, road geometry, vehicle mix conflicts)
Urban including public transport	Bus interchange and other upgrades, QLD (Cairns, Townsville, Mackay, Rockhampton)	Demand	Bus interchange (Cairns) and bus stop or station upgrades (Cairns, Townsville, Mackay, Rockhampton) can improve service and help attract patronage, limiting urban congestion growth over the period to 2031
	Bus priority measures, QLD (Cairns, Townsville)	Demand	Bus priority measures to reduce the impact of peak period congestion on on-time running and service reliability, together with improved ticketing and bus information systems
	Cairns to Mossman, QLD (Captain Cook Highway)	Service standard	Address safety (vehicle mix conflicts), delays through Cairns, flooding (reliability)
	Dysart to Middlemount, QLD	Demand, service standard	Address safety (narrow pavement), flooding resilience
	Proserpine to Shute Harbour, QLD	Service standard	Address safety (vehicle mix conflicts), urban delays
	Rockhampton to Yeppoon, QLD	Demand, service standard	Address safety (vehicle mix conflicts), urban delays
	Darwin International Airport, NT (Henry Wrigley Drive)	Demand	Address duplication and increase capacity of airport link
	Tiger Brennan Drive, NT	Demand	Address safety (vehicle mix conflicts), urban delays and capacity through complete duplication from Darwin to Berrimah
	Dampier Highway to North West Coastal Highway, WA (Madigan Road, Karratha)	Demand, service standard	Address seal width, seal shoulders, pavement rehabilitation, strength and lane duplication

Infrastructure grouping	Location	Primary infrastructure gap(s)	Areas for investigation
Roads			
Urban including public transport	Jigal Drive, WA (Broome Road – Gubinge Road)	Service standard	Address safety (vehicle mix conflicts) and freight efficiency through urban area
	North West Coastal Highway to Karratha, WA (Dampier Road)	Demand, service standard	Address safety (narrow pavement and structures, vehicle conflicts) and capacity/congestion (e.g. Balmoral Road West to Burrup Road)
	Onslow to North West Coastal Highway, WA (Onslow Road)	Demand, service standard	Address safety (road geometry), seal width, pavement design for increasing traffic and heavy vehicles
Energy			
High electricity cost or inefficient supply	North Queensland (National Electricity Market)	Opportunity, cost	Review locational incentives for loads and generation in the region
		Demand	Strategically placed electricity generation to lower locational costs
		Demand	Review cost of electricity connections to the network for new resource developments
		Demand	Shared network extension to efficiently connect new northern Galilee loads
	Mount Isa	Opportunity, cost	Review commercial incentives for power generation in the region
		Demand	Additional electricity generation
		Demand	Electricity connections to the network for new resource developments
		Demand	Shared network extension to connect to National Electricity Market
		Demand	Review gas supply alternatives for generation in the region
	Pilbara	Opportunity, cost	Greater planning coordination to achieve more efficient outcomes
		Demand	Additional electricity generation connected to the shared network
		Demand, opportunity	Shared network extension to efficiently connect new resource developments
		Demand, opportunity	Review gas supply alternatives for generation in the region
Electricity demand growth	Galilee and Bowen Basins	Demand, opportunity	Generation capacity upgrades
		Demand	Electricity connections to the network for new resource developments
		Demand	Renewable generation alternatives
	Carpentaria minerals province	Opportunity	Additional generation capacity
		Demand	Electricity connections
		Opportunity	Rail and port connections to support resource developments
	Pilbara	Demand	Additional generation capacity
		Opportunity	Electricity connections to the network for new resource developments
		Demand, opportunity	Rail and port connections to support resource developments

Infrastructure grouping	Location	Primary infrastructure gap(s)	Areas for investigation
Energy			
Electricity demand growth	Northern Territory	Demand	Additional generation capacity
		Demand	Electricity connections to the network for new resource developments
Ageing assets / decarbonisation policies	Isolated WA, NT and QLD systems	Demand, service standard	Replacement of generating systems after deferral using distributed renewable energy
Link to eastern gas markets	Alice Springs to Moomba	Demand, opportunity	Gas pipeline link
Water			
Urban water storage and supply	Alice Springs	Demand, service standard	Borefield augmentation works are required to maintain existing borefield capacity and investigation of additional borefield
	Cairns	Demand, opportunity	Surface water storage or other water supply infrastructure assets (e.g. recycling facilities) as well as water efficiency management measures – may be needed sooner if Aquis development eventuates
	Darwin	Demand	Surface water storage capacity increase
	Mackay	Demand	Upgrade water entitlement profile before consideration of possible surface water storage capacity increase
		Demand, service standard	Water treatment facility upgrade
	Mount Isa	Demand, service standard	Increase water supply e.g. through pumping water from Julius Dam and reserving it in Moondarra Dam for town use, to address emerging shortages
	Kimberley region	Demand, opportunity	Water bores system renewal
	Pilbara region	Demand	Connecting and trunk infrastructure
		Demand	Water bores system renewal
	Rockhampton	Demand	Surface water storage capacity increase
	Tennant Creek	Demand, service standard	Water bores system renewal
	Townsville	Demand	Surface water storage capacity increase
Bulk water storage and supply	Adelaide River	Demand	Off-stream storage
	Darwin Rural Area	Demand, opportunity	Off-stream storage
	Flinders catchment	Opportunity	Multiple water harvesting developments (off-stream storages etc.)
	Galilee Basin	Demand, opportunity, cost	Connecting and trunk infrastructure
		Demand, opportunity, cost	Surface water storage capacity increase/new storage
		Opportunity	Surface water storage and water distribution network
	Gilbert catchment	Opportunity	Surface water storage and water distribution network
	Katherine/Daly Basin	Opportunity	Conjunctive groundwater use and managed aquifer recharge supporting irrigation development
	Kimberley region	Opportunity	Borefield supported irrigation development
	Mataranka	Opportunity	Borefield supported irrigation development
	Ngukurr (Roper River area)	Opportunity	Borefield supported irrigation development
	Ord	Demand, opportunity	Ord River Scheme/Dam – raising of spillway, pumps and possible additional pipelines/channels or efficiency improvement to open channel system

Infrastructure grouping	Location	Primary infrastructure gap(s)	Areas for investigation
Water			
Bulk water storage and supply	Pilbara region	Opportunity	Borefield supported irrigation development
	Upper Burdekin	Opportunity	Connecting and trunk/distribution infrastructure
		Opportunity	Surface water storage capacity increase/new storage development
Communications			
Broadband service	Throughout Northern Australia	Demand, service standard	Progressive rollout of NBN, both to catch up on existing deficiency and to accommodate growth, with the program to be determined by NBN Co. Note specific needs below
		Demand, service standard	Incentivise, require or subsidise provision of higher quality communications to remote regions through universal service obligation, or other arrangements, e.g. infrastructure programs
Mobile service	Inland Western Australia	Demand, service standard	Expand mobile coverage away from Highway 1 to the interior of the state, with associated loop backhaul
Transmission infrastructure	Central and Western Queensland	Demand, cost, service standard	Leverage investment in resources infrastructure to create new backhaul and mobile coverage
	Across Northern Australia	Demand, cost, service standard	Seek opportunities to incentivise existing private communications infrastructure owners to allow third party access
International connections	North Western Australia, Northern Territory	Demand, service standard	Encourage international cable link via Northern Western Australia or Northern Territory with associated domestic backbone connections


Photo courtesy of Pilbara Ports Authority

Abbreviations and glossary

AADT	Annual average daily traffic
ACCC	Australian Competition and Consumer Commission
ACMA	Australian Communications and Media Authority
ADSL	Asymmetric digital subscriber line data communications technology
AM	Amplitude modulation radio broadcasting services
Break bulk goods	Cargo on a ship stored without a container
B-double	A combination of a prime mover hauling unit towing two trailers consisting on 1 semitrailer supported at the front by, and connected to, the other semitrailer
CAGR	Compound annual growth rate
CDMA	Code division multiple access, a channel access used by various radio communications technologies
Containerised goods	Freight in large standardised, sealed containers whose contents do not have to be unloaded at each point of transfer
DA	Telstra Distribution Area
DTCS	Domestic transmission capacity service
FIFO	Fly-in, fly-out
FLNG	The floating production unit of liquefied natural gas
FM	Frequency modulation radio broadcasting services
FTTB	Fibre to the building
FTTdp	Fibre to the distribution point
FTTN	Fibre to the node
FTTP	Fibre to the premises
FY	Financial year
GA	General aviation
GCCSA	Greater capital city statistical area
GDP	Gross domestic product
GEM	Geospatial Economic Model
GL	Gigalitre
GPRS	General packet radio service
GSM	Global system for mobile communications
GVA	Gross value added measures the value of output less the value of intermediate consumption
Headroom allowance	Unused train paths in a railway network, that are maintained to allow necessary operational flexibility
HFC	Hybrid fibre-coaxial, a broadband network that combines optical fibre with coaxial cable
HPON	High Power Open Narrowcast radio services
IP	Internet Protocol
ISDN	Integrated Service Digital Network
ISS	Interim Satellite Service
Kbps	Kilobits per second
Kl	Kilolitre
LAT	Lowest Astronomical Tide, i.e. the lowest levels which can be predicted to occur under average meteorological conditions
Latency	Communications signal delay
LGA	Local government area

Photo courtesy of Aurizon Holdings Ltd

LTE	Long term evolution technology, a fourth generation (4G) wireless technology
LTSS	Long Term Satellite Service
M2M	Machine to machine
Mbps	Megabits per second
Mobile equipment	Non-fixed port infrastructure such as mobile cranes and loaders
MF	Medium frequency
MHz	Megahertz
Ml	Megalitre
MW	Megawatt
N/A	Not available
NAIA	Northern Australia infrastructure audit
Nameplate capacity	The maximum continuous output or consumption in megawatts of an item of electricity infrastructure, as specified by the manufacturer, or as subsequently modified
NBN	National Broadband Network
NCL	North Coast Line
NIM	Net internal migration
NLTN	National Land Transport Network
NOM	Net overseas migration
NSS	Satellite Support Scheme
OTT	Over the top
PJ	Petajoule, a standard unit of energy, equivalent to 277.78 million kilowatt hours of electricity and 31.6 million cubic metres of natural gas
PSTN	Public switched telephone networks
RBBP	Regional Backbone Blackspots Program
RC	Regional council
RT	Road Train, heavy vehicle other than a B-double
ROP	Resource operations plan, through which, under the Queensland Water Act 2000, water resource plans are implemented
RPT	Regular public transport air services, to be distinguished from charter air services
WAP	Water allocation plan, Northern Territory
WRP	Water resource plans, which apply to each water catchment region in Queensland
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SHDSL	Symmetrical high-speed digital subscriber line
Ships' gear	Cranes and discharging equipment attached to vessels which is used to transfer product between a ship and a berth without the need for landside infrastructure
SA2	Australian Bureau of Statistics (ABS) Statistical Area Level 2, one of the six units in the ABS' statistical geography framework
TJ	Terajoule
Tph	Tonnes per hour
Transhipment	The transfer of goods at port from one conveyance to another for reshipment.

Type 1 RT	A road train using either a rigid truck hauling unit towing one trailer when the combination length is no longer than 31.5m or for a road train using a prime mover hauling unit towing two trailers when the combination length is no longer than 36.5m
Type 2 RT	A road train using either a rigid truck hauling unit towing two trailers when the combination length is no longer than 47.5m or a road train using a prime mover hauling unit towing three or four trailers when the combination length is no longer than 53.5m
UCL	Urban centre and locality, an Australian Bureau of Statistics unit of analysis

USB	Universal Serial Bus
USO	Universal service obligation
UHF	Ultra high frequency
VHA	Vodafone Hutchison Australia
VHF	Very high frequency
VKT	Vehicle kilometres travelled
VOIP	Voice over internet protocol
WAP	Water allocation plan, Northern Territory
Wi-Fi	Wireless local area network (proprietary name)
WRP	Water resource plans, which apply to each water catchment region in Queensland
xDSL	(Generic) digital subscriber line

Photo courtesy of Pilbara Ports Authority

Introduction

1.1 Project objectives

The Deputy Prime Minister and Minister for Infrastructure and Regional Development, the Hon. Warren Truss MP, requested Infrastructure Australia to undertake an evidence-based audit of Australia's current infrastructure base in collaboration with Commonwealth, state and territory governments.

Infrastructure Australia has been requested to conduct the first Northern Australia infrastructure audit (NAIA) and develop a list of critical infrastructure requirements in the transport, water, energy and communications sectors over the period to FY31.

The audit findings are to provide input into the Australian Government's White Paper on developing Northern Australia and the Australian Infrastructure Plan. The role of the White Paper is to set out a policy framework to foster the development of Northern Australia. The framework is to build on the region's often underutilised competitive advantages in agriculture, minerals, energy and tourism, as well as other assets including proximity to the growing Asian region and the tropical location, with associated leading expertise in health and education for tropical regions.

1.1.1 Infrastructure and Northern Australia economic development

Northern Australia's industries have differing if overlapping infrastructure needs, with resource industries dependent on: access to ports and rail infrastructure, to move product; air links, to move non-resident workforces; and road links, for site supply and access. Agriculture and tourism are highly reliant on road infrastructure and domestic and international air links.

Viewed from an infrastructure perspective, the region's economic development requires:

- Resilient export-related infrastructure (variously, ports, airports, roads and railways) with sufficient capacity
- Good connections with southern Australia (air, communications, rail and road)
- Expanding links between the growing urban economies of, in particular, the major centres of Darwin, Cairns, Townsville and Mackay and their hinterlands.

In addition, efficient water, power and communications infrastructure are integral to all industry sectors in the north and to support populations and communities.

1.2 Project scope

In addition to auditing infrastructure capacity in the context of five, 10 and 20 year population growth, this project includes preparation of a list of critical infrastructure requirements. The audit addresses the four recognised economic infrastructure sectors of transport, energy, water and communications.

The project's geographic scope is defined in Section 1.2.1 and the criteria for the infrastructure in scope are covered in Section 1.3.

The audit focuses primarily on infrastructure connecting to larger northern population centres (3,000 persons or more), as well as to areas of

significant existing or prospective economic activity (see Section 2.2). In consequence, the essential infrastructure needs of the many smaller remote Indigenous communities fall outside the scope of the audit. These matters are addressed in the concurrent Northern Territory Regional Infrastructure Study and in a Council of Australian Governments Remote and Regional Transport Infrastructure Study, being led by the Northern Territory Government.

1.2.1 Definition of Northern Australia

Northern Australia is commonly defined as the area north of the Tropic of Capricorn. However, from a policy, economic and social data perspective, this latitude does not align precisely with key geographical collection areas, namely ABS Statistical Area Level 2 boundaries (SA2).[2] This latitude also excludes key centres such as Alice Springs and Newman, which have in the past been included in discussions on Northern Australia. Furthermore, a number of state and territory policy documents and submissions to recent inquiries suggest alternate and inconsistent definitions of the Northern Australia region.

Through analysis and consultation with stakeholders, PwC, GHD and Infrastructure Australia explored five options to define Northern Australia and agreed that Option 4 would best meet a number of stakeholder needs and perceived geographies that are not necessarily reflected by a strict application of the SA2-based decision rule. The options considered are outlined below:

1. SA4 level boundaries – capturing all SA4s which intersect the Tropic of Capricorn
2. SA3 level boundaries – capturing all SA3s which intersect the Tropic of Capricorn
3. SA2 level boundaries – capturing all SA2s which intersect the Tropic of Capricorn
4. SA2 level boundaries – capturing SA2s which intersect the Tropic of Capricorn, however, adjusted to reflect differing notions of Northern Australia
5. Mesh block level analysis to align boundaries most closely to the Tropic of Capricorn.

The agreed definition of Northern Australia (Option 4) incorporates the SA2s that intersect the Tropic of Capricorn, adjusted to reflect stakeholders' understanding of Northern Australia. The agreed boundaries consider the definitions proposed in the following:

- *The Coalition's 2030 Vision for Developing Northern Australia (the 2030 Vision)*, Liberal Party, June 2013
- *Commonwealth Green Paper on Developing Northern Australia*

2. SA2s are a spatial unit in the Australian Statistical Geography Standard (ASGS) used by the ABS to disseminate a broad range of social, demographic and economic statistics. The ASGS is broadly based on the concept of a functional area from which people come to access services from a centre. The ASGS has six hierarchical levels comprising in ascending order: Mesh Blocks, SA1s, SA2s, SA3s, SA4s and States/ Territories. Each level directly aggregates to the level above and each hierarchical level collectively covers all of Australia without gaps or overlaps. SA2s are a general-purpose medium-sized area built from whole SA1s. Their aim is to represent a community that interacts together socially and economically.

- *Submission to the Joint Select Committee on Northern Australia Inquiry into the Development of Northern Australia*, Northern Territory Government, February 2014
- Consultation with the Queensland Department of State Development, Infrastructure and Planning
- Consultation with the Northern Territory Department of Treasury and Finance
- Consultation with Western Australian Government departments and agencies
- Consultation and agreement with the Department of the Prime Minister and Cabinet.

These adjustments are to:

Include all SA2s in the Northern Territory, Newman SA2 in Western Australia, Gladstone SA2 in Queensland and Gladstone Hinterland SA2 in Queensland, as these are key centres which have, in the past, been included in discussions on Northern Australia and/or have serviced major export industries located inland of the Port of Gladstone.

Exclude Exmouth SA2 and Carnarvon SA2 (which is surrounded by Exmouth SA2), as only a very small part of the area is north of the Tropic of Capricorn. However, critical infrastructure in Exmouth has been considered as part of the audit given its role in facilitating and servicing the mining and gas industries in the north. For the purposes of infrastructure planning, Western Australian Government departments and agencies consider Exmouth and Carnarvon within the scope of northern Western Australia.

Map 1 maps the agreed definition of Northern Australia. A list of all SA2s in Northern Australia is included in Appendix A.

1.3 Project approach

The key steps in the audit's approach are summarised below:

- **Analysis of population and industry drivers of economic growth,** involving developing baseline population projections, regional economic growth projections and identification of key growth regions.
- **Identification of critical infrastructure in Northern Australia,** involving developing a definition of 'critical infrastructure' (see 2.3.1) and applying it, in conjunction with jurisdiction infrastructure planning information, to a candidate set of infrastructure assets and networks to identify the 'in scope' infrastructure for the audit. There are eight primary sectors, each of which has a separate section in this report: transport – airports; transport – ports; transport – rail; transport – roads; energy – electricity; energy – gas pipelines; water; and communications.
- **Audit of critical infrastructure:** Using public sources and information from infrastructure managers and other parties, information was assembled on existing critical infrastructure assets and networks covering configuration, capacity, capacity usage (demand), planned capacity increases/upgrades and relevant service quality information, together with available future demand projections.
- **Identification of future critical infrastructure gaps:** Using the study's baseline population projections for Northern Australia and future industry and infrastructure demand information, the audit identified critical infrastructure gaps across the four sectors over the period to FY31. The FY31 date, together with a FY11 common base year, coincides with the horizon for the Australian Infrastructure Audit and the associated 15 year Australian Infrastructure Plan. Gaps relate to potential future as well as existing infrastructure. The audit also sought to identify gaps at the interim milestones of FY16 and FY21. However, with insufficient data to support more precise timings in numerous instances, these are not included in this report.
- **Development of future growth scenarios for Northern Australia development,** including analysing the regional population impacts of the scenarios.
- **Identification of critical infrastructure gaps against the growth scenarios** in similar manner to the baseline infrastructure gap assessment.
- **Development of a list of critical infrastructure requirements,** involving preparing a list of critical infrastructure requirements to address identified gaps. As the larger exercise, the main focus is on baseline infrastructure requirements, while additional requirements to meet the scenario targets are also identified.

These steps are further explained in Section 2, Methodology Overview.

1.4 Report outline

This report is structured as follows:

- **Section 2** outlines the key steps in the audit methodology
- **Section 3** describes the Northern Australia growth and development context, sets out the baseline economic and population projections for Northern Australia, the audit's understanding of key growth regions and also outlines four specific growth scenarios.

The following sections present the findings of the baseline infrastructure audit by sector, including infrastructure gaps and critical infrastructure requirements, as follows:

- **Section 4: Transport – airports**
- **Section 5: Transport – ports**
- **Section 6: Transport – rail**
- **Section 7: Transport – roads**
- **Section 8: Energy – electricity**
- **Section 9: Energy – gas pipelines**
- **Section 10: Water**
- **Section 11: Communications**

Finally:

- **Section 12 Growth scenarios** provides population impacts, infrastructure gap and critical infrastructure requirement assessment for the four scenarios
- **Section 13 Concluding issues** closes the report.

1.5 Acknowledgement

Many organisations and individuals have assisted the audit, in the four jurisdictions involved, in industry and elsewhere, taking time to provide invaluable information and insights. Infrastructure Australia gratefully acknowledge all of those contributions.

Methodology overview

This section briefly sets out the methodology for the audit (see Figure 1 for an illustration).

2.1 Population and industry drivers of growth

The outlook for population growth and economic growth are key drivers of infrastructure capacity requirements in Northern Australia, as defined for purposes of the audit in Section 1.2.1, while other factors, such as infrastructure maintenance and judgements about acceptable service levels also play a role. Accordingly, a key step in the methodology was to identify a baseline population growth path and an economic growth outlook, as an overarching framework for the infrastructure gap analysis. These aspects are outlined in Section 3.

2.2 Determining critical infrastructure for Northern Australia development

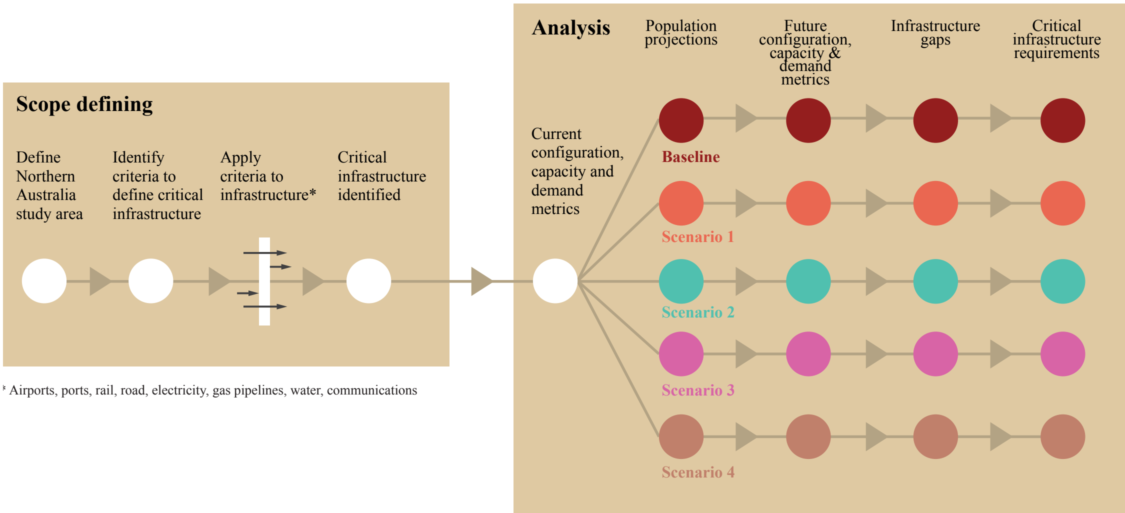
2.2.1 Definition of 'critical infrastructure'

The transport, energy, water and communications sectors all provide services that are essential to the functioning of Northern Australia's economy and society. However, not all essential infrastructure in the sectors can be deemed 'critical' for the purposes of the audit. The following criteria were specified to aid in categorising the infrastructure. The criteria involve considering whether or not the asset or network:

- **Connects to either a major Northern Australia population centre(s) or to regional areas of significant economic activity in the resources, agricultural, tourism or other industry sectors**
  The population geography of Northern Australia differs from the rest of the country, in that it comprises a number of comparatively small larger centres amid a widely dispersed total population. For the purposes of the audit, a major population centre was defined as an urban centre or locality (UCL) with a population over a threshold of 3,000 (ABS 2011 Census basis, see Table 3: Urban centres and localities scope). There are 31 UCLs in scope in Queensland, a third of which comprise the major centres (Townsville, Cairns, Mackay, Rockhampton and Gladstone), together with suburbs and satellite locations, seven in Western Australia and six in the Northern Territory, from a total of 138 SA2s across Northern Australia. Assets and networks serving these areas are classified as critically significant.

- Assets and networks serving regional or remote areas of significant current or prospective economic activity across our target sectors (i.e. resources, agricultural and tourism sectors) are also defined as critically significant. For the purpose of the audit, areas with a gross value added (GVA) that is not less than 0.3 per cent of total Northern Australia GVA are considered in scope. Table 4 sets out these SA2s. There are 69 SA2s in Queensland in scope, 15 in

Figure 1: Audit methodology



* Airports, ports, rail, road, electricity, gas pipelines, water, communications

the Northern Territory and nine in Western Australia. Particularly in Queensland and in the Northern Territory, with a more dispersed northern population, this criterion captures a number of locations with populations lower than 3,000.

- **Occupies a dominant or central network position**
  The audit is primarily concerned with trunk or nodal assets, rather than spur or branch or subsidiary assets. Thus in the roads sector, arterial roads may be included, but most local roads would be excluded. Airports servicing single mine sites are similarly excluded.

- **Rates as 'nationally significant' in the context of Infrastructure Australia's Australian Infrastructure Audit**
  In the parallel Australian Infrastructure Audit,[3] Infrastructure Australia reviewed a range of criteria that could be used to define nationally significant infrastructure. However, due to timing considerations for the respective audits, it did not prove practical to explicitly cross-check the infrastructure in scope of the two audits.

  In addition, infrastructure identified as important in jurisdiction planning and strategy documentation was included in the scope of the audit.

3. The objective of this audit is to develop a 15-year project pipeline based on national priorities and 'nationally significant infrastructure'.

2.2.2 Applying the criteria

The audit applied the criteria, in conjunction with information on priority assets and networks in jurisdiction planning and strategy documents, to infrastructure assets in the following sectors and subsectors:

- Transport: airports, ports, rail, road
- Energy: electricity generators and networks, and gas pipelines
- Water, including both urban (potable) and bulk (industry) uses
- Communications covering fixed and mobile infrastructure (for both data and voice).

Access to social infrastructure, including health, education and cultural facilities is outside the scope of this report. However, it is acknowledged that the provision of social infrastructure presents a serious challenge in some areas of Northern Australia.

2.3 Infrastructure audit – configuration, capacity and demand

The audit involved identifying and accessing selected configuration, capacity and demand metrics for each infrastructure sub-sector.

In principle, data collection should aim to identify the 'maximum capacity' of the asset or network, so that capacity surpluses and deficits can be gauged as a basis for the infrastructure gap analysis. In practice, this is often not feasible without an in-depth study. Levels of capacity utilisation on the one hand and service quality on the other are closely related, with congestion typically increasing and reliability decreasing as utilisation rates approach, or in some cases exceed, 100 per cent. A decision on whether (and when) capacity is 'full' and expansion should take place can often involve complex managerial judgements in which a range of considerations including the pace and scale of demand increase, level of service and financial implications are all weighed up. In many cases these decisions must also take close account of regulatory requirements. Assessment of maximum capacity is also particularly complex for those facilities, such as many ports, with multiple product lines and a range of specialised infrastructure.

Infrastructure service and capacity are also affected by the level of infrastructure maintenance and renewal and fitness for purpose. For example, a road with an ageing pavement may involve high operating costs and low speeds for users and, if the alignment is flood-prone in the northern wet season, is likely to have comparatively low availability.

The audit data collection focuses on some key metrics for each sector which, particularly when considered together and in the context of future demand estimates, provide a helpful contextual basis for consideration of potential future infrastructure capacity needs. Much of this information is included in Appendix B.

2.3.1 Future infrastructure demand

To gain an understanding of future infrastructure demand, the audit accessed available forecast and projection information from individual infrastructure managers (e.g. airport and port master plans, electricity network statements of corporate intent), which are referenced in the text. The audit sought to ensure a level of internal consistency between projections that are variously derived. At the same time, due to both the logistical considerations of the audit and data availability limitations, it was not practical to provide projections for all infrastructure assets and networks.

Additional key inputs are projected population and regional economic projections, together with information assembled on expected future key Northern Australia growth regions and resource hot spots.

Future infrastructure requirements and the gaps to which they relate are often market-dependent with timing uncertain. However, to avoid excluding potentially important infrastructure requirements, in assessing baseline infrastructure gaps the audit adopted an 'optimistic' approach that developments may take place before FY31, rather than after that date.

2.4 Infrastructure gaps

2.4.1 Concepts

The audit has identified four broad and (to some extent) overlapping types of infrastructure gap. Three of these gaps indicate infrastructure availability, service or price shortfalls. However, the fourth class, opportunity gaps, considers the role of infrastructure as an enabler of growth in unlocking new economic capacity, engaging with the 'positive externalities' of infrastructure investment.[4]

1. *Demand gaps,* where demand exceeds capacity, or demand approaches capacity such that the service becomes congested, unreliable, or unsafe, or alternatively again, where capacity is inadequate for the larger, more efficient equipment that the level of demand can support –

4. See Garnaut Climate Change Review (2008)

> To gain an understanding of future infrastructure demand, the audit accessed available forecast and projection information from individual infrastructure managers."

an example of the latter being runway widening to better accommodate wide-body aircraft.

2. *Opportunity gaps,* where the provision of infrastructure, or provision of improved or lower cost infrastructure could generate demand that is not currently present, stimulating economic development and/or population growth – for example, rail lines that provide an opportunity to shift freight from road to a lower cost rail alternative, or safer, more weather-resilient rural roads that serve to promote remote pastoral industry development.
3. *Cost gaps,* where the cost of providing infrastructure is higher than in other locations, due to scale differences or other factors, limiting or deterring economic development activity. The high relative cost of delivered power in Northern Australia is an example. Any infrastructure which facilitates an increase in operating scale or filling a missing link by, say, reducing infrastructure and/or business unit costs will have a beneficial impact here. The problem of 'first mover disadvantage', in which the project capital cost is prohibitive for the initiator, while benefits for the initiator and subsequent users exceed costs, is also a form of cost gap.
4. *Service standard gaps,* where the prevailing level of infrastructure service falls short of community, policy-based or legislated standards, for example water treatment infrastructure that falls short of health-related regulatory requirements for service attributes such as safety, availability and quality. It also includes considerations of access for population served, associated reductions in the cost of living, or other social and community benefits.

While the level of current demand is relevant information for each type of gap, it is not a prime indicator for opportunity gaps (or for service standard gaps). Opportunity gaps exist where associated economic opportunities are deterred by either lack of infrastructure or poor level of service of existing infrastructure. Opportunity gaps presuppose a step change in capacity and/or service level, rather than a more incremental increase in relation to existing and growing demand. Opportunity gaps are often easier to recognise in retrospect than to plan to fill in advance, complicating the development of robust business cases. Notably, rural roads in developing regions are cited as stimulating economic development in this way, including in Northern Australia,[5] while the Northern Territory Government has noted that the Alice Springs to Darwin Railway has enabled the establishment of several mining operations, in effect extending the reach of the Port of Darwin, that would not have been feasible without it.[6]

Gaps can have a mixture of demand, opportunity, cost and service standard aspects. To illustrate, a new water treatment plant may be triggered by both rising water demand (demand gap) and new health-related regulatory requirements (service standard gap). Equally, a new port may be constructed in response to increased demand – and in the process move to a lower cost profile that sets up economic opportunities for resource development that might not otherwise exist (opportunity and cost gap).

5. See World Bank (2005) and Gleeson et al (2012)

6. Northern Territory Government input to the audit

2.4.2 Infrastructure gaps, market failure and government response

Market failure is pervasive in the infrastructure sectors in general and in Northern Australia in particular, indicating some accent towards government action in addressing infrastructure gaps. Sources of market failure include:

- Limited economic scale, exacerbated by distance and remoteness, such that infrastructure services are provided at high cost, and/or at a standard that falls below community expectations, and/or without a competitive choice of provider, or in some circumstances not at all
- Low socio-economic circumstances, with resulting weak capacity to pay for infrastructure services
- First mover disadvantage, such that a project initiator cannot afford the capital costs that must be borne in a commercial market, but where total benefits to all users are likely to exceed total costs
- Coordination externalities where the transaction costs involved in combining with other users prevent development of networks from which all would benefit through lower costs and/or greater reliability, due to scale economies
- Public good or quasi-public good features, i.e. infrastructure that is non-rival when uncongested and, in practical terms, non-excludable
- The capacity of infrastructure to stimulate economic growth through removing blockages – the positive externalities of infrastructure investment.

Infrastructure gaps respond to both demand pressure and to sources of market failure, the latter calling necessarily for some degree of government response.

Whether or not demand gaps require a government response is largely a matter of institutional arrangements regarding asset ownership and level of commerciality. Demand gaps in the roads sector, where assets are publicly owned and usage is unpriced, typically rely on a government response, whereas in the electricity, ports and rail freight sectors, the response is largely a commercial matter, albeit subject in some circumstances to government economic regulation. In these settings, government involvement may be nil, or limited to areas such as land title/assembly issues, planning and environmental approvals.

Infrastructure owners may not capture the full benefits that result from addressing opportunity gaps, i.e. the economic growth resulting from increased scale in downstream industries (e.g. agriculture, mining). In these circumstances, infrastructure that unlocks economic opportunities will be under-provided if left entirely to the market.

Cost gaps, involving a high cost of infrastructure service, are often linked to low economic scale. This is a possible source of market failure if it leads to an absence of infrastructure service or a single monopoly provider. Addressing cost gaps can be hampered if there is no infrastructure customer with sufficient demand to fund an increase in facility scale and resulting lower costs. ‘First mover disadvantage’, where a first mover bears all of the capital costs while others receive some of the benefits can add to the sense of stand-off. This may provide a rationale for government response, whether this involves partly or wholly funding an investment or working to facilitate cooperation between private parties.

Service standard gaps, where the service is of a low standard and/or high cost, or in some cases partly or wholly absent, are similarly linked to the problem of low economic scale, exacerbated in the north by circumstances of distance and remoteness. Service standard gaps and a need for government response, whether through direct provision or through incentivising private provision, are found in all infrastructure sectors.

The audit notes where infrastructure gaps are market-dependent, for example as with much port, rail and electricity infrastructure that is linked to demand developments in particular commodity markets and where infrastructure provision is more likely to be wholly or partly through the private sector. Equally, infrastructure gaps that involve addressing poor service standards can be seen as policy-dependent, in the sense that there is a discretionary element in both the timing and extent of action to address them.

Where relevant, the audit asks whether there may be ‘non-build’ alternatives, such as demand management or supply management strategies, for example in the case of urban water supply infrastructure gaps.

2.5 Future growth scenarios

In addition to the baseline infrastructure gap assessment (in sections 4 to 11), the audit identifies and assesses infrastructure gaps against high-level growth targets contained in the *2030 Vision*[7] and also population-specific growth targets.

Section 3.6 introduces the four scenarios and Section 12 provides the scenario population impacts and infrastructure gap analysis. Further details of the scenario methodology are provided in Appendix C.

2.6 Critical infrastructure requirements

Identifying critical infrastructure requirements is undertaken in relation to the baseline infrastructure gap analysis in each sector and having regard to jurisdiction strategy and planning documents and information provided to the audit. Critical infrastructure requirements are 'pre-project' and are specified more generally than would be necessary for project planning, costing and evaluation. Accordingly, the list does not include prioritisation of these requirements.

2.7 Desk research and consultation

The audit has involved a mixture of desk research and consultation. Desk research comprised accessing existing jurisdiction sector plans and strategies, infrastructure asset and network master plans and annual reports and other publicly available information.

Consultation focused primarily on government policy agencies and infrastructure managers. In particular, Infrastructure Australia and PwC and GHD (and ACIL Allen for the Australian Infrastructure Audit) met with officials of the Commonwealth, Northern Territory, Queensland and Western Australian governments in March, June, July and September 2014 (the last via telepresence). Appendix E provides a full consultation listing.

Table 3: Urban centres and localities scope

UCL Name	Population (FY11)
Northern Territory	
Darwin	103,016
Alice Springs	24,208
Katherine	6,094
Nhulunbuy	3,933
Tennant Creek	3,062
Western Australia	
Karratha	16,475
Port Hedland	13,772
Broome	12,766
Newman	5,478
Kununurra	4,573
Derby	3,261
Tom Price	3,134
Queensland	
Townsville	157,748
Cairns	133,893
Mackay	74,219
Rockhampton	61,724
Gladstone	32,073
Mount Isa	20,570
Yeppoon	15,141
Emerald	12,895
Tannum Sands – Boyne Island	9,348
Moranbah	8,626
Bowen	8,604
Ayr	8,392
Charters Towers	8,234
Gracemere	8,159
Airlie Beach – Cannonvale	7,868
Mareeba	7,294
Innisfail	7,176
Atherton	6,676
Gordonvale	5,482
Blackwater	4,837
Ingham	4,706
Port Douglas – Craiglie	3,939
Emu Park	3,736
Sarina	3,539
Proserpine	3,390
Weipa	3,334
Longreach	3,137
Walkerston	3,089
Calliope	3,058
Home Hill	3,027
Dysart	3,003

Note: The ABS produces several versions of sub-state and sub-territory population estimates. The figures in this table have been derived from the 2011 Census and may differ slightly from other ABS estimates.

Source: Australian Bureau of Statistics (2011).

7. PwC Geospatial Economic Model (GEM) V1.0 April 2014 or "PwC's GEM". All economic output is in Chain Volume Measures referenced to the 2010-11 (FY11) base year to allow comparisons of real change over time.

Table 4: SA2s with at least 0.3 per cent total Northern Australia gross value added

SA2 Name	GVA (per cent)
Northern Territory	
Darwin City	1.4%
Woolner – Bayview – Winnellie	0.8%
Charles	0.7%
Tanami	0.7%
East Arnhem	0.5%
Berrimah	0.5%
Alligator	0.4%
Anindilyakwa	0.4%
Katherine	0.4%
Barkly	0.3%
Howard Springs	0.3%
Daly	0.3%
Palmerston – North	0.3%
Brinkin – Nakara	0.3%
Tiwi	0.3%
Western Australia	
Ashburton (WA)	14.3%
East Pilbara	14.1%
Roebourne	12.2%
Karratha	1.2%
Port Hedland	1.0%
Broome	0.6%
Kununurra	0.6%
Derby – West Kimberley	0.5%
South Hedland	0.3%
Queensland	
Broadsound – Nebo	3.5%
Central Highlands – West	2.8%
Central Highlands – East	2.1%
Moranbah	2.1%
Mount Isa	1.8%
Cairns City	1.4%
Collinsville	1.2%
Ooralea – Bakers Creek	1.1%
Mount Isa Region	1.1%
Northern Highlands	1.1%

SA2 Name	GVA (per cent)
Queensland	
Garbutt – West End	1.1%
Westcourt – Bungalow	1.0%
Mackay	0.9%
Rockhampton City	0.9%
Townsville City – North Ward	0.8%
Gladstone	0.6%
Gladstone Hinterland	0.5%
Mount Louisa	0.5%
Emerald	0.5%
Parkhurst – Kawana	0.5%
Douglas	0.4%
Sarina	0.4%
Airlie – Whitsundays	0.4%
Cape York	0.4%
Annandale	0.4%
The Range – Allenstown	0.4%
Boyne Island – Tannum Sands	0.4%
Tully	0.3%
Clermont	0.3%
Yeppoon	0.3%
Burdekin	0.3%
Aitkenvale	0.3%
Callemondah	0.3%
Atherton	0.3%
Mount Pleasant – Glenella	0.3%
Ayr	0.3%
Mareeba	0.3%
West Mackay	0.3%
South Townsville – Railway Estate	0.3%
Trinity Beach – Smithfield	0.3%
Tablelands	0.3%
Freshwater – Stratford	0.3%
Innisfail	0.3%
Kirwan – West	0.3%
Carpentaria	0.3%

Source: Australian Bureau of Statistics (2011).

"The audit identifies and assesses infrastructure gaps against high level growth targets."

Northern Australia growth and development

3.1 Introduction

Northern Australia is often seen as the 'next frontier', a region of natural resources, agriculture, cultural assets and, in some areas, growing communities. Significant opportunities exist for Northern Australia to capitalise on its strengths and unlock major economic value and simultaneously improve the liveability of the region for its residents.

3.2 Overview of Northern Australia

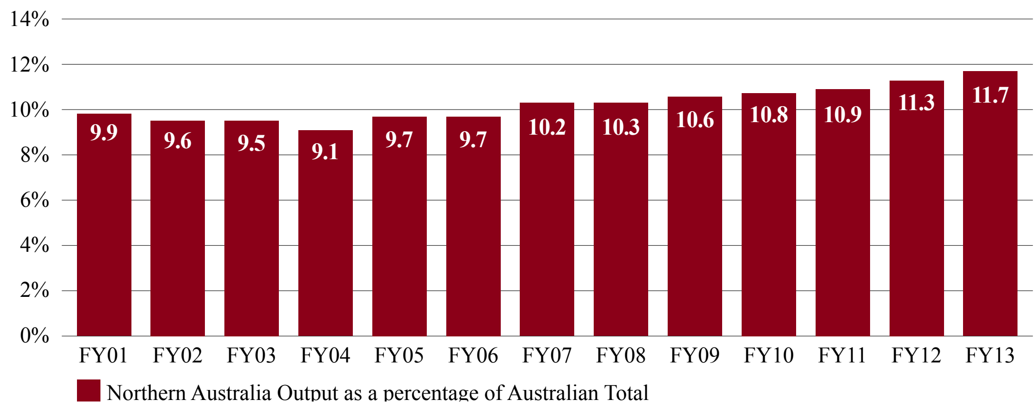
Northern Australia is culturally, economically and industrially diverse. Historically accepted approaches of understanding Northern Australia at an aggregate level are not sufficient, as they do not consider the diversity within the economy and region. The different economic and demographic profiles and spatial distribution of Northern Australia drive the necessity to consider the infrastructure needs of the Northern Australian population at the regional level.

This section expands further on these themes.

3.2.1 Economic profile of Northern Australia

Northern Australia is playing an increasingly important role in the Australian economy. The size of the Northern Australian economy was \$178 billion[8] in FY13,[9] making up an estimated 11.7 per cent of Australia's GDP. This proportion has risen over the past nine years from a low of 9.1 per cent in FY04 (Figure 2).

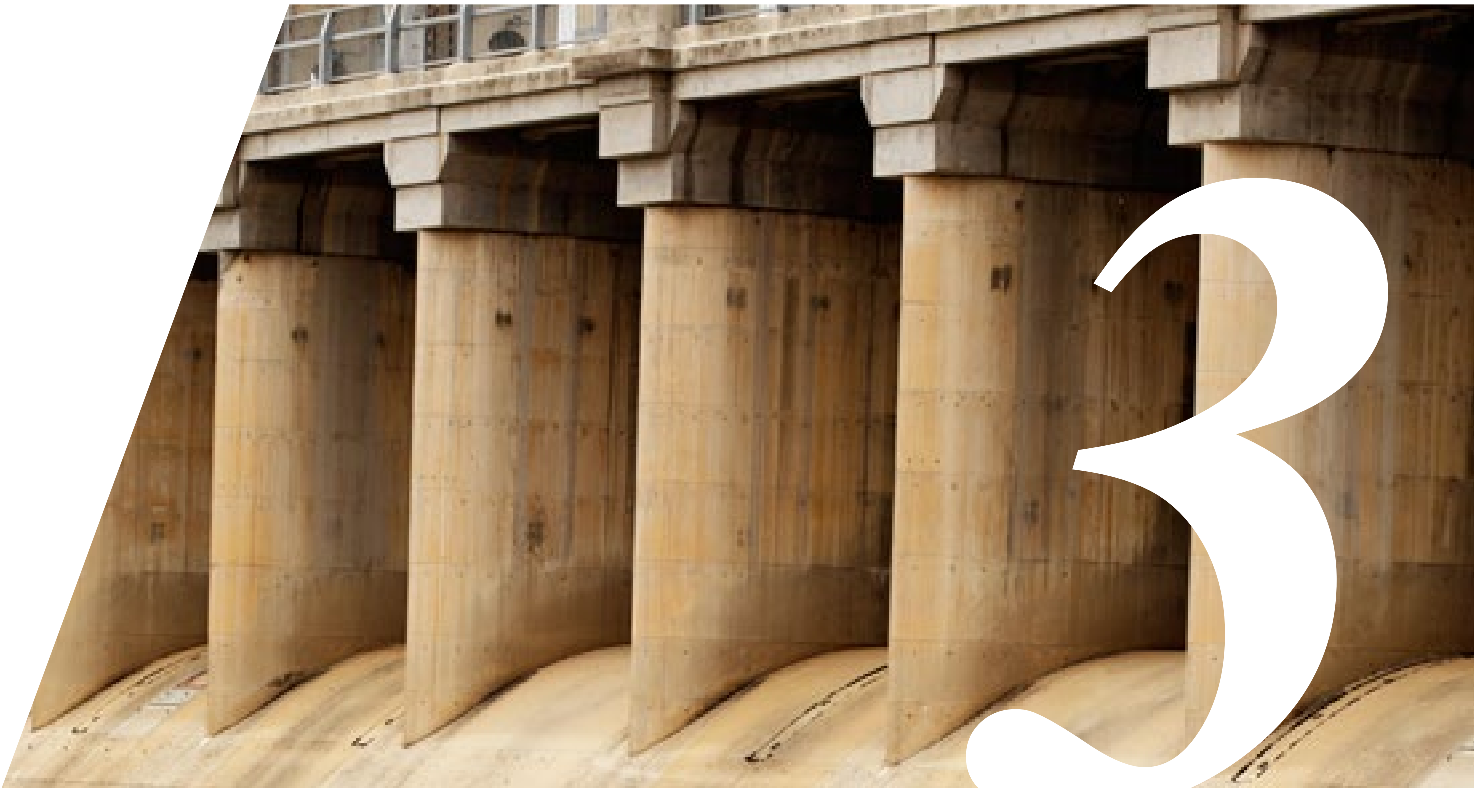
Figure 2: Economic output from Northern Australia as a share of Australian GDP (FY01 to FY13)



Source: PwC's Geospatial Economic Model (GEM)

8. PwC Geospatial Economic Model (GEM) V1.0 April 2014 or "PwC's GEM". All economic output is in Chain Volume Measures referenced to the 2010-11 (FY11) base year to allow comparisons of real change over time.

9. FY13 indicates the 2012/13 financial year



Average economic output per employee in FY13 was $369,900, almost double Australia's economic output per employee of $185,900.[10]

Sustained economic growth, above the levels seen in the rest of Australia, has been the driving force behind the growing economic importance of the region. This growth has been almost entirely driven by the expansion of the resources sector in Northern Australia and the associated construction activity required to support this growth. The emergence of growth from these industries began in FY05, reversing the trend witnessed from FY01 – FY04 when the economy of Northern Australia was contracting in terms of its share of the national economy.

Since FY05, the Northern Australia economy has been growing at an estimated average rate of 5.3 per cent per annum. This is significantly above the 2.8 per cent annual economic growth in the national economy over the same period. This implies that the region has been playing a disproportionately large role in driving the growth of the national economy. In FY13, despite only making up 11.7 per cent of GDP, an estimated 30.6 per cent of Australia's *growth* in GDP was driven by Northern Australia.

Exports from Northern Australia have played a vital role in Australia's success. Minerals and fuels, especially iron ore and coal, make up around half of the nation's exports ($157 billion in 2013). Northern Australia is a key driver of this export sector – in 2013, Northern Australia was responsible for over two-thirds of Australia's minerals and fuels exports.[11]

3.2.1.1 Structure of the Northern Australian economy

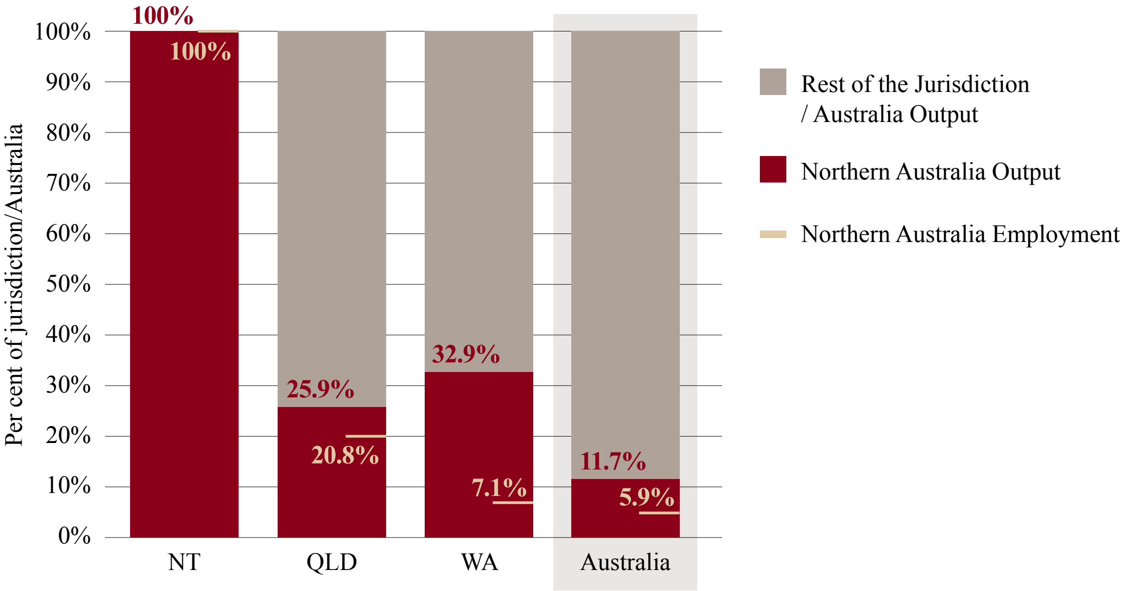
While the Northern Australia economy made up 11.7 per cent of Australian GDP in FY13, it only supported an estimated 5.9 per cent of total jobs in Australia. This difference between output and employment hints at the unique and differentiated nature of the Northern Australia economy. This is predominately driven by the importance of the resource sector within the Northern Australia economy and the capital, rather than labour, intensive requirements of this industry.

This trend is more apparent when looking at the areas of Western Australia captured within the Northern Australia boundary definition. These areas, which include the Pilbara, generated 32.9 per cent of Western Australia's Gross State Product (GSP) in FY13 but only employed 7.1 per cent of the Western Australia workforce (Figure 3).

10. PwC's Geospatial Economic Model (GEM)

11. Department of Foreign Affairs and Trade Submission to the Joint Select Committee on Northern Australia – March 2014, p4

Figure 3: Northern Australia output and employees as a per cent of jurisdiction / Australia (FY13)



Source: PwC's GEM

This presents both unique challenges and opportunity for the economic development of Northern Australia.

The resources/ mining sector is the most important sector based on contribution to both economic output and employment in Northern Australia. This sector accounts for the majority (55.7 per cent) of economic output, but only 13.4 per cent of total employment in the region reflecting the capital intensive, as opposed to labour intensive nature of resource extraction. The construction industry is the second largest contributor to economic output, having grown over the past decade to support the expansion of the resources sector.

The concentration of mining and resource activity in Northern Australia means that all other industries have a smaller percentage contribution to the Northern Australia economy than they do Australia-wide (Figure 4). This does not mean they are unimportant. The Agriculture, Forestry and Fishing industries play a vital role in many of Northern Australia's regional areas such as Barcaldine – Blackall, Burdekin, Tully and Carpentaria SA2s.

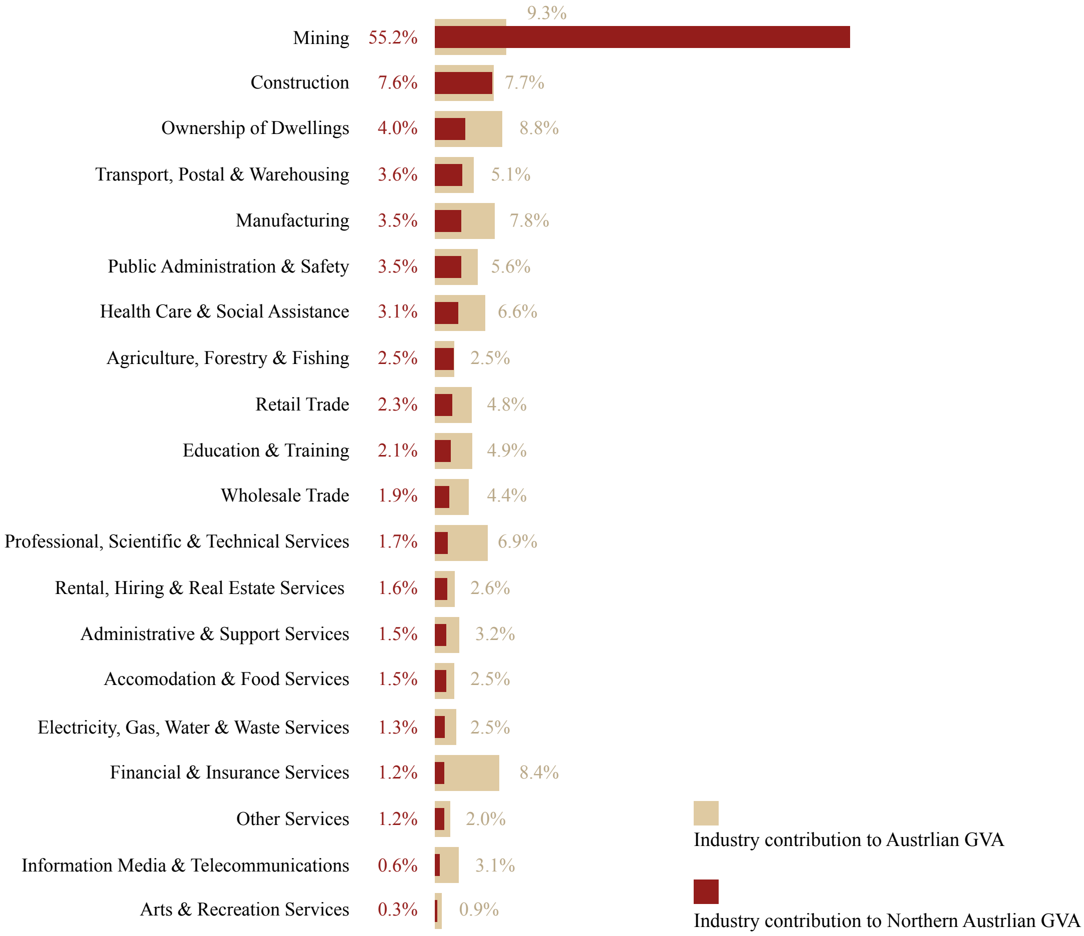
For the economically important infrastructure sectors which facilitate other activity in the north, the transport sector contributes 3.6 per cent of Northern Australia gross value added, the electricity, gas, water and waste services sector contributes 1.3 per cent and telecommunications contributes 0.6 per cent.

The Public Administration and Safety industry made up 3.5 per cent of Northern Australia's economic output but 10.7 per cent of Northern Australia's employment in FY11. Within this industry, Defence in Northern Australia is strategically and economically important for Australia. Strategically, most credible military threats to Australia would come from north of Australia while economically, a significant proportion of Australia's offshore energy resources and land-based mineral resources are based in the north. Almost one third of Northern Australia's Public Administration and Safety workforce, or 15,200 people, are employed across the Navy, Army, Air Force and Australian Public Service.[12]

The tourism sector (comprising a mix of industries including the Accommodation and Food Services Industry and Retail Trade Industry) adds to the diversity of many of Northern Australia's regions where they have traditionally relied on primary industries.

12. Defence (2014), pp. 1-3

Figure 4: Industry composition in Northern Australia compared to Australia (FY11, percentage industry Gross Value Added (GVA))



Source: PwC's GEM

3.2.2 Demographic profile of Northern Australia

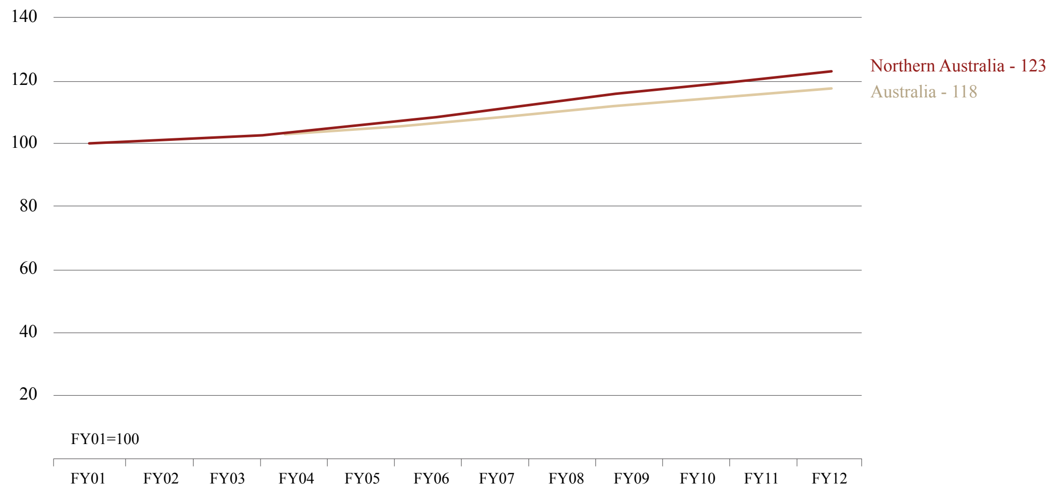
Northern Australia's demographic profile is characterised by a younger population relative to the rest of Australia, living in a number of urban centres scattered across some of the nation's most remote areas. The population of the region has grown faster than that of Australia as a whole in the past decade, driven by higher than average fertility rates and high levels of migration attracted by the emerging economic opportunities in the North. The different demographic profile and spatial distribution of Northern Australia's population drive the need to consider its infrastructure requirements.

3.2.2.1 Size of Northern Australia's population

Northern Australia is a sparsely populated region with 1.2 million people spread across more than 45 per cent of Australia's land mass. These 1.2 million people represent only 5.6 per cent of Australia's 22.7 million residents.

While the population of Northern Australia is small, it has grown at a faster rate than the population of Australia as a whole. From FY01 to FY12, an index of population shows a 23 per cent increase in Northern Australia's population, compared to 18 per cent across the whole of Australia (Figure 5), representing year-on-year growth rates of 1.7 per cent and 1.4 per cent respectively. The divergence in population growth emerged around FY05, corresponding to the increase in economic activity associated with the expanding resources sector.

Figure 5: Growth in population of Northern Australia and Australia (FY01 to FY12) (Index: FY01 = 100)



Source: Based on PwC's GEM and analysis of data from the ABS Census 2011 and ABS Cat. No. 3235.0 – Population by age and sex, regions of Australia, 2012

The northern Queensland population, which makes up more than 20 per cent of the Queensland population and almost 75 per cent of the Northern Australia population (see Table 5), is projected to drive population growth in the north with year-on-year growth of 1.9 per cent to FY31. Across the border, the Northern Territory population is projected to grow in line with the Australian average at 1.6 per cent year-on-year. Population growth in northern Western Australia is projected to be higher than the Australian average at 1.7 per cent year on year, but lower than state growth of 2.7 per cent year-on-year (ABS Series B). As a result, northern Western Australia's share of the state population is projected to fall from 4.2 per cent in FY11 to 3.5 per cent in FY31.

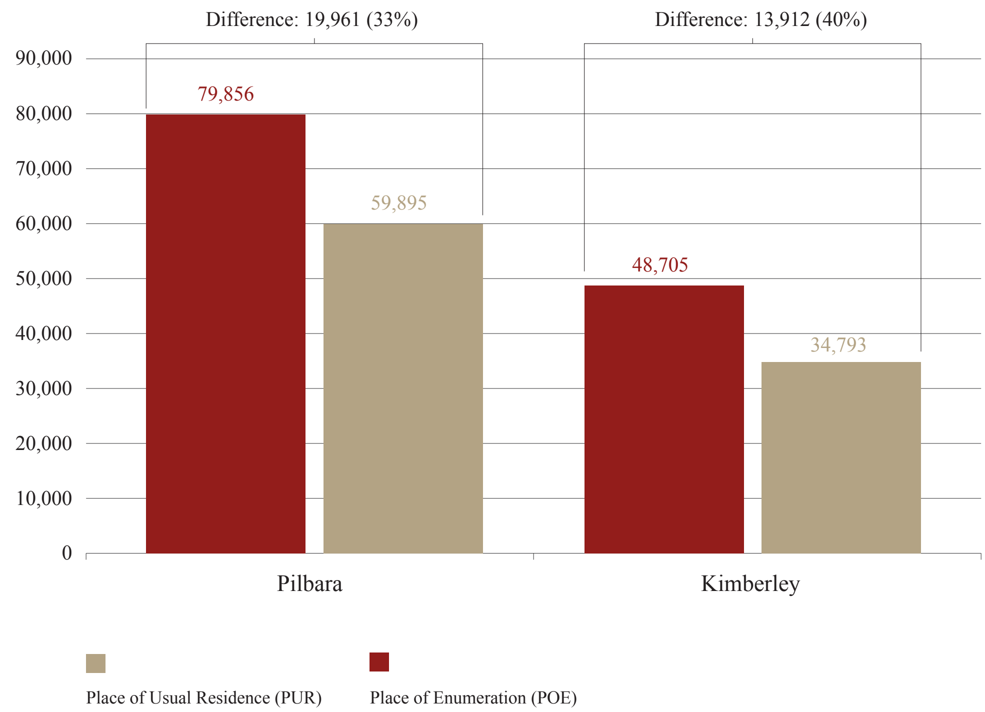
Table 5: Projected Northern Australia and Australia population growth, FY11 to FY31

Region	FY11 (millions)	FY31 (millions)	Growth (FY11 – FY31) # (millions)	Growth (FY11 – FY31) %	Growth (FY11 – FY31) CAGR*(%)
Queensland (NAIA)	0.90	1.31	0.41	45.1	1.9
Queensland (ABS Series B)	4.48	6.45	1.98	44.0	1.8
% NAIA	*20.2*	*20.4*			
Western Australia (NAIA)	0.10	0.14	0.04	41.3	1.7
Western Australia (ABS Series B)	2.34	3.97	1.63	69.5	2.7
% NAIA	*4.2*	*3.5*			
Northern Territory (NAIA and ABS Series B)	0.23	0.32	0.09	36.9	1.6
% NAIA	*100.0*	*100.0*			
Northern Australia	**1.23**	**1.77**	**0.53**	**43.3**	**1.8**
Australia (ABS Series B)	**22.33**	**30.50**	**8.17**	**36.6**	**1.6**
% Northern Australia	*5.5*	*5.8*			

**CAGR indicates compound annual growth rate from FY11 to FY31*

Source: Based on PwC's GEM and analysis of data from the ABS Census 2011 and ABS Cat. No. 3235.0 – Population by age and sex, regions of Australia, 2012

Figure 6: Comparison of enumerated and usual residence populations (2011)



Source: ABS Cat. No. 2071.0 – Reflecting a Nation: Stories from the 2011 Census, 2012–2013

3.2.2.2 Northern Australia's transient population

Many Northern Australia centres and localities experience large population fluctuations throughout the year due to employment, tourism or seasonal factors. This dynamic means that population estimates for Northern Australia need to be interpreted with additional care.

For example, baseline population projections do not capture fly-in fly-out (FIFO) workers whose usual residence is outside of Northern Australia.[13] This will have a disproportionately larger effect on resource intensive regions such as the Pilbara and Kimberley in Western Australia, where population can vary significantly throughout the year.

Of those who stated Pilbara SA3 as their place of work in the 2011 Census (46,316), around 39 per cent had travelled 1000 kilometres or more from their place of usual residence to their place of work. This figure was 16 per cent for the Kimberley SA3, where a total of 15,118 people stated the region as their place of work.[14]

Figure 6 shows that the population counted on the night of the 2011 Census (place of enumeration) exceeded the usual resident population by as much as 40 per cent. This report considers the economic infrastructure gaps and requirements for a scenario where FIFO workers are converted to usual resident population.

The transient population in tourism hotspots such as Darwin, Alice Springs, the Whitsundays, Cairns and Broome can add significantly to the usual resident population in these areas. For example, Broome is a small centre with around 13,000 usual residents but the population can triple in the peak tourism months of June to October.[15]

While the transient population are not captured in the baseline population projections, they are modelled in the economic and population growth Scenarios in Section 12.

13. The ABS definition of the Australian population is on a 'usual residence' basis. The definition of usual residence in the Census, and associated population statistics, is the location where a person spends more than six months out of the year. On this basis, some FIFO workers will be included in the usual resident population of their FIFO community, while others will be included in the population of their home city or town. In practice, when FIFO workers respond to the Census, they provide their interpretation of which location they believe to be their usual residence at the time. In some cases, a person may 'fly-in' to multiple locations, or stay in a variety of accommodation throughout the year. For such a person their home city or town may be the only fixed address they can provide, despite being resident there for less than six months of the year. This should be taken into account when using the usual resident population from ABS data to draw conclusions about FIFO and other topics. Source: ABS Cat. No. 6105.0 – Australian Labour Market Statistics, July 2013

14. ABS Cat. No. 2071.0 – Reflecting a Nation: Stories from the 2011 Census, 2012–2013

15. Water Corporation of WA – New tank will boost water storage in Broome [Minister]'. (2014). Available at: http://www.watercorporation.com.au/about-us/media/media-releases/media-release?id=%7B838D12DE-961B-41D2-902A-6ED442FCAE61%7D accessed 9 October. 2014.

3.2.2.3 Composition of Northern Australia's population

In June 2012, Northern Australia's age and gender profile described a young to middle-aged population (Figure 7). The average age of a resident in Northern Australia was 35 years old, compared to 38 years old for the whole of Australia.

The Australian population is ageing. Northern Australia has not matched the ageing population profile of Australia, with all of the age groups above 55 years old making up a smaller proportion of the region's population compared to the composition across the whole of Australia.

The Aboriginal and Torres Strait Islander population is an integral part of the Northern Australia community. There were around 275,000 people who identified themselves as Indigenous in the 2011 Census, making up approximately 22 per cent of Northern Australia's total population.[16] Indigenous people account for 30 per cent of the Northern Territory population,[17] and this is expected to rise rapidly with the Indigenous population growing at four times the national average rate of population growth.[18]

The Indigenous population of Northern Australia is younger overall than the non-Indigenous population (Figure 8), with the average age of an Indigenous person in Northern Australia being 27 years old, compared to 36 years old for the average non-Indigenous resident. This is attributable to the large proportion of the Indigenous population who have a relatively lower life expectancy.[19]

PwC and GHD's approach to developing the baseline population projections endeavoured to capture each state and territory's understanding and modelling of Indigenous population growth. However the population centre size threshold of 3,000 removed the focus of the study away from the many northern Indigenous communities, which range from tiny outstations with up to 20 people to communities with 1,000 persons or more. The infrastructure needs of these smaller communities are being considered in the parallel Northern Territory Regional Infrastructure Study and a National Remote and Regional Transport Infrastructure Strategy, being led by the Northern Territory Government.

3.3 Baseline population growth to FY31

3.3.1 Approach

PwC and GHD investigated four different methods of modelling population projections, as outlined in Figure 9, as there is no nationally consistent set of projections produced at the level of granularity required for the NAIA.

The Australian Bureau of Statistics (ABS) produces the most comprehensive set of national projections. States and Territories produce more granular projections for their own planning purposes, using differing methods. There are inconsistencies across these sources, ranging from the geographical areas of measurement (e.g. greater capital city versus Local Government Area versus SA2), assumptions on fertility and migration and even inconsistencies at state level totals.

The Australian Infrastructure Audit projections provide a further reference point against which to understand and test the plausible future population of Northern Australia.

The results of these four methods were reconciled and calibrated to form the core audit baseline population projections and to understand where there are important divergences at the SA2 level.

The core audit population baseline combines method 1, which allocates ABS projections top down to SA2s based on Census data on age and gender, and method 2 by calibrating the results of method 1 to existing State projections for a corresponding region. These projections reflect the outcomes of applying a set of assumptions about the future direction of fertility, mortality and migration based on past demographic trends. Results of these were compared with results from methods 2 and 4, which are built bottom up based on assumptions on fertility, mortality and migration, to identify locations where changes in future populations are sensitive to core assumptions and hence, potential infrastructure decisions.

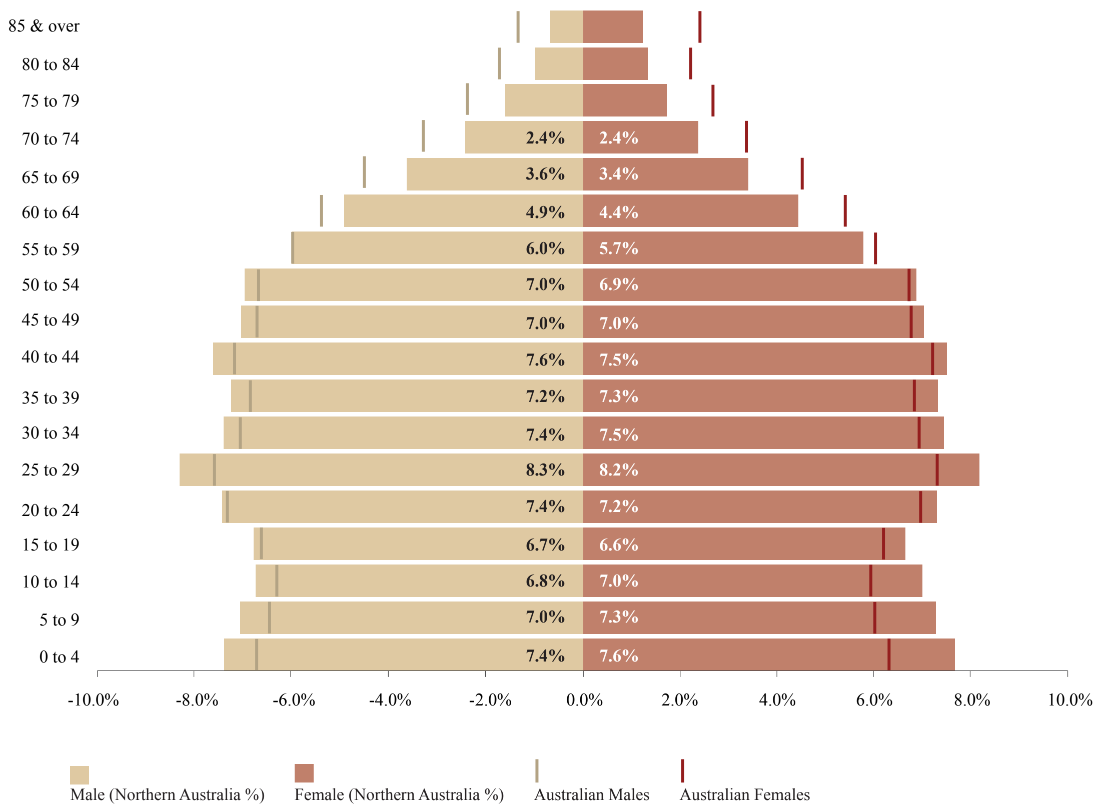
16. Based on analysis of data from the ABS Census 2001, 2006 and 2011 using PwC's Geospatial Economic Model

17. Department of Treasury and Finance (Northern Territory Government), Northern Territory Population Projections: Interim – Update (2013 Release), March 2013 [available at http://www.treasury.nt.gov.au/PMS/Publications/Economics/PopProjections/I-POP-1301.pdf]

18. MomeNTum (2014)

19. MomeNTum (2014)

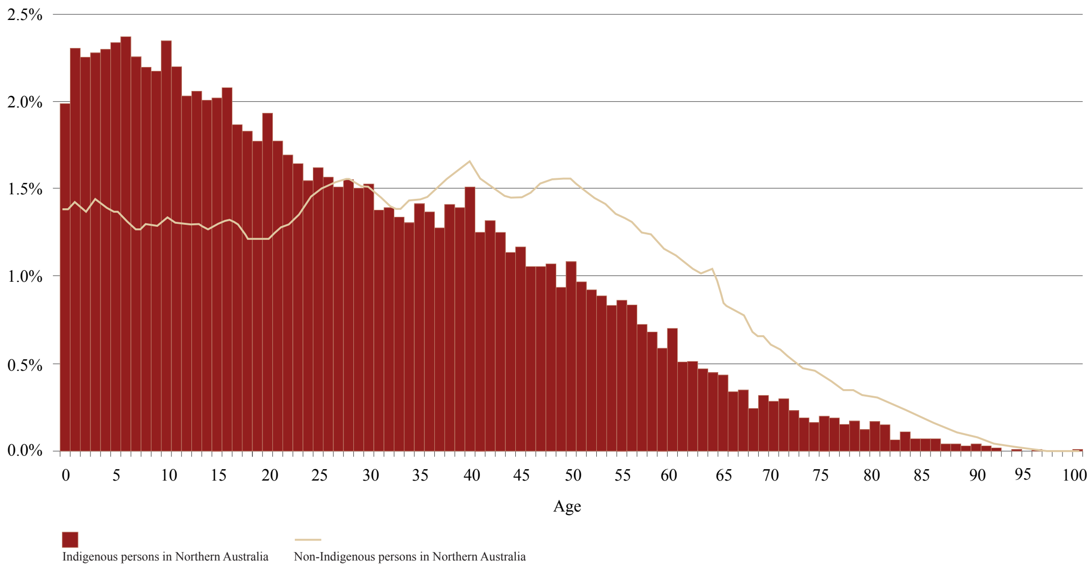
Figure 7: Population pyramid of Northern Australia and Australia (gender and age structure) (June 2012)



Note: Percentages indicate the distribution of Northern Australia's male and female population by age group. This is compared to the distribution of Australia's population as indicated by the dashes.

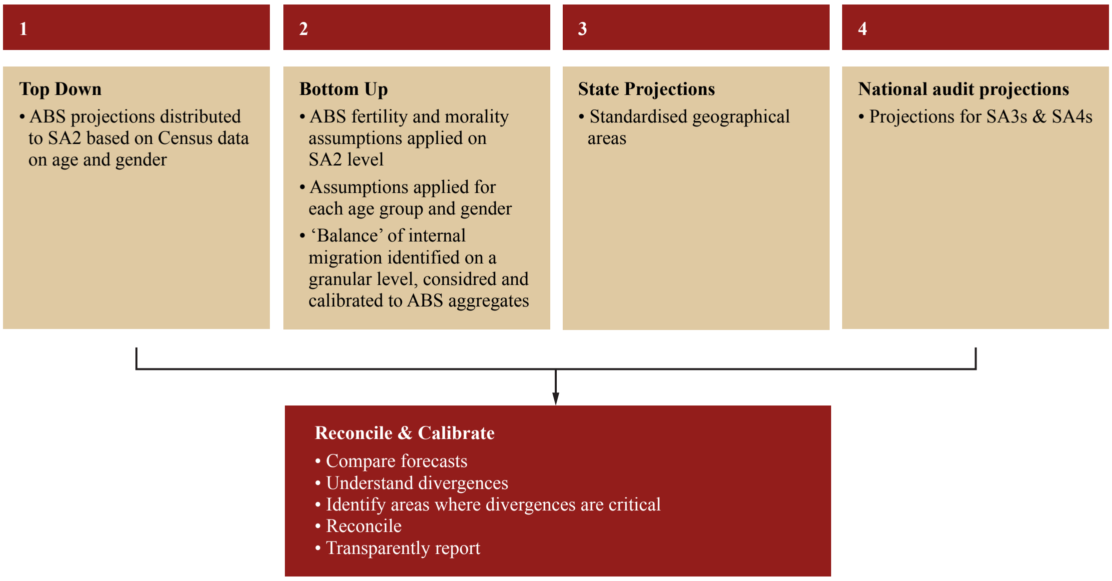
Source: PwC analysis of data from the ABS Census 2011 and ABS Cat. No. 3235.0 – Population by age and sex, regions of Australia, 2012

Figure 8: Population pyramid of Northern Australia, Indigenous and non-Indigenous (June 2011)



Source: PwC analysis of data from the ABS Census 2011

Figure 9: Approach to developing baseline population projections



By the end of FY31, the population of Northern Australia is projected to be between 1,665,081 and 1,816,161 persons, with a Core NAIA population projection of 1,767,845 persons (Table 6).

3.3.2 Baseline population projections

The core population baseline used in the NAIA is a hybrid of ABS and State/Territory projections, which best reflects the current understanding of Northern Australia's demographic and economic composition.[20] However, it is important to note that as with all projections, there is uncertainty as to how these will develop over the projection horizon. To account for this uncertainty, different projection series have been tested to provide a realistic view of the plausible range of the future size and distribution of Northern Australia's population. These differing projections include ABS Series A, ABS Series C and the Infrastructure Australia Australian Infrastructure Audit population projections.

ABS Series C projects the lowest population growth and ABS Series A projects the highest population growth from FY11 to FY31 with an increase of 34.9 per cent and 47.2 per cent respectively. The Core NAIA population projection is within this range, and is between the Series B population projection and Australian Infrastructure Audit population projection.

20. The relevant State/Territory projections referenced include:

- Queensland Treasury and Trade, Queensland Government population projections, 2013 edition: Methodology and assumptions, March 2014 [available at http://www.qgso.qld.gov.au/products/publications/qld-govt-pop-proj-reference-info/qld-govt-pop-proj-2013-methodology-assumptions.pdf]
- Regional population distributions from the Department of Treasury and Finance (Northern Territory Government), Northern Territory Population Projections: Interim – Update (2013 Release), March 2013 [available at http://www.treasury.nt.gov.au/PMS/Publications/Economics/PopProjections/I-POP-1301.pdf]. The Northern Territory Population Projections: 2014 Main Update was released after the baseline population projections had been established. However, the differences between the 2014 Main Update and the Core NAIA baseline for Northern Territory adopted in this report are minor at the Territory level (with a maximum difference of 0.9% in 2031). The greatest percentage differences are for smaller regions where the population base is low (e.g. Katherine and Barkly) where Core NAIA projections are slightly higher than the 2014 Main Update.
- Regional population distributions from the Western Australia Planning Commission (Western Australia Government), Western Australia Tomorrow, Population Report No.7, 2006 to 2026, February 2012 [available at http://www.planning.wa.gov.au/publications/6195.asp]

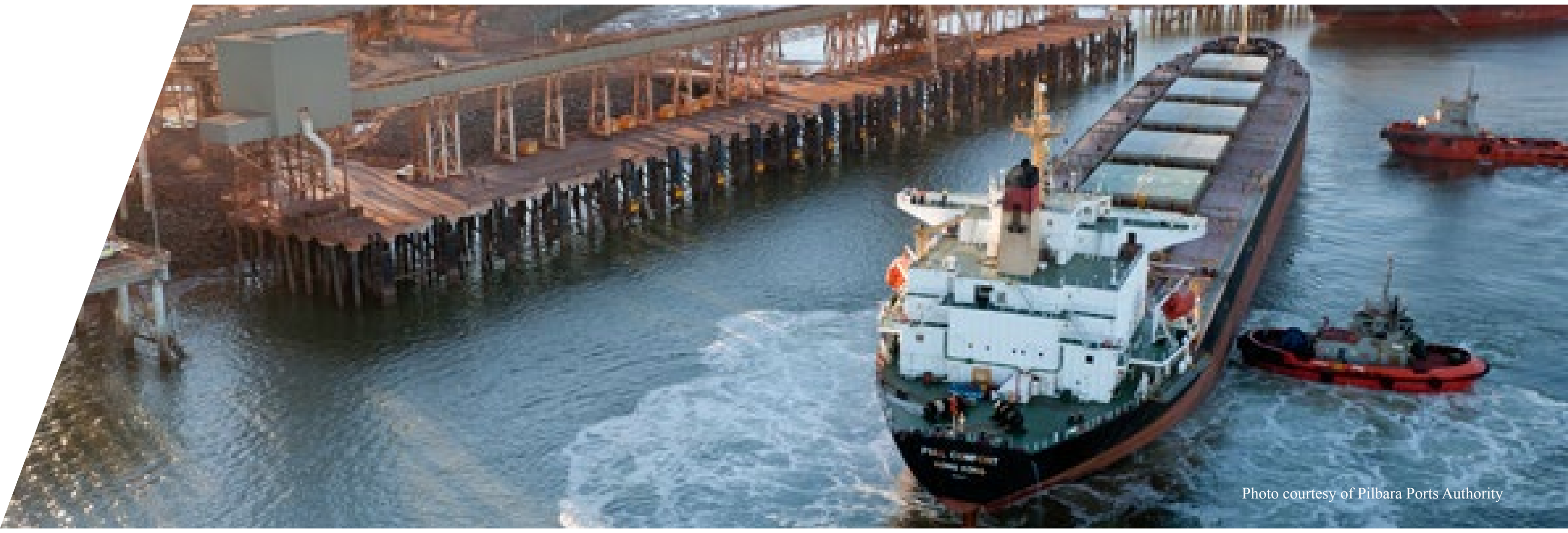


Table 6: Baseline population projections – Northern Australia (FY12 to FY31)

Source	FY11 Actual	FY12	FY16	FY21	FY26	FY31	Growth FY11-FY31	Growth FY11-FY31	CAGR* FY11-FY31
ABS Series C	1,234,059	1,262,185	1,352,956	1,459,737	1,563,274	1,665,081	431,022	34.9%	1.5%
ABS Series B		1,262,185	1,361,739	1,485,243	1,606,043	1,723,556	489,497	39.7%	1.7%
Core NAIA		1,260,566	1,363,762	1,498,059	1,631,887	1,767,845	533,786	43.3%	1.8%
National audit		1,260,617	1,375,314	1,517,653	1,655,416	1,787,654	553,595	44.9%	1.9%
ABS Series A		1,262,185	1,369,744	1,513,372	1,663,320	1,816,161	582,102	47.2%	2.0%

** Compound Annual Growth Rate*
*** ABS Series A, B and C are distributed top-down to SA2s based on the demographic profile of SA2 residents (age and gender) in the 2011 Census*
Source: Based on PwC's GEM and analysis of data from the ABS Census 2011 and ABS Cat. No. 3235.0 – Population by age and sex, regions of Australia, 2012

Under the audit's core baseline population projections, Northern Australia is projected to grow at 1.8 per cent year-on-year, compared to 1.6 per cent for Australia as a whole (Table 7). Northern Australia's population as a proportion of total Australian population is projected to increase to 5.8 per cent in FY31, up from 5.5 per cent in FY11.

Table 7: Baseline population projections – Northern Australia (FY12 to FY31)

Source	FY11 Actual	FY12	FY16	FY21	FY31	CAGR* (%) FY11-FY31
Northern Australia (Core NAIA)	1,234,059	1,260,566	1,363,762	1,498,059	1,767,845	1.8
Australia (ABS Series B)	22,329,407	22,707,239	24,356,334	26,448,724	30,497,651	1.6
Northern Australia Share	5.5%	5.6%	5.6%	5.7%	5.8%	

This approach to the baseline projection captures the assumptions contained within ABS Series B and jurisdictional work. Importantly, the trend of the strong recent population growth experienced by Northern Australia is reflected in forward projections. The ABS population projection methodology uses historical trends to inform key forward-looking assumptions, implying that the projections reflect at least a proportion of the recent strong growth.

3.4 Baseline economic growth to FY31

3.4.1 Approach

The audit established baseline economic growth from FY11 to FY31 for 217 regions, using economic forecasts developed in the (ACIL Allen Consulting) Australian Infrastructure Audit and baseline economic activity by industry and region contained in PwC's Geospatial Economic Model.

The Australian Infrastructure Audit developed forecasts of baseline economic growth for its 73 audit regions to FY31. The forecasts considered baseline forecasts in factors including demographic drivers, changing incomes, changing technology, trends in industry performance and productivity, changes in external demand and Australian competitiveness and prices of infrastructure services.

The 73 regions in the Australian Infrastructure Audit are at a more aggregated geographic level than the regions in the Northern Australia audit (Table 8). The growth rates in the Australian Infrastructure Audit for the corresponding geographic region were applied to each SA2 to establish the baseline economic growth forecasts for the Northern Australia infrastructure audit.[21]

3.4.2 Baseline economic forecasts

Modelling of baseline economic growth in the Australian Infrastructure Audit indicates that the Northern Australia economy will expand at a faster rate than the national average over the period FY11 to FY21, with growth easing between FY21 and FY31.

Economic output (as measured by real gross value added) in Northern Australia is forecast to be 143 per cent of FY11 levels by FY21, representing year-on-year growth of 3.7 per cent. After FY21, economic growth will ease and reach 181 per cent of FY11 levels by FY31 (approximately 127 per cent of FY21 levels or year-on-year growth of 2.4 per cent).[22] In comparison, Australia's Gross Value Added is forecast to grow to 136 per cent of FY11 levels by FY21 and 183 per cent of FY11 levels by FY31, representing growth of 3.2 per cent and 3.0 per cent respectively (Figure 10).

Table 8: Comparison of the national and Northern Australia audit regions

Region	National audit	Northern audit
Northern Territory	6 regions comprising: • 1 GCCSA • 5 SA3s	68 SA2s
Northern Western Australia	2 regions comprising: • 2 SA3s	12 SA2s
Northern Queensland	13 regions comprising: • 11 SA3s • 2 SA2s	137 SA2s
Northern Australia	21 regions comprising: • 1 GCCSA • 18 SA3s • 2 SA2s	217 regions at SA2 level

21. The baseline economic growth projections in the Australian Infrastructure Audit consider ABS Series B population projections which are not dissimilar to the Core NAIA baseline population projections adopted in this report.

22. There are differences in the total Northern Territory baseline economic growth index in the Australian Infrastructure Audit and the index contained in this report due to differences in the baseline economic output measure at the audit region level. This report adopts measures of economic output from PwC's Geospatial Economic Model, which is based on the income method of calculating Gross Domestic Product and Gross State Product. Gross State Product is distributed to locations based on weightings derived from Census and industry data. All SA2 economic and industry estimates reconcile to State level totals produced by the ABS. Economic output in the Australian Infrastructure Audit is derived from ACIL Allen's model of the economy.

Figure 10: Baseline economic growth in real gross value added terms (index, FY11 = 1)

Source: PwC analysis of ACIL Allen Consulting draft baseline economic growth, 13 May 2014 version

By applying the baseline economic growth forecasts to FY11 economic output by industry in each SA2, economic output in Northern Australia is forecast to reach $274 billion by FY31.

The baseline economic growth forecasts from the Australian Infrastructure Audit indicate that the Northern Territory will experience the highest growth in the period to FY31, albeit from a low base. Economic output in the Northern Territory is forecast to increase to 204 per cent of FY11 values by FY31 (Figure 10). Northern Queensland is forecast to experience the second highest growth in Northern Australia to 191 per cent of FY11 levels by FY31.

3.5 Potential key growth regions

The baseline outlook takes account of future key growth regions and associated project clusters that may not have yet reached a committed stage of development, but are nonetheless likely to go ahead in the future, subject to market fluctuations and approvals processes. To facilitate the analysis, a handful of locations are designated as future key growth regions where there are significant known economic resources that are currently under-exploited. The aim is to ascertain the infrastructure requirements of these developments (opportunity gaps) if even a small number of all the possible projects go ahead during the next 20 years. Clearly also, other regions may emerge over the next 20 years as having significant promise.

Designated future growth regions are included in the baseline assessment of infrastructure gaps. The criteria for selecting growth regions are as follows.

- Economic opportunity – there must be in existence a well-proven and significant yet-to-be developed economic opportunity in the region, based on one or more resources, be it minerals, agriculture, tourism or other industry
- Government support – there must be a level of policy and preferably material support from government for development of the region, possibly derived from the necessity of infrastructure coordination
- Advanced projects – there must be proven projects in the region already, or alternatively advanced planning for one or more projects to develop the resource(s)
- Infrastructure requirements – the region must be poorly served by existing infrastructure, relative to the resource exploitation needs, and preferably require coordinated infrastructure of different types or sharing between different projects
- Likely to be developed – there must be an expectation that the resource will be developed to a greater or lesser extent in the next 20 years, with project timing largely subject to market fluctuations and approvals processes.

The selection of particular growth regions acknowledges the existence of other potential key growth regions.

Table 9: Future key growth regions

Region	Economic opportunity	Jurisdiction	Government support	Advanced projects	Infrastructure requirements	Likelihood / risks
Burdekin-Flinders-Gilbert river system	Irrigated agriculture, renewable energy	Queensland	Medium – support for high-level investigative study, policy to increase agricultural production		Dam, pipelines, channels, electricity (renewable energy opportunities), rail, roads	Likely in the next 20 years
Galilee Basin-Bowen Basin	Coal	Queensland	Strong – refer 'Galilee Basin Development Strategy' (DSDIP, 2013)	Kevin's Corner, Alpha, Alpha West, Carmichael, China First and South Galilee	Electricity, rail, water, roads, port access	Significant development very likely in next 20 years
North-west minerals province	Base metals and other minerals	Queensland	Medium – material support for minerals exploration	Barbara, Kalman, Mount Dore, Mount Isa Open Pit, Mount Oxide, Rosebay, Swan/Mount Elliott, White Range, D-Tree, Korella, Paradise North, Lorena, Westmoreland, Valhalla	Electricity, water, roads	Development very likely in next 10 years
Darwin-Katherine region/ Wolfe basin	Base metals and other minerals	Northern Territory	Medium – Territory exploration grants and support and advice for investors		Electricity, water, roads	Development very likely in next 20 years
Roper River/ McArthur River	Base metals and other minerals	Northern Territory	Medium – Territory exploration grants and support and advice for investors		Electricity, water, roads, ports	Development very likely in next 20 years
Tennant region/ Wonarah	Base metals and other minerals	Northern Territory	Medium – Territory exploration grants and support and advice for investors		Electricity, water, roads, ports	Development very likely in next 20 years
Tanami/ Arunta regions	Base metals and other minerals	Northern Territory	Medium – Territory exploration grants and support and advice for investors		Electricity, water, roads	Development very likely in next 20 years
Irinina province	Base metals and other minerals	Northern Territory	Medium – Territory exploration grants and support and advice for investors		Electricity, water, roads	Development very likely in next 20 years
Amadeus basin	Oil, shale gas	Northern Territory	Medium – Territory exploration grants and support and advice for investors		Electricity, water, roads	Development very likely in next 20 years
McArthur Basin	Oil, shale gas	Northern Territory	Medium – Territory exploration grants and support and advice for investors		Electricity, water, roads, ports	Development very likely in next 20 years
Pilbara	Iron ore expansion	Western Australia	Medium – State exploration incentive scheme, support and advice for investors	Balla Balla, Balmoral South, Buckland, Horizon, Iron Bridge, Iron Valley, Roy Hill, Solomon Hub, West Pilbara	Electricity, rail, water, roads, ports	Significant development very likely in next 20 years
Canning Basin	Oil, shale gas	Western Australia	Medium – State exploration incentive scheme, support and advice for investors	Ungani	Electricity, pipelines, water, roads	Development very likely in next 20 years
East Kimberley (Ord expansion)	Irrigated agricultural land	Western Australia	Strong – State development plan and funding for Phase 2	Ord River stage 3	Electricity, rail, water, roads	Significant development very likely in next 20 years
Browse Basin	LNG	Western Australia	Medium-Strong – State development of Browse LNG Precinct	Brecknock, Calliani, Torosa	Electricity, pipelines, water, roads	Significant development very likely in next 20 years
North-West Shelf	Oil, gas	Western Australia	Medium-Strong – State development of Ashburton North Strategic Industrial Area and infrastructure at Onslow		Electricity, rail, water, roads	Significant development very likely in next 10 years

3.6 Northern Australia growth scenarios

The audit developed future economic and population growth scenarios for Northern Australia development as a basis for measuring future infrastructure gaps.

Analysing infrastructure needs in the context of population growth scenarios is an important part of the audit. Population growth is both a catalyst for and outcome of economic growth and hence is a direct driver of urban and local transport infrastructure and of electricity, water and communications requirements.

Federal, state and territory governments aim to promote economic growth, and in some cases population growth, through policy drivers and regional plans. Accordingly, the audit assesses critical infrastructure gaps under both policy and plan-driven economic and population growth scenarios.

More specifically, the audit's growth scenarios take account of both the Coalition *2030 Vision* and state and territory plans and targets. The scenarios are outlined in Table 10 and described in further detail in Section 12.

Table 10: Summary of Northern Australia baseline growth and the four scenarios

Baseline or scenario	Description	Impacts assessed
Baseline – broadly a continuation of current trends	Models the population outcomes through to FY31 of applying a set of assumptions about the future direction of fertility, mortality and migration based on past demographic trends. Economic outcomes are consistent with Australian Infrastructure Audit forecasts.	Infrastructure gaps to meet economic and population growth and expected market opportunities
Scenario 1 – aspirational economic growth against industry opportunities outlined in the 2030 Vision	By FY31, achieve aspirational economic growth adapted from the opportunities identified in the 2030 Vision (with minor adaptations): • Increasing the real value of Northern Australia's real agricultural output to $14,906 million by FY31, which helps double Northern Australia's contribution to Australia's agricultural output to 24.4 per cent • Increasing international visitor stopovers to 2.8 million per annum by FY31 • Increasing energy exports from Northern Australia to $150 billion by FY31 with all publicly announced energy projects, projects in feasibility stage and committed projects proceeding to completion.	Additional infrastructure gaps, relative to the FY31 baseline, to meet the scenario targets
Scenario 2 – medium economic growth against industry opportunities outlined in the 2030 Vision	By FY31, achieve medium levels of economic growth adapted from the opportunities identified in the 2030 Vision (with minor adaptations): • Increasing the real value of Northern Australia's real agricultural output to $7,452 million in FY31 (double the FY11 level) • Increasing international visitor stopovers to 2.0 million per annum by FY31 • Increasing energy exports from Northern Australia to $150 billion by FY31 with a weighted probability that publicly announced energy projects, projects in feasibility stage and committed projects proceeding to completion (based on their capital expenditure value and progress to date).	Additional infrastructure gaps, relative to the FY31 baseline, to meet the scenario targets
Scenario 3 – northern population shift in Queensland and Western Australia	Achieve a northern shift in population consistent with: • The target in the Queensland Plan of doubling the Queensland population outside of South East Queensland by 2044 (approximately 1.52 million people in Northern Queensland by FY31) • The Pilbara Cities vision of growing the population in the Pilbara region from 68,000 in FY11 to 140,000 by FY35 (approximately 126,000 by FY31).	Additional population-specific infrastructure gaps, relative to the FY31 baseline
Scenario 4 – Low population growth	Realise lower than baseline population growth due to lower overseas migration and lower net internal migration to Northern Australia (the more volatile components of population growth).	Reduction in population-specific infrastructure gaps, relative to the baseline

Transport – airports

4.1 Introduction

Northern Australia has some 80 airports that receive regular public transport (RPT) services. Many of these airports also receive charter services, in some cases involving significant numbers of additional passengers to service resource industry fly-in fly-out (FIFO) demand. In addition, there are a large number of other aerodromes providing essential, all-weather transport links that are used for charter, Royal Flying Doctor Service and other services, providing transport connectivity throughout the north, including for remote Indigenous communities. The Northern Territory Government provides maintenance funding for some 69 aerodromes, including a minority that receive RPT services. Finally, there are numbers of privately owned airfields servicing individual remote mine sites with charter services.

4.2 Airports in scope

Even the smallest airport provides a connection, direct or indirect, to a major centre such as Darwin or Townsville. It could therefore be argued that all airports are critical for Northern Australia's development, helping integrate the region's labour, product and service markets, particularly given that airports (together with barge landings) underpin the all-weather transport links in many parts of Northern Australia.

Table 11 lists the 49 airports that are in scope against the audit's regional population and economic criteria (see Section 2.2), together with a limited number of others that are identified as either critically or strategically important in jurisdiction planning documents.[23] One airport, Ayers Rock (Yulara), is included as a prominent (top 15) RPT airport, despite not qualifying against either the population or the regional economic criteria. Airports are mapped in Map 6. Airports servicing individual mine sites are not included.

In practice, there is limited publicly available data on many of the airports listed, due either to the absence of any public master plan for smaller airports, or to commercial confidentiality considerations, with single airline operations at these airports constraining publication of airport traffic data.

23. DOT (2013), DSDIP (2013)

Table 11: Airports in scope

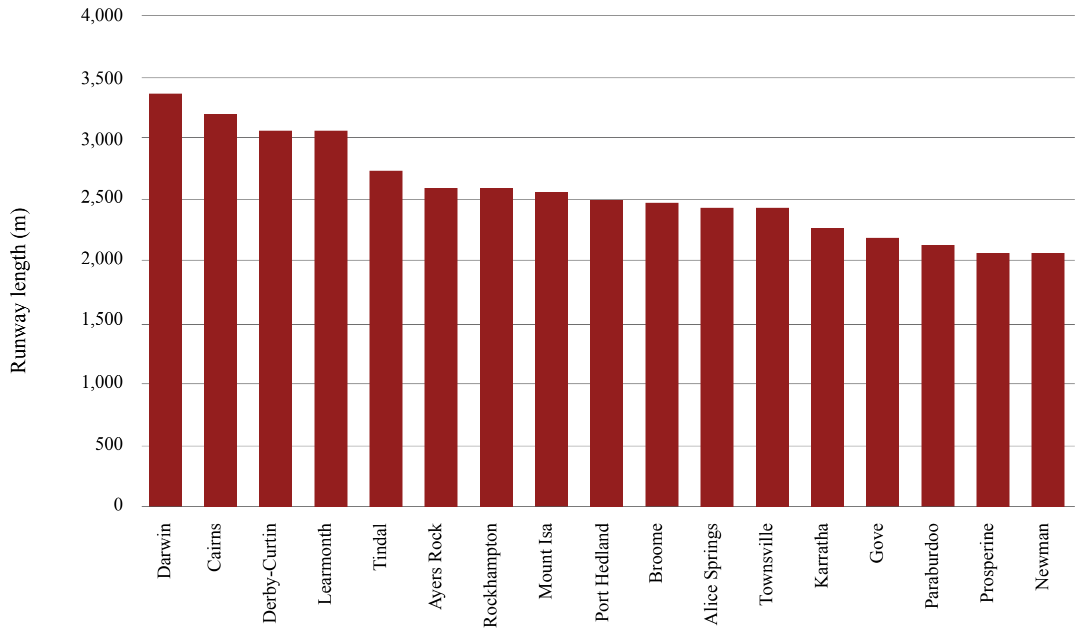
Queensland		Northern Territory	Western Australia
Alpha	Hughenden	Alice Springs	Broome
Barcaldine	Julia Creek	Ayers Rock	Derby-Curtin
Blackall	Lockhart River	Darwin	Fitzroy Crossing
Blackwater	Longreach	Elcho Island	Halls Creek
Cairns	Mackay	Gove	Karratha
Clermont	Moranbah	Groote Eylandt	Kununurra
Cloncurry	Mount Isa	Katherine	Learmonth
Coen	Proserpine	Milingimbi	Mungalalu-Truscott
Cooktown	Richmond	Port Keats	Newman
Emerald	Rockhampton	Ramingining	Onslow
Gladstone	Townsville	Tennant Creek	Paraburdoo
Rockhampton	Weipa		Port Hedland
Townsville			

4.3 Existing airport capacity

While major FIFO airports have strong weekday and afternoon peak periods, no major Northern Australia airport faces pressure to build a new runway to accommodate growing demand. Many airports have runways of 2,000 metres or more (see Figure 11) that, as per International Civil Aviation Organization aerodrome reference standards, are adequate for connecting to southern capitals and to short-haul international destinations, using B737 or A320 (200 seat) aircraft.[24] Planned runway extensions are also limited. Kununurra, with a runway length less than 2,000 metres, plans an extension within the audit projection period, and Karratha has identified an extension from 2,280 to 2,500 metres to accommodate medium to long-haul international operations. See Table B.1 for detailed airport capacity and demand statistics.

24. To illustrate, the Airbus A320 is an ICAO Code 4C aircraft, requiring a runway of 1,800 metres or greater. See http://www.airbus.com/fileadmin/media_gallery/files/tech_data/General_information/Airbus_ICAO-ARC_FAA-ADG_App-Cat-Feb2013.pdf and ICAO (1999).

Figure 11: Northern Australia airports with runways of 2000 metres or more



Source: Airservices Australia and GHD analysis

Aircraft parking (apron) space constraints are more widely experienced as the number of aircraft movements increase, and with FIFO (charter) aircraft often spending longer periods on the ground before departure than scheduled aircraft. Many airports have apron expansions planned, including in some cases (e.g. Ayers Rock, Karratha) fully powered ('pushback') parking bays, which permit more efficient use of scarce airside space.

A capacity constraint that is common to virtually all airports as demand grows is terminal size. Smaller airports seek to plan schedules so that only one aircraft is on the ground at a time, in order to minimise crowding and may be severely constrained if more than two aircraft passenger loads need to be processed simultaneously. Darwin, the region's second largest airport in terms of both passengers and aircraft movements, is currently completing a new terminal development and expects that this will meet capacity needs for at least the next decade.

4.4 Drivers of additional airport capacity

4.4.1 Growth drivers

Airports in Northern Australia are typically established to service new economic opportunities (e.g. large mines), or are expanded to accommodate increased market demand. Market opportunities influence the type of aircraft equipment that is operated and the intensity of its use; in turn both of these drive the infrastructure requirements.

Growth in the mining and energy sectors has been the largest source of increased capacity over the past decade. In addition to Pilbara iron ore development, off-shore oil and gas development has triggered expansion at Karratha and Broome airports, including facilities for helicopter operations. Future development at Exmouth-Learmonth and Derby-Curtin are also expected in future.[25] With the peak in mining investment and construction activity now having passed, it is open to question whether demand may fall in absolute terms at these airports. However, the mining industry notes that FIFO shifts are shorter for operational workers than for construction ones, which should tend to keep aviation demand constant.

A traditionally strong Northern Australia tourism sector has, over the last decade, faced challenges from:

25. DOT (2013)

- A high Australian dollar, which deters overseas visitors and encourages Australians to holiday overseas
- A sharp fall in northern hemisphere demand following the 2008 global financial crisis
- An apparent reduction in interest from the key market of Japan, without any comparable offsetting replacement
- Limited services and connectivity between many locations, reflecting relatively weak overall demand, with new airport locations also needing to cover the cost of border control services.

Industry observers note that tourism facilities would benefit from a 'refresh', particularly high quality resort-style accommodation that might attract greater interest from the growing and more affluent Chinese market (e.g. the Aquis Resort Project in Cairns). Regional airports such as Ayers Rock and Broome continue to pursue direct tourism flights from South-East Asia (Hong Kong and Singapore), but are yet to find success.

4.4.2 Capacity drivers

In addition to these general market considerations, airport capacity is increasing to meet both government regulatory requirements and rising community standards. Many regional airports in Northern Australia were not previously required to perform compulsory passenger or baggage screening. Passengers simply checked in their baggage and then boarded the plane. However, new Commonwealth aviation regulations (effective 1 July 2012) stipulate airports that service aircraft with a maximum take-off weight of 20 tonnes or more must conform with prescribed requirements for airport security. These requirements include the installation of bag security screening which has been a recent driver of terminal capacity increase.[26] Initiatives such as moving baggage reclaim from outside to inside the terminal (as at Mount Isa) also drive terminal expansion.

Aircraft size and flying distance to destinations drive runway length (a higher payload due to more fuel implies a longer take-off distance). Similarly, wide-body aircraft (with an excess of 200 seats) may in some instances require increased runway width, runway strengthening, wider taxiways and a larger apron (aircraft parking) area. However, runway widening requirements appear likely to be quite limited, due to market size considerations. Notably, Ayers Rock airport is keen to limit future infrastructure spending and to maximise the potential of its existing 30 metre wide runway.

Aircraft size changes (widening in some cases, narrowing and lengthening in others) also drive change in aviation rescue/firefighting service requirements. At Katherine, the alternate airport for Darwin and receiving on average around one flight per year, the service is provided by the Royal Australian Air Force and the Department of Defence has indicated that it requires an upgrade from Category 4 to Category 5.

With small numbers of daily flights at Northern Australia airports, total available runway capacity will remain high for the foreseeable future. Runway infrastructure requirements are likely to be driven mainly by changes in aircraft equipment choice and adjusting to longer flying distances to destinations.

4.5 Future airport demand

4.5.1 Historical demand

The airports listed in Table 12 are grouped into airport types of major centre (including international) airports, resource, tourism and other airports. While the influence of one or both of the two key Northern Australia export sectors of resources and tourism is pervasive across all of the airports, each of the airport types has a somewhat different historical demand growth profile.

Table 12: Northern Australia airport groupings

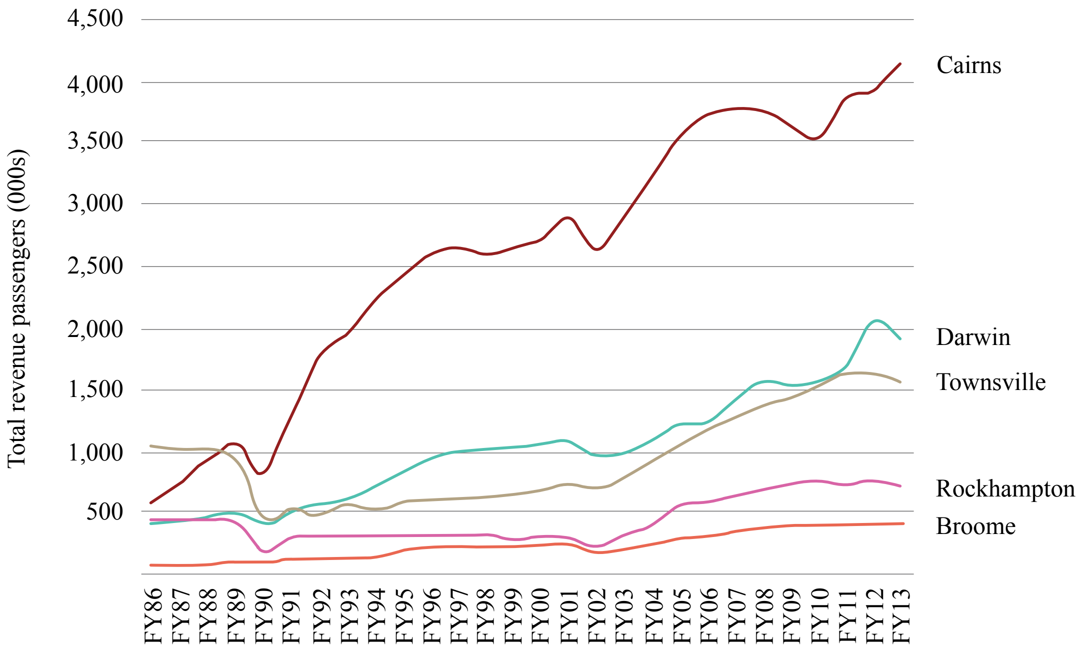
Airport type	Airports
Major centre	Broome, Darwin, Cairns, Gladstone, Karratha, Mackay, Port Hedland, Rockhampton, Townsville
Resource	Alpha, Clermont, Cloncurry, Emerald, Exmouth, Groote Eylandt, Mackay, Moranbah, Mount Isa, Newman, Paraburdoo, Weipa
Tourism	Alice Springs, Ayers Rock, Hamilton Island, Proserpine
Other	Gove, Kununurra

Source: GHD analysis

26. The Western Australian Government has noted that Commonwealth Government security requirements have the effect of limiting use of larger aircraft at regional airports and adversely affecting the cost of airfares, impeding tourism, social connectivity and economic development.

Major centre airports service the largest urban populations. This provides greater demand diversity and generally less volatility than for other airports. However, volatility is a constant of the Northern Australia aviation environment. All major centre airports experienced a decline in passenger numbers following the collapse of Ansett Airlines and the event of '9/11' in 2001. This period was followed by a slow recovery that has tapered off in recent years at most of the non-resource major airports (Figure 12).

Figure 12: Passenger demand trends at Northern Australia major centre airports



Source: Bureau of Infrastructure , Transport and Regional Economics (2013a) and GHD analysis

The resource airports listed in Table 12, together with the resource-based major centres of Karratha and Port Hedland, have experienced very high rates of traffic growth in recent years (15 per cent a year, or more), in the context of high mineral prices, high mineral demand and extensive resource project development and construction. See Figure 13.

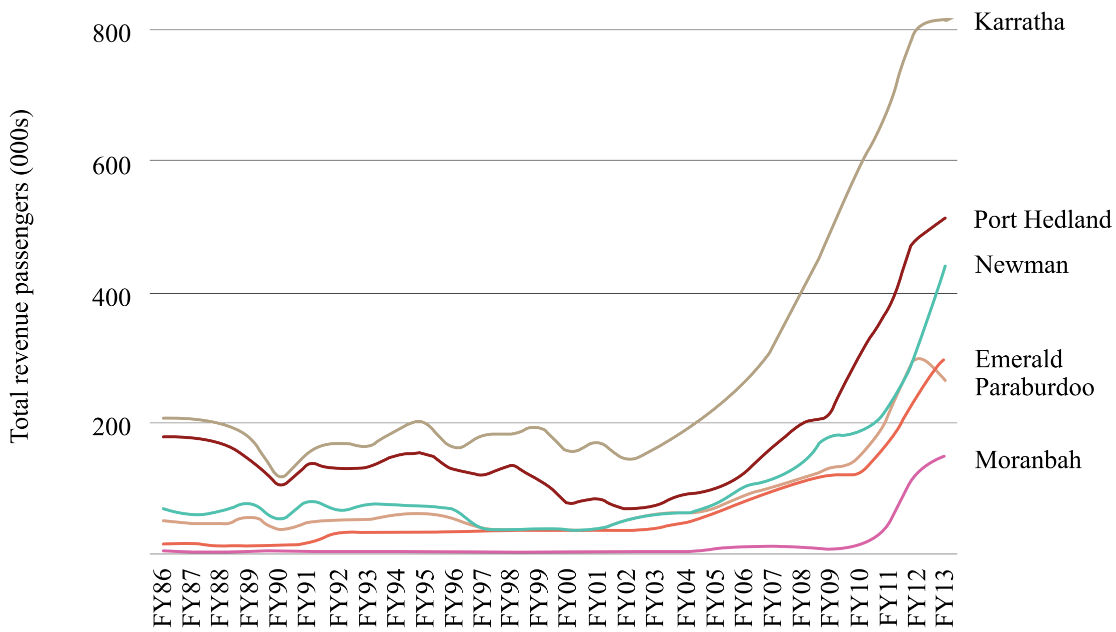
By contrast, tourism airports have generally experienced low rates of growth, i.e. negative to less than five per cent per year (see Figure 14). Industry considers that the tourism airports have bottomed out and that there will be moderate upward growth into the future.

Other airports exhibit a less clear pattern. Kununurra, despite its small size, has a level of diversity and relative stability that is more characteristic of the major centres. Gove has experienced negative recent traffic growth, in the context of resource-based manufacturing closure. Understanding airport busy hour dynamics is helpful in assessing terminal capacity utilisation but has limited relevance to runway infrastructure requirements.

4.5.2 Future airport demand

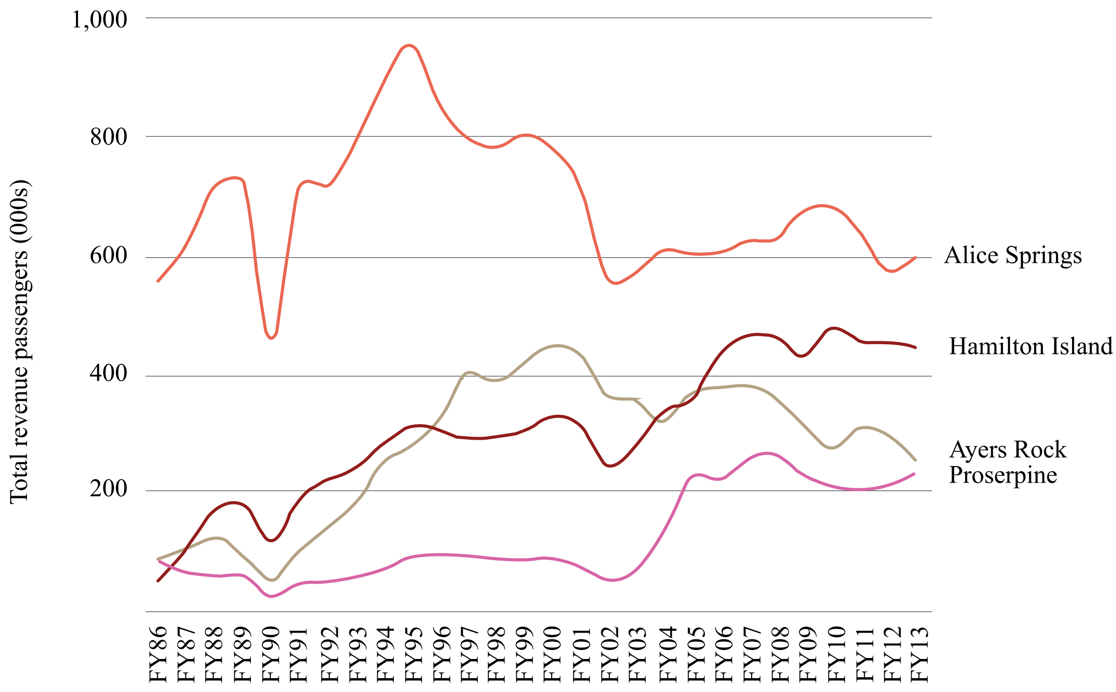
Future airport demand is estimated, where available master plans allow, in terms of total RPT passengers and total aircraft movements. Table 13 shows the estimated growth in aircraft movements at six major northern airports and confirms that runway capacity is unlikely to be of concern over the period to FY31. However, this does not preclude other upgrade requirements (notably apron, taxiways and terminals).

Figure 13: Passenger demand trends at Pilbara and Queensland resource airports



Source: BITRE and GHD analysis

Figure 14: Passenger demand trends at tourism airports



Source: BITRE and GHD Analysis

Table 13: Projected aircraft movements at certain major airports

Airport	Runway capacity (000 fixed wing aircraft movements)	Actual FY11	Projected FY31	Runway capacity utilisation FY31
Alice Springs	80	24	30	37.5%
Broome	160	16	44	27.5%
Darwin	200	86	121	60.5%
Karratha	100	18	37	37.0%
Port Hedland	N/A	17	23	N/A
Townsville	175	65	80	45.7%

Source: Master plans and GHD analysis

4.6 Airport infrastructure gaps

4.6.1 North-south links and major centre airports

Numerous Northern Australia airports have runways of 2,000 metres or more, which are necessary to accommodate jet aircraft to and from southern capitals. Capital city infrastructure, however, is especially vital given the central role these airports play in Northern Australia air networks. In view of thin intra-regional northern markets, it is, for example, not possible to fly directly from Karratha to Kununurra; a triangular trip to Perth (or alternatively Darwin) is required.

In this context, increasing capacity and improving reliability at the two key gateway airports, Brisbane and Perth, are essential for the aviation system in Northern Australia. At both airports, capacity has become strained in recent years, particularly due to the pressure of early morning FIFO flights to mining destinations and afternoon flight arrivals. Both airports are in the early stages of planning for a second major runway, which should relieve this constraint.

A number of major centre airports (e.g. Gladstone, Townsville) will face limited terminal and other capacity expansions to accommodate growing demand. While Darwin has a terminal expansion nearing completion, its alternate airport, Katherine requires rescue firefighting services, terminal and other upgrades.

4.6.2 Fly-in fly-out airports

With the exceptional rates of passenger growth to Western Australia Pilbara region airports, and to some extent Queensland airports (e.g. Gladstone, Mackay, Moranbah), airports have been in an infrastructure 'catch-up position' in recent years, which will continue over the period to 2021. Newman Airport, for example, completed a terminal expansion in 2009 but within months the terminal had become too small to efficiently deal with passengers. Built for an inflow/outflow of 200 people at one time, the terminal is now dealing with over three times that amount and passenger numbers are continuing to grow very strongly.

Some or all of apron, taxiway and terminal expansions are planned at Broome, Derby-Curtin, Exmouth-Learmonth, Gladstone, Karratha, Newman, Paraburdoo and Port Hedland airports. The Western Australian Government is also giving consideration to a longer term relocation of Broome International Airport to accommodate growing heliport traffic that services the off-shore oil and gas industry.

Over the period to FY31, development of Galilee Basin resources will generate additional demand for air services, with development likely at Alpha, Clermont and Emerald airports.

4.6.3 Air freight airport capacity

Northern Australia airports, as with its ports, have no refrigerated container capability that could in principle reduce the costs of high quality agricultural exports from the region. Anecdotally, substantial volumes of fruit and vegetables are trucked to Brisbane, Adelaide and Melbourne, taking advantage of competitive trucking back haul rates, for subsequent air freighting to Southeast Asia (together with domestic capital city use). A combination of factors – a substantial domestic market in the southern capitals, a highly efficient road freight sector (with refrigerated capability), low international air freight rates from airports in southern capitals, due to wide-body passenger aircraft use that northern air markets could not sustain –appear likely to preclude development of northern air freight capacity for the foreseeable future.

Cold storage capability at Darwin Airport or elsewhere would therefore appear a longer term option which is unlikely within the audit timeframe to FY31.However, one possible exception would be if year-round time-sensitive agricultural products were to be produced in the Ord region in sufficient volume, potentially underwriting a freighter service (e.g. from Kununurra).

4.7 Airport critical infrastructure requirements

Critical infrastructure requirements in relation to the infrastructure gaps are shown in Table 14. Information sources comprise the Western Australian draft state aviation strategy, detailed information available in public master plans, supplemented by targeted consultation information.

Most of the airports identified, whether privately or publicly owned,[27] largely manage and fund their own infrastructure investment programs. Exceptions are Milingimbi, Port Keats and Ramingining, three Northern Territory airports which lack the market size for fully commercially funded operations and are reliant on government investment and maintenance funding. In addition, larger airports owned by local governments in Western Australia and elsewhere may also be restricted in their access to funding. Private leasing arrangements along similar lines to the major Commonwealth-owned airports could, if feasible, offer an improved funding and governance pathway.[28]

The list of airport critical infrastructure requirements does not include any airport infrastructure outside Northern Australia. However, timely investment in airport infrastructure in southern capitals is also critical to Northern Australia development. As noted in Section 4.6.1, peak period capacity at Brisbane and Perth airports has faced emerging constraints in recent years, linked to fly-in fly-out services to Northern Australia resource regions.

Table 14: Airport critical infrastructure requirements

Location	Primary infrastructure gap(s)	Infrastructure requirements
Alice Springs	Demand	Runway and taxiway improvements
	Demand	Terminal facilities upgrade to accommodate passenger increase
Ayers Rock (Yulara)	Demand	Apron (aircraft parking) facilities, runway strengthening, taxiway improvements
	Demand	Terminal facilities upgrade to accommodate passenger increase
Broome	Demand	Apron (aircraft parking), taxiway and terminal facilities
	Demand	New airport location to accommodate growing heliport needs
Darwin	Demand	Taxiway improvements
Galilee Basin	Demand	Airport upgrading to accommodate resource development traffic (possible airports include Alpha, Clermont, Emerald)
Gladstone	Demand	Apron (aircraft parking) facilities including for helicopter relocation, runway improvements and terminal facilities
Karratha	Demand	Apron (aircraft parking) facilities, runway extension, taxiway improvements and terminal facilities
Katherine	Demand, service standard	Taxiway, apron and fire service upgrade to maintain international alternate airport status for Darwin Airport
Kununurra	Demand, opportunity	Runway improvements, including extension to accommodate larger aircraft
	Demand	Terminal facilities to accommodate passenger increase
Milingimbi	Service standard	Runway sealing and extension
Newman	Demand	Apron (aircraft parking) facilities, runway improvements and terminal facilities
Port Hedland	Demand	Apron (aircraft parking) facilities, taxiway improvements and terminal facilities
Port Keats	Demand, service standard	Expansion of the length and width of this runway is required to facilitate movement of larger aircraft
Ramingining	Service standard	Runway needs length and width extensions
Townsville	Demand	Apron (aircraft parking) facilities
	Demand	Terminal facilities to accommodate passenger increase

27. Airport operator names are included in Table B.1.

28. See Department of Transport (2013), pp.72-75.

Transport – ports

5.1 Introduction

Northern Australia has more than 25 ports, excluding offshore offloading stations, which are serviced by commercial vessels. These vessels include a number of scheduled shipping line services for the import and export of containerised and break bulk goods, as well as chartered vessels, primarily for the import of project cargo and the export of mining and agricultural products. In addition to a freight gateway function, the major ports in Northern Australia are also transhipment and domestic distribution points for coastal remote and isolated communities and for service facilities for the offshore oil and gas industry. The ports of Northern Australia also provide facilities for the cruise ship industry as well as military and paramilitary vessels.[29]

The development of ports in Northern Australia, as is typical elsewhere, is the result of an evolution of services demand, where ports exist to service the demand generated by connected population centres (traditional ports), and of ports that have been specifically developed to facilitate the export (and to some degree imports) of mining and agricultural products (specialised ports). As a result, the ports of Northern Australia comprise a mix of public and privately owned facilities, with a range of specialisations to meet the particular service demand needs of the connected hinterland or catchment area.

5.2 Ports in scope

Even the smallest community port or jetty provides a connection, direct or indirect, to major centres such as Darwin, Broome or Townsville. It could therefore be argued that all ports and jetties are critical for the development of Northern Australia, working to provide cost-effective gateways for consumer and export goods. This report focuses on those ports that are critically or strategically important trade gateways, or larger distribution points for essential services. The ports in scope are shown in Table 15 and are mapped in Map 7.

5.3 Existing port capacity

Each port is unique in terms of the services it provides and the constraints (both physical and market related) that limit it. As a port is the transfer point between land and sea, there are distinct but interdependent waterside and landside infrastructure functions that influence port capacity.

The waterside function of port capacity is driven by the:

- Nature of the commodities traded, including market requirements and physical handling characteristics of the products
- Number and type of berths, including berth length (contiguous and non-contiguous berth face) and berth pocket depth

29. The Department of Defence operates Royal Australian Navy bases in Cairns and Darwin and maintains an amphibious battle group at Townsville. See Department of Defence (2014).


Photo courtesy of Pilbara Ports Authority

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> Northern Australia has more than 25 ports, excluding offshore offloading stations, which are serviced by commercial vessels."

Table 15: Port infrastructure in scope

Queensland		Northern Territory	Western Australia
Abbot Point	Mackay	Bing Bong	Anketell (future)
Cairns	Mourilyan	Darwin (incl. private off shore gas facilities)	Ashburton (future)
Cape Flattery	Quintell Beach	Gove	Barrow Island
Cooktown	Rockhampton	Milner Bay	Broome
Gladstone	Skardon River	Port Melville	Cape Preston
Hay Point	Thursday Island	Regional barge facilities – e.g. Maningrida, Tiwi Islands, Wadeye	Dampier
Karumba	Townsville		Onslow (incl. Thevenard Island, Airlie Island)
Lucinda	Weipa		Port Hedland
			Port Walcott (incl. Cape Lambert)
			Wyndham

- Channel depth and tidal range (at both the origin and destination port), which limit the size of vessels and access to the port
- Level of protection from sea state conditions, which limits operability and availability
- Loading capability of the market driven vessel fleet (type and size of ships).

The landside function of port capacity is largely driven by the transfer rates of the handling infrastructure at the port (and its terminals), warehousing capacity and the capability of the connecting land transport systems. As such, terminal capacity is driven by the:

- Level of dedicated infrastructure (terminals) for specific and targeted commodity trade. This includes berthing priority rules for particular commodities for multi-cargo wharves
- Achievable transfer rates of ship's gear (cranes and discharging equipment) and mobile equipment (such as mobile cranes and loaders) where no dedicated terminal infrastructure is constructed
- Achievable transfer rates (and number) of specialised infrastructure, such as dry bulk ship loaders and bulk liquid pipelines, at dedicated or specialised berths
- Terminal land area for cargo assembly, buffering and storage/ stockpiling.

Due to the complex relationship between the physical attributes of a port, the level of port specialisation (and its associated terminals), as well as external market-driven factors, the ability to reasonably determine a port's throughput capacity is limited. As a result, estimating a port's maximum capacity involves making many assumptions, to which there are broad ranging opinions which may or may not have any material bearing on the ability of the port to facilitate current and future trade. Key specialisation features and constraints for each of the ports are listed in Table 16. The features and constraints provide an indicator of each port's specialised capability to facilitate trade, as a proxy for commodity type capacity.

5.4 Drivers of additional port capacity

The need to provide additional port capacity in Northern Australia is primarily driven by transformational change that result from mining project development, through both the construction and operational phases of projects, as well as change to industry practices within its catchment. As such, the primary drivers for additional port capacity are:

- A fundamental change in the nature of commodities at a port, such as expansion of livestock exports from Darwin, potentially requiring specialised or dedicated cargo handling infrastructure
- A fundamental change in the throughput volume of a specific commodity at the port, such as the expansion of iron ore exports from the Pilbara.

These fundamental changes, as a result, drive the need to:

- Provide specialised (or additional) landside infrastructure, such as high speed bulk ship loaders and coal stockpiles at Townsville, or additional berths and ship loaders at Port Hedland
- Meet the market driven shipping requirements of products, such as additional dredging at Townsville to allow efficient use of deep draughted vessels used in the global maritime trade of coal.

In addition, policy and planning drivers have a role to play in shaping the capacity outcome, for example, urban planning and environmental risk (including iron ore dust) considerations which, in conjunction with market realities, are important to the Northern Territory Government's longer term interest in developing Glyde Point as a second Darwin port.

5.5 Future port demand

5.5.1 Recent demand trends

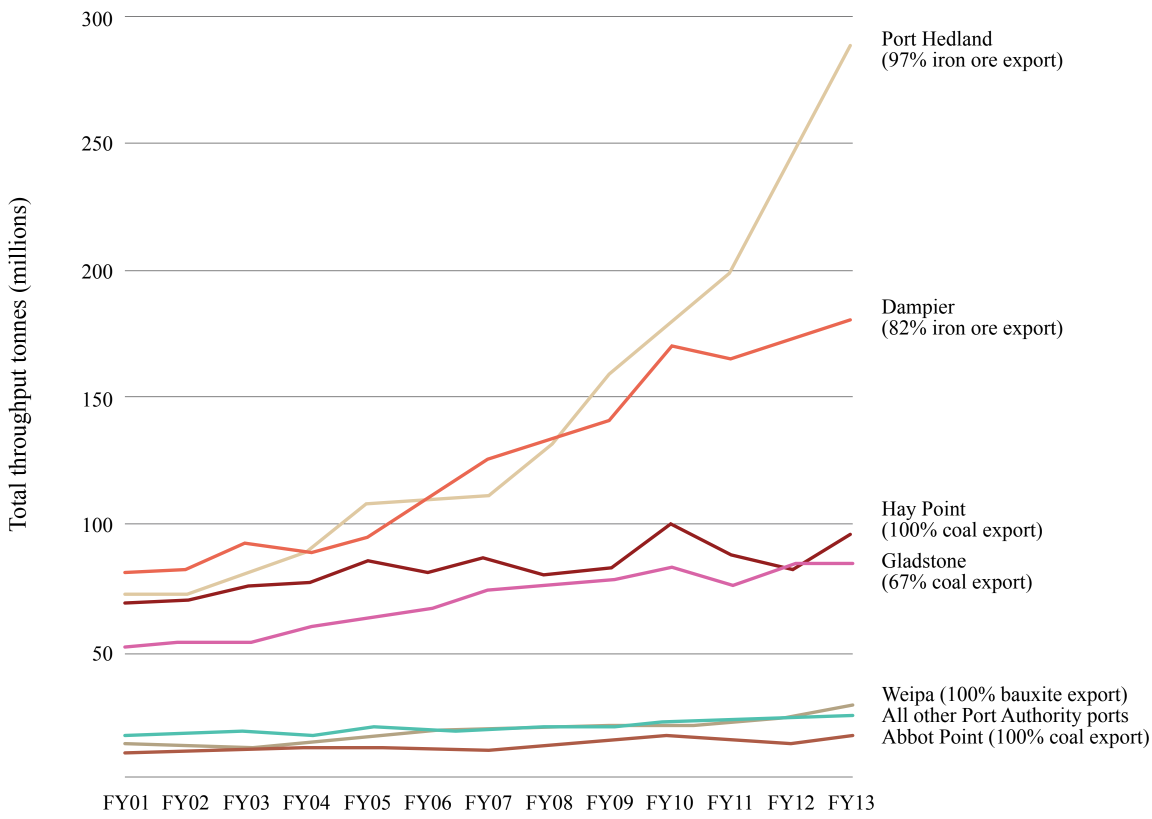
Western Australian iron ore ports (Dampier, Port Hedland, Port Walcott) have experienced exceptional rates of growth over the past decade with expansion of mining capacity to meet fast growing Asian demand (see Figure 15). Coal ports (Abbot Point, Hay Point, Gladstone) have also experienced quite strong growth.

Townsville (12 million tonnes in FY 13) is the largest of Northern Australia's mixed commodity ports, with relatively slow recent growth. In contrast, Darwin, from a low base, has experienced a comparable rate of growth to Port Hedland, with development of bulk mining and livestock exports (see Figure 16 and Figure 17).

Coastal freight primarily comprises dry bulk (iron ore, bauxite) and liquid bulk (petroleum), with key flows between Weipa and Gladstone and Port Hedland and Melbourne. With a total of 29 million tonnes in FY12, the overall trend has been flat over the past 10 years.[30]

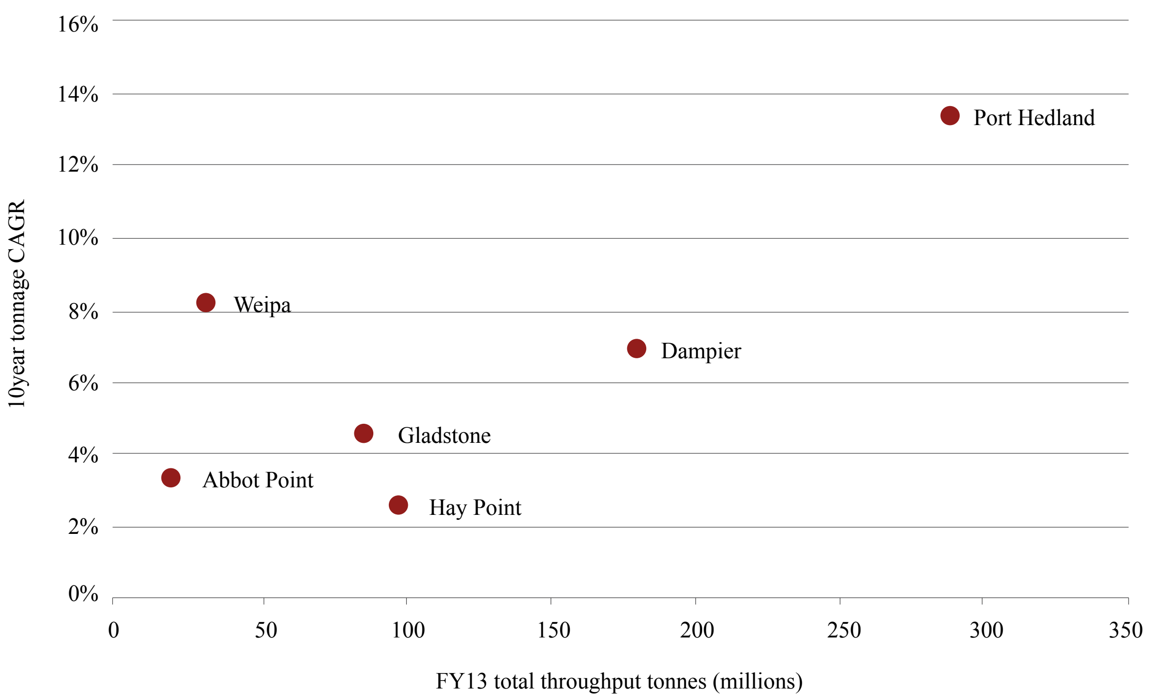
30. Bureau of Infrastructure, Transport and Regional Economics (2013)

Figure 15: Northern Australia port throughput trends



Source: Ports Australia and GHD analysis

Figure 16: Growth rates and throughput at the larger bulk export ports



Source: Ports Australia and GHD analysis

5.5.2 Demand outlook

Future port demand is largely driven by a potential change in activity within the connected hinterland or catchment. For many of the ports in Northern Australia, as with other ports, total supply costs and port capabilities influence the reach and desirability of the catchment for individual commodities in trying to both access capacity and achieve a least-cost pathway to market. As a result, and in combination with the land transport network, many of the ports have overlapping and competing catchment areas for some or all commodities.

Within the port catchments, organic, or incremental growth, driven by a change in population and local industries is likely to generate modest growth for Northern Australian ports. However, the major population locations are served, in part, by the key national container ports of Fremantle, Adelaide and Brisbane. Transformational change arising from significant industry adjustment, expansion projects and new developments has a more significant impact. These adjustments or projects, depending on location, are potentially located within the catchments of multiple ports, and demand specialised port infrastructure.

There are several regions within Northern Australia that are current or potential hot spots for transformational change. These regions, including the identified growth commodities, are presented in Figure 15. In addition, Table 16 presents the potential port gateways from these regions and the specialised port infrastructure that is required to facilitate the efficient movement of these commodities.

Growing the coastal freight task faces the challenge of distances for many routes that are too short to offset high costs of loading, unloading and transfer relative to other modes, together with progressive improvement in the performance of alternative modes. However, there is a degree of renewed government and community interest in coastal shipping, in view of its potential role as an essential service supplier in flood-related emergency situations.

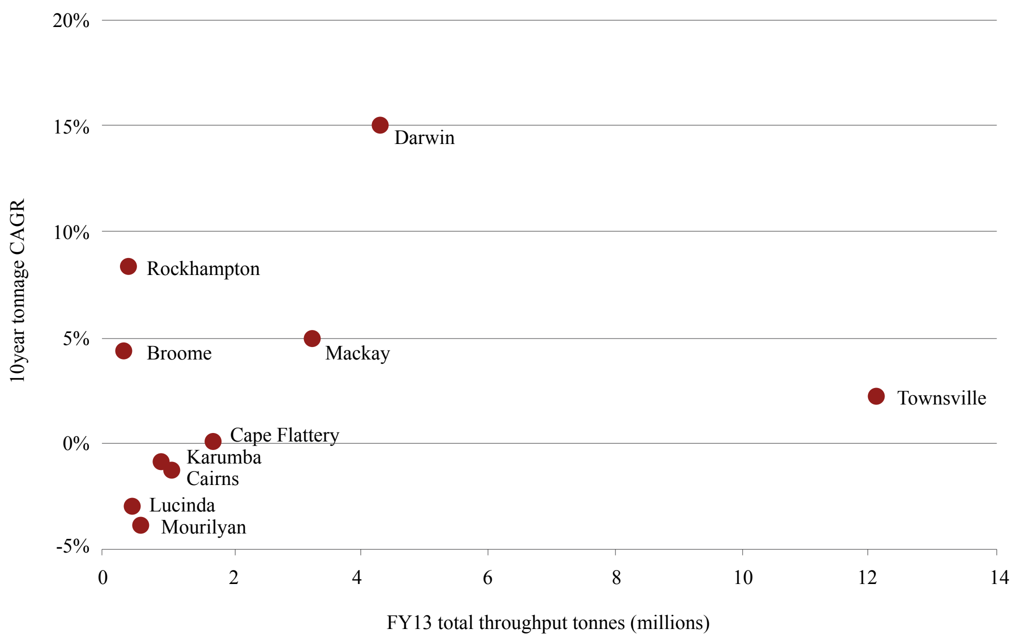
5.6 Port infrastructure gaps

Due to the relationship between multiple port catchments and the level and type of specialisation of a port, infrastructure gaps should be considered within the context of each region. As identified in Table 16, for each region there are a range of potential port gateways, and specialised port infrastructure demanded to facilitate the trades. As such, port infrastructure gaps are discussed through the remainder of this section, within the context of the regions that will potentially undergo transformational change.

5.6.1 Galilee and Bowen basins

The Galilee and Bowen basins make up a large area with significant quantities of black coal. The area has attracted significant interest in recent years on how to appropriately facilitate the infrastructure required to support expansion (and sustaining export) levels from the mature Bowen Basin (predominantly metallurgical coal) area with a changing spatial distribution of demand, and enabling new exports from the Galilee Basin (predominantly thermal coal).

Figure 17: Growth rates and throughput at mixed commodity and smaller ports



Source: Ports Australia and GHD analysis

Photo courtesy of Pilbara Ports Authority

Within the region there are numerous projects at various levels of approvals, including, but not limited to the new coal mines of Kevin's Corner, Alpha, Alpha West, Carmichael, China First and South Galilee in the Galilee Basin, most of which are likely to export through Abbot Point, and developments including, but not limited to, Caval Ridge, Moranbah South, Springsure Creek, Byerwen and Minyango, which are likely to export through a combination of Hay Point (Hay Point Coal Terminal and Dalrymple Bay Coal Terminal), Gladstone, Wiggins Island Coal Export Terminal, and Abbot Point. The scale and timing of each of these projects will trigger demand for the development of additional port and landside infrastructure, as well as dredging and terminal infrastructure in some ports. While throughput at Abbot Point was 17.7 million tonnes per annum (mtpa) in FY13, the increase resulting from the South Galilee projects, above committed Bowen Basin projects, may be in excess of 200 mtpa. This will require significant new port (and landside) infrastructure expansion, with the timing of the first stages of export likely to be market dependent.

In addition to the South Galilee projects, there are a number of potential coal mines in the North Galilee, located in and around Hughenden and Pentland. These projects have a potential export volume in the order of 40 mtpa, but first potential exports of coal likely depend on the strength and depth of the coal demand. These mines are connected (via the Mount Isa to Townsville rail line) with the Port of Townsville, which is not a traditional coal port. Investment in specialised infrastructure to facilitate cost effective exports would arguably be required in the longer term. In contrast, the port of Abbot Point is a specialised coal port with significant coal expansion plans, but usage by North Galilee developments would involve hauling coal an additional 180 km via the Mount Isa Line and North Coast Line (NCL) or alternatively via a new rail line connecting the Mount Isa Line and NCL together and upgrading these lines.[31]

While the primary focus for the region has been on export freight demand, there is a significant import freight task for the construction and ongoing operation of the mines. Due to the different nature of these imports, demand from new projects in the Galilee and Bowen basins will be most likely through the ports of Townsville, Mackay or Gladstone. Demand for imports will be linked with construction activities in the two to three years before production commences. This is possible before 2016 and continuing through to 2021, with operational consumables demand throughout the life of the mining operations which will extend beyond FY31.

31. GHD and BDO (2012)

5.6.2 Mount Isa and Cloncurry region

The Mount Isa and Cloncurry region has historically been a base metal and pastoral region, largely focused on the production of copper, lead and zinc and cattle. The Mount Isa rail line and the Barkly and Flinders Highways connect this region with the Port of Townsville, where the majority of imports and exports, which comprise metal concentrates and refined metal products, are handled. More recently, the product mix hauled along the Mount Isa Line has included significant volumes of fertiliser and inputs to fertiliser production (acid and sulphur).

Despite the region being connected with the Port of Townsville, it is also connected by road with the Port of Karumba. The Port of Karumba, which is closer to the region than Townsville, presents as a potential alternative. However, the lack of rail connectivity, road reliability and port physical constraints limit the attractiveness of the port to exporters.

There are a number of key projects committed or currently under development within the region that are likely to be handled at the Port of Townsville. These include, but are not limited to, copper, zinc and lead projects, a number of phosphate and fertiliser projects and the potential long term development of unconventional oil and gas. The ability to sustainably export magnetite has not, as yet, been achieved. While the majority of this potential additional production may be realised between FY16 and FY21, there are a number of structural changes underway as a result of mine closures and changes in metal processing in the same period.

Table 16: Key growth regions, port gateways and specialised port infrastructure

Region	Growth commodities	Potential port gateways	Additional specialised port infrastructure demanded
Galilee and Bowen basins	Black coal	Abbot Point Townsville Hay Point	Dry bulk berths and ship loaders Stockpiles Heavy load berths Capesize channel depth
Cloncurry	Copper, gold, zinc, lead, magnetite	Townsville Karumba	Dry bulk ship loaders Stockpile area
Roper River / McArthur basin	Iron ore, lead, zinc, silver	Bing Bong Darwin Roper River	Dry bulk berths and ship loaders Stockpiles Deep water channel or barge
Tennant Creek	Phosphate	Bing Bong Darwin Karumba Townsville	Dry bulk berths and ship loaders Stockpiles Deep water channel depth
Alice Springs	Oil, shale gas, rare earths (2)	Darwin South Australian ports	Bulk liquid tank farm Bulk liquid berths (including pipeline) Dry bulk berths and ship loaders (if in bulk) Deep water channel depth
Pilbara	Iron ore	Port Hedland Cape Lambert Dampier Anketell Point	Dry bulk berths and ship loaders Stockpiles Heavy load berths Capesize channel depth
Canning Basin	Oil, shale gas	Wyndham Broome Port Hedland	Bulk liquid tank farm Bulk liquid berths (including pipeline) Deep water channel depth
East Kimberly / Ord	Irrigated agricultural land	Wyndham Darwin	Dry bulk berths and ship loaders Storage sheds Bulk liquid pipeline Bulk liquid tank farm Deep water channel depth
Browse Basin	LNG	Broome Port Hedland Dampier	Heavy load berths Services and supply base
North-West Shelf	Oil, gas	Ashburton North (Onslow) Barrow Island Burrup Peninsula	Gas processing facilities Gas storage facilities Bulk liquid berths (including pipelines) Deep water channel depth
Burdekin, Flinders and Gilbert Rivers	Irrigated agricultural land	North Queensland Ports Brisbane	Dry bulk berths and ship loaders Storage sheds Refrigerated container storage
Cairns	Tourism	Cairns	Cruise terminal(s)
Darwin	Tourism	Darwin	Cruise terminal(s)

Notes: Potential to develop private use barging infrastructure. Oil and gas developments may be used for domestic consumption. Port considerations are limited to potential exports only. Source: Various and GHD analysis

This will result in higher transport volumes of intermediate product which will be handled at one or both of the connected ports. The cumulative impact of these changes will be likely to expand demand for facilities at the Port of Townsville, or require significant investment to increase the capacity at the Port of Karumba to improve port and landside constraints to cost effectively facilitate new and potentially different trade.

5.6.3 Roper River/McArthur Basin

The McArthur Basin currently hosts extraction of base metals, particularly around the McArthur River area, as well as small scale iron ore operations in the Roper River area. Currently, the majority of base metal products are exported from Bing Bong port, with recent trial shipments of iron ore from Roper River via the Port of Darwin. The expansion of base metal production, continued development of iron ore reserves, particularly in the Roper River area, and development of ilmenite reserves may see a potential significant increase in the scale of exports from the region between FY16 and FY21.

While the majority of base metal exports currently occur through the port of Bing Bong, up to three million tonnes per year of iron ore exports are also expected to be exported through the port within the next five years.[32] In addition to exports through Bing Bong, an additional three million tonnes per year from the region could potentially be exported through Port of Darwin. Limited landside infrastructure connecting the region with Darwin could potentially result in barging operations to the Gulf of Carpentaria as an alternative;[33] however, significant port or landside development is required for these opportunities to be cost effectively realised.

5.6.4 Tennant Creek

The Tennant Creek region is a traditional gold and copper mining area that falls within the Port of Darwin catchment. While this has been the case for current and historical producers, including manganese, there is potential for significant exports of phosphate from the region, which could consider alternative export gateways.

Phosphate reserves in the Georgina Basin could potentially be exported through a number of ports, including Bing Bong, Darwin, Karumba or Townsville. The ultimate decision of which port may facilitate the export of phosphate, which could potentially commence prior to 2016, will be influenced by the total supply chain cost, particularly land transport and the capacity and capability of the ports. Due to the scale of the projects, it is likely that landside infrastructure may need to be developed, as well as port infrastructure at one or more of the potential export gateways to achieve a low cost pathway.

5.6.5 Alice Springs

The Alice Springs area has numerous potential developments, particularly oil and gas from the Amadeus Basin, and deposits of rare earths. Potential oil and gas developments may or may not be exported, depending on available volume and domestic supply opportunities and requirements. However, where oil and gas developments may be exported, and for the export of rare earths, Alice Springs' location at approximately half way between Adelaide and Darwin results in Darwin Port and a number of ports in South Australia as potential port gateways. The potential export volume is small in scale when compared with other developments across Northern Australia. Development of these resources is potentially between 2016 and 2021.

5.6.6 Pilbara

The Pilbara is Australia's dominant iron ore exporting region, where most of the export volume is handled at the ports of Port Hedland, Dampier and Cape Lambert. The major producers have traditionally exported iron product through their own private terminal developments in a single port or area (such as Dampier and Cape Lambert for Rio Tinto). Significant expansion of iron ore production is proposed in the East and South Pilbara, both from existing producers, as well as numerous aspiring producers such as Roy Hill and Brockman Resources, which are expected to develop dedicated private facilities in Port Hedland over the next five to 10 years. Exports from the region could potentially double from current levels, with the majority of growth expected to be handled at Port Hedland, but realisation of these exports is dependent on expansion of existing infrastructure or development of new rail and port infrastructure in line with production increases.

In addition to port facilities at Port Hedland, Dampier and Cape Lambert, there is a potential port development at Anketell Point which will provide an export gateway for potential mine development in the West Pilbara. Production from many of these proposed mines, which underpin the development of the port, can only be realised with development and access to cost effective rail and port infrastructure. Development of Anketell Point and the West Pilbara mines are therefore more likely over the longer term, depending on the ability to reach market at a competitive cost.

32. http://www.ntepa.nt.gov.au/__data/assets/pdf_file/0018/131382/WesternDesertResourcesRoperBarFINAL.pdf

33. http://www.core.nt.gov.au/Content/File/InvestmentAlert/MiningDevelopmentsInTheNT.pdf

5.6.7 Canning Basin

The Canning Basin holds significant unconventional oil and gas resources, which could potentially see a significant increase in imports and exports through the ports in the region. There are several potential land based projects in the Kimberly region that would generate significant demand for port infrastructure. Following the decision not to proceed with the development of James Price Point, which would have provided the most likely gateway to market for Canning Basin producers, a number of alternatives can be considered, including ports such as Port Hedland and Wyndham (which has seen a number of shipments) in addition to Broome. In order to fully realise these developments, significant infrastructure, both land and port, will be required to facilitate expansion of the region through to 2016 and beyond.

5.6.8 East Kimberley/ Ord River

The East Kimberley is primarily an agricultural region for the growth of fruit and vegetables and hosts significant Indian sandalwood plantations. The agricultural area is supported by the Ord River Irrigation Scheme and Lake Argyle, which traditionally exported sugar through the Port of Wyndham. The Stage 2 expansion of the Ord River Irrigation Area has the potential to significantly increase agricultural production from the region. The Stage 3 expansion, which is currently under consideration, could potentially result in significant long term increases in exports (including sugar exports) from the region.

As with the East Kimberley, the Ord River Irrigation Area sits within the Port of Wyndham catchment. As such, the Port of Wyndham will potentially see significant growth in trade. However the Port of Darwin, as the next closest land connected port, may serve as an alternative for product generated by the region, depending on the scale of increase in exports through the Port of Wyndham and the supply chain cost difference between expanding Wyndham, if required, and the use of the alternative Port of Darwin, or use of air freight.

5.6.9 Browse Basin

The Browse Basin is a large hydrocarbon province with major undeveloped gas and condensate fields in North West Australia, located about 220 kilometres offshore.

The Ichthys LNG project was discovered in 2000 and is currently in construction, with first production scheduled for the end of 2016. The project is expected to produce 8.4 million tonnes of liquefied natural gas (LNG) and 1.6 million tonnes of LPG per annum, along with more than 100,000 barrels of condensate per day at peak.

Gas condensate from the Ichthys Field will be exported to onshore facilities for processing near Darwin via an 889 km pipeline. Most condensate will be directly shipped to global markets from a floating production, storage and offloading facility permanently moored near the Ichthys Field in the Browse Basin. A marine supply base is under development at the Port of Darwin to support the project. (Gas from the Bayu-Undan gas field in the Timor Sea is currently brought on shore at Wickham Point, Darwin, where it is liquefied at a single-train processing plant before being shipped as LNG to Japan.)

Development of the basin has also been proposed by Browse LNG, as a LNG plant at James Price Point, north of Broome. The onshore project was not developed, due largely to project costs, which affected the long term viability of the operations. As a result, potential developers of the basin are considering the use of floating LNG vessels for processing and offloading at sea. The change to offshore processing and offloading will result in limited port volume growth, with the majority of port demand likely to occur during the construction phase and ongoing support services potentially prior to 2021.

5.6.10 North West Shelf

The North West Shelf is an extensive oil and gas region off the North West Australia coast. The two main production areas are known as the Thevenard Production Area, close to Onslow, and the Varanus Production Area, located west of Dampier. There is significant development in the region, particularly with current development of the Gorgon gas project, the Pluto LNG Project and Wheatstone LNG project. The Gorgon gas project includes development of the gas fields, sub-sea gas-gathering infrastructure and processing plant at Barrow Island. The Pluto LNG project includes an offshore platform and sub-sea wells which will be piped to the onshore facility at the Burrup Peninsula. The Wheatstone LNG Project includes the installation of a LNG plant at Ashburton, west of Onslow.

These large scale developments have significant port infrastructure requirements both through construction and the operational phases. Key to these projects is the development of critical private use infrastructure for the export of oil and gas products; however, the support requirements for these projects once operational will potentially place additional demand on port infrastructure that may require development and/or expansion beyond FY31.

5.6.11 Burdekin, Flinders and Gilbert Rivers

There is the potential for significant development in irrigated agriculture, which could include surface catchment, storage and irrigation from the Flinders and Gilbert River catchments, as well as the Burdekin River. This has the potential to generate a significant increase in perishable and chilled port volume, particularly for exports over the long term. However, it is likely that some of the exports would be transported by air freight to international destinations.

Port exports could be potentially handled at the ports of Weipa, Karumba, Cairns, Townsville or other North Queensland ports, as well as Brisbane. The port decision, due to the time critical and high value nature of the exports, will be driven by both the total supply chain costs and the time to reach market. As a result, the scale of increase for the export of perishable goods and the need for refrigerated transport may call for infrastructure development at the ports, but will be significantly influenced by shipping line call frequency and the associated ports of call.

5.6.12 Tourism ports

The popularity of Cairns and Darwin as cruise destinations has resulted in a significant number of ship visits to these ports. Continued expansion of the cruise industry, and continued popularity of Cairns and Darwin as ports of call by cruise companies will put increasing pressure on existing port infrastructure and the effective use of berths. This may lead to the need for additional dedicated cruise facilities at the ports in order to maintain separation between industrial and freight uses, and passengers.

5.6.13 Regional ports and barge facilities

As well as providing all-weather deliveries to a number of remote coastal communities, coastal barges facilitate the transport of supplies and machinery to significant mining ventures at Gove and Groote Eylandt. These barges also serve as supply vessels for the townspeople and mine workers.

Some of these barge and wharf facilities in the Northern Territory are in need of repair and maintenance if they are to continue to effectively and efficiently serve the needs of connected communities. The government wharf at Nhulunbuy, for example, has been assessed as beyond economic repair and may require investment in new wharfing facilities.

5.7 Port critical infrastructure requirements

Port critical infrastructure requirements (see Table 17) are based on analysis of infrastructure gaps and take account of existing port master plans and jurisdiction freight and port strategy plans.[34]

Queensland ports are to prepare master plans on the basis of new guidelines over the coming year.[35] In addition, the Queensland Government has indicated that it will prohibit dredging for the development of new ports, or the expansion of existing, port facilities for the next 10 years around the environmentally sensitive Great Barrier Reef World Heritage Area. In particular, these constraints may limit the extent of channel development achievable at Cairns.

34. See Department of State Development, Infrastructure and Planning (2014), Western Australia Department of Transport (2013), Department of Transport and Main Roads (2013).

35. Queensland Government (2014)

Table 17: Port critical infrastructure requirements

Location	Primary infrastructure gap(s)	Infrastructure requirements
Abbot Point	Demand	Expansion (potential for two additional 60 million tonne terminals) for Galilee Basin coal development, with resolution of dredging issue required
Anketell	Demand	Dry bulk dedicated infrastructure (West Pilbara iron ore)
Ashburton	Demand	Bulk liquid dedicated infrastructure (North West Shelf and Carnarvon Basin LNG)
Bing Bong	Demand	Iron ore specialised handling equipment upgrade – possible (alternative to Darwin)
Broome	Demand	Bulk liquid dedicated infrastructure (North West Shelf, Canning Basin oil and gas) – possible
Cairns	Demand	Cruise vessel facilities, including channel capacity and wharf extension, subject to Queensland Ports Strategy constraints on dredging
Dampier	Demand	Iron ore (Pilbara) and bulk liquid (Carnarvon Basin LNG) upgrade
Darwin	Demand	Dedicated livestock handling and storage facilities
	Demand, opportunity	Dry bulk berth and handling facilities
	Demand	Rail loop or other rail receival solution to accommodate mining throughput growth
	Demand	Improved cruise vessel facilities and associated infrastructure
Gladstone	Demand	Coal specialised handling equipment upgrade and channel duplication
Hay Point	Demand	Coal specialised handling equipment's upgrade (25 million tonne metallurgical coal demand)
Karumba	Demand	Expansion, including transhipment infrastructure, to accommodate possible future irrigated agricultural exports and North West Queensland mineral exports
Mackay	Demand	Intermodal facilities and infrastructure and improved land transport access for imports
Nhulunbuy	Opportunity, service standard	Repair and upgrade of government wharf for freight and fishing (commercial, recreational use) – possible following investigation
Port Hedland	Demand	Outer Harbour development (Pilbara iron ore, Canning Basin oil and gas)
		Intermodal and logistics facilities
Port Melville	Demand, opportunity	Development of ancillary port infrastructure to service the oil, gas, mineral sands and agricultural industries
Townsville	Demand	Additional bulk berth for increased mining output
	Demand	Common user rail receival facility
	Demand	Outer Harbour development for potential large-scale mining export increase
Wyndham	Demand	Dry bulk dedicated infrastructure (Ord Stage 2 and Canning Basin)

Photo courtesy of Pilbara Ports Authority

Transport – rail

6.1 Introduction

Rail in Northern Australia is the main transport mode for moving bulk minerals, including iron ore, coal and base metal concentrates, from mine to port. Rail also supports road transport in moving grains, livestock and other agricultural products. The two north-south lines, the Adelaide-Darwin line and the North Coast Line, are important for transporting intermodal freight into the region, with notably around 70 per cent of the Northern Territory's freight that originates in South Australia moved by rail.[36]

6.1.1 Northern Territory

The North-South transcontinental railway from Darwin to Adelaide is a key intermodal and bulk freight route. The line operates six intermodal services a week from Adelaide to Darwin and carries around 800,000 tonnes of intermodal freight every year. This rail route is capable of delivering freight between Adelaide and Darwin at a lower cost than road, with comparable transit times. The critical importance of this line is demonstrated during washouts (most recently in January 2014), when there is intense pressure for the line to be fixed quickly as Darwin only has three to four days of food retained in inventories.

The line also operates 24 bulk trains a week between mining sites and the Port of Darwin, and carries in excess of three million tonnes of bulk freight per annum. Mining developments along the central corridor will continue to drive demand along this route.

6.1.2 Queensland

There is extensive rail freight activity across Northern Queensland supported by multiple connected trading ports, i.e. (from north to south) Townsville, Abbot Point, Mackay, Hay Point, and Gladstone.

Coal is by far the most significant export commodity by volume in Queensland; exports have increased by more than 50 per cent since 2001, accounting for more than 84 per cent of all Queensland exports.[37] Strong, continued demand for coal will continue to drive tonnage on the Central Queensland Coal Network.

The Mount Isa region is one of world's richest mineral resource regions and a significant global producer of silver, lead and zinc. In FY13 the Mount Isa system moved over five million tonnes of product and supported mineral production of $6.7 billion in the region. New mineral deposits, coupled with the discovery of major coal deposits in the Northern Galilee Basin, indicate that the Mount Isa Line may experience significant transformation in the type and quantity of tonnage it will move in the future. Further, the region surrounding the Mount Isa Line produces 75 per cent of Queensland non-coal mineral output.[38]

The Central West System is used both for mixed commodity services and for the Spirit of the Outback passenger service, a once-weekly service between Longreach and Brisbane, accommodating up to 200 passengers per trip.

36. Bureau of Infrastructure, Transport and Regional Economics (2012)

37. Office of Economic and Statistical Research (2013)

38. Mount Isa Line Rail Infrastructure Master Plan (2012)

Photo courtesy of Aurizon Holdings Ltd

"Rail in Northern Australia is the main transport mode for moving bulk minerals, including iron ore, coal and base metal concentrates, from mine to port."

In addition, Queensland Rail Travel offers passenger services between Cairns and Brisbane (e.g. Spirit of Queensland and The Sunlander on the North Coast Line). There are also three Tableland System passenger routes, Cairns to Forsayth, Croydon to Normanton and the Kuranda Scenic Railway (Cairns-Kuranda).

6.1.3 Western Australia

The total value of mineral production from the Pilbara region in Western Australia in FY13 was in excess of $67 billion. Over 94 per cent of Australia's iron ore exports are sourced from the Pilbara region with the majority of this supplied by three companies, Rio Tinto, BHP Billiton and Fortescue Metals Group,[39] and transported along the Pilbara Iron Ore Railways.

The Pilbara Railways consist of four private, heavy duty lines for the cartage of iron ore from mines in the Pilbara region to the export ports of Port Hedland, Cape Lambert and Dampier.

Major iron projects in the Pilbara region will continue to be a key driver of the capabilities of the railways in this region. The three incumbent railway operators will shortly be joined by a fourth, as the Roy Hill Project (in which Hancock Prospecting is the majority shareholder) becomes operational. Fast growing miners like Atlas Iron and Brockman Mining are pursuing their own rail infrastructure which, when developed, will free up the roads in the Pilbara region for smaller miners.[40] This will trigger a new cycle of smaller mining companies moving minerals by road and then transitioning to rail when they expand and it becomes commercially viable for them to do so.

39. Bureau of Infrastructure, Transport and Regional Economics (2014)

40. Atlas operates its current mines on the basis of road haulage to Port Hedland but Brockman is stifled by its geographical location in that it lacks road haulage infrastructure

6.2 Rail infrastructure in scope

Existing rail infrastructure in scope is summarised in Table 18. Rail infrastructure is mapped in Map 8.

Table 18: Rail infrastructure in scope

Jurisdiction	Rail line/network
Northern Territory	Tarcoola to Darwin Line (part of the Adelaide-Darwin Railway)
Queensland	Central Queensland Coal Network (Blackwater, Goonyella, Newlands systems)
	Central Western Line (Emerald-Clermont, Emerald-Winton)
	Mount Isa Line (Mount Isa – Townsville)
	North Coast Line (Brisbane – Cairns, via Rockhampton)
	Tablelands System (Cairns – Forsayth, Normanton-Croydon, Cairns – Kuranda)
Western Australia	Hamersley and Robe River Railway (Pilbara mines – Port Dampier/Cape Lambert)
	Goldsworthy Railway (Pilbara mines – Port Hedland)
	Fortescue Railway (Chichester – Port Hedland, Solomon – Port Hedland)
	Mount Newman Railway (Newman – Port Hedland)

Source: GHD analysis

6.3 Existing rail infrastructure capacity

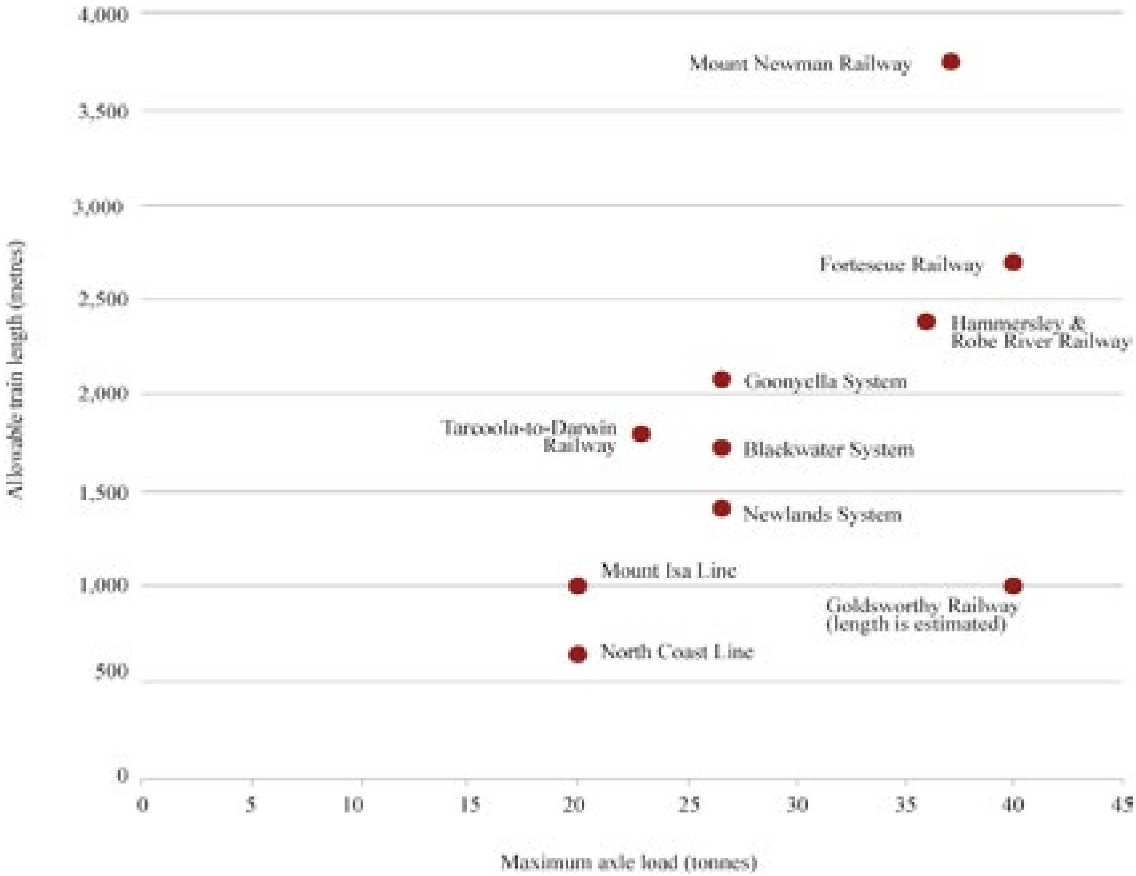
The capacity of a railway line has many determinants. Axle loadings limit load size, signalling influences train headways, passing loop lengths limit train length on unduplicated track and horizontal (curvature), and vertical (grade) alignments affect both train operating speeds and train length.

In addition, in Northern Australia capacity is influenced by weather-related availability. For example, washouts, where heavy rain erodes the rail bed, will interrupt services for a minimum of two to three days, while loss of a bridge during the wet season is likely to affect track availability for several weeks. During the summer months of high temperatures (40 degrees Celsius and above), hot weather precautions for track stability are followed in order to reduce the risk of incident. This includes speed restrictions that could be as low as 40 km/h on timber sleepered track.[41]

Figure 18 presents the range of allowable train lengths and maximum axle loads for the various railways. Detailed configuration and capacity and usage information for the rail infrastructure in scope is shown in Table B.4.

41. Queensland Rail (2007)

Figure 18: Allowable train length and maximum axle loads



Source: Railway operators' web sites, system information packs, master plans and GHD analysis

6.3.1 Darwin to Tarcoola Line

The Adelaide-Darwin Line was opened in 2004 and has successfully captured the vast majority of northbound intermodal freight from the road system. It is a single track line on which intermodal train lengths of 1.8 km are feasible. The line has a total of 16 passing loops (12 north of Alice Springs and four south of it, some of suboptimal length – i.e. less than two kilometres). The total length of these passing loops is 32 kilometres over the entire 2,244 kilometres length of the rail line.

The six weekly intermodal services are mostly container traffic. There is a growing need for a seventh train service on the back of strong northbound container demand in Darwin and Alice Springs. Up to 700 containers are conveyed north every week, although there is southbound capacity. Operators along the central corridor have reported growth of around nine per cent a year in intermodal freight and this is anticipated to grow as the Northern Territory economy expands.

Given the current rail line structure (single track with 16 passing loops) the bottlenecks to increasing capacity are not the size and weight of the train, but rather getting access to the line. The lack of duplicated track limits the line's ability to increase train movements.

The cost of increasing the line's capabilities, through the use of passing loops, is borne by the miner that desires the passing loop and is willing to pay for it. For a 1.8 kilometre train, a 2.0 kilometre passing loop is required (at a cost of approximately $8 to $10 million), and possibly a siding for bulk minerals. The track is capable of carrying payloads of 8,500 tonnes on 15,000 tonne trains at current axle loads. Higher axle loads would be needed to carry Pilbara sized wagons.

Derailments and washouts of the track in the last five years have been attributed to extreme weather conditions (track buckled under the heat or was washed away during the wet). Two years ago extreme weather weakened a bridge and caused a freight train to derail[42] – the bridge took six weeks to replace.

42. The Australian, Crash sparks calls for Adelaide to Darwin rail line probe, June 2012, http://www.theaustralian.com.au/national-affairs/crash-sparks-calls-for-adelaide-to -darwin-rail-line-probe/story-fn59niix-1226390639315 accessed 13 May 2014

6.3.2 Central Queensland Coal Network

Across the Central Queensland Coal Network there are varying degrees of duplications. The Goonyella System is almost entirely duplicated, while the Blackwater System is mostly duplicated except for seven sections. The Newlands System is mostly single track with passing loops. This level of duplication determines the maximum train length across each of the sections: this is 2 kilometres on the Goonyella System, 1.7 kilometres on the Blackwater System and 1.4 km in the Newlands System. All three of the systems have an axle load of 26.5 tonnes.[43]

Aurizon has conducted track capacity analysis on each individual section. The analysis includes an availability allowance of 15 per cent (to allow for maintenance) and a headroom allowance (i.e. unused train paths, in place to allow operational flexibility) of 25 to 30 per cent.

The Newlands System services the northern end of the Bowen Basin and 11 coal mines in the area, connecting them to the Abbot Point Coal Terminal. It has a committed capacity of 50 million tonnes per year (across the system) and its lowest uncommitted track capacity (less than 5 million tonnes per year) is in the section between Havallah and Newlands.

The Goonyella System services Central Bowen Basin and 25 mines in the area, connecting them to the Hay Point Coal Terminal and the Dalrymple Bay Coal Terminal. It has a committed capacity of 140 million tonnes per year. There is a minimum of at least five million tonnes per year uncommitted capacity across the system.

The Blackwater System services the Central and Southern Bowen Basin and 20 mines in the area, connecting them to the RG Tanna Coal Terminal, the Wiggins Island Coal Export Terminal (which is to commence operations in 2015) and the Barney Coal Terminal (at the Port of Gladstone).

Both the Blackwater and Newlands Systems interact with non-coal traffic on the North Coast Line – this negatively impacts train cycle times and capacity. The lowest uncommitted track capacity (less than five million tonnes per year) is in the section between Rolleston and Memooloo.

6.3.3 Central Western Line

The Central Western Line relies on a total length of 780 kilometres of track, which may carry containerised freight, grain, livestock and passengers. During periods of peak temperatures, operational requirements can involve reducing line speed to minimise the risk of incident (e.g. train derailment as a result of track buckling).

The Central Western Line comprises a single line track west from Emerald to Winton (via Longreach) and a branch line from Emerald to Clermont. The line connects with the Goonyella System Blair Athol Junction. Such track features commit to nine passing loops, 15.75 tonnes maximum axle load, and a maximum allowable speed range of 50 to 100 kilometres per hour.[44]

The Emerald to Longreach section has a 15.75 tonnes axle load limit and a 70 kilometres per hour speed limit through 18 passing loops. From Longreach to Winton the allowable axle load remains the same, yet the maximum speed drops to 50 kilometres per hour.

6.3.4 Mount Isa Line

The Mount Isa Line is a single track rail line with passing loops that moved over five million tonnes of product in FY13. The Mount Isa Line has an axle load of 20 tonnes, which is significantly lower than both the Pilbara Railways and the Central Queensland Coal Network. There is some spare capacity available on the line for contracted tonnes but any significant increases in tonnage will be accompanied by increased maintenance costs and the need for track renewal (to replace light rail with heavy rail and steel sleepers with concrete sleepers).

Extreme weather in the area, such as heat and flooding, reduces the reliability of the line during the summer months. Queensland Rail continues to address the impact of severe weather on this track through infrastructure upgrades, targeted maintenance practices and by installing weather monitoring stations across the network. These stations provide real time information and warnings on temperature, rainfall and the height of rising water around fixed infrastructure. This information assists Queensland Rail with the delivery of asset maintenance and repair resources and aids Queensland Rail, and the above rail operators, in amending operations to avoid potential flood affected areas.

6.3.5 North Coast Line

The North Coast Line is a critical north-south route that connects east-west rail lines (including the Mount Isa Line) to regional ports. The line supports the movement of a broad range of commodities throughout Queensland including general freight, livestock, grain, sugar, produce, minerals and coal. The line is the primary

43. This section is substantially sourced from Aurizon (2013)

44. See http://www.queenslandrail.com.au/NetworkServices/Documents/Central%20West%20System%20Information%20Pack%20-%20Issue%202%20-%20April%202008.pdf> Accessed 15 June 2014

intermodal freight route connecting Brisbane and central and north Queensland. The North Coast Line also carries long distance passenger traffic.

A number of issues confront the line, which impact reliability and performance of freight services and consequently the line's ability to support future growth. These factors include:

- Timber bridges that are nearing the end of their economic life, resulting in higher maintenance costs and speed restrictions
- Low speed alignment including sharp curves and steep grades which impact on train performance
- Flooding to various degrees
- Short crossing loops when compared with crossing loop lengths on the major interstate rail freight routes which limits train length and impacts on system productivity (Queensland Rail 2014).[45]

While not solely confined to the North Coast Line, planning efficient intermodal transfers, through appropriately sited and equipped intermodal terminals in locations including Gladstone, Mackay, Rockhampton, Townsville and Cairns is also critical to the future development of efficient rail networks in Queensland.

6.3.6 Pilbara iron railways

The Pilbara iron ore railways, owned and operated by BHP Billiton, Fortescue Metals Group and Rio Tinto, have Australia's highest axle loads, train lengths, number of trains and tonnages moved.

The Pilbara railways largely extend to mines in the south and east Pilbara. The rail lines are privately owned with limited opportunity for third party access. This was a major driver for Fortescue Metals Group to develop its own railway to its Christmas Creek and Firetail Mine sites. The Rio Tinto and BHP Billiton railways overlap, where the producers have extended their mining activity as part of the ongoing growth plan.

All current rail owners are expanding their network – either physically or via operational and capacity improvements. Some of these capacity improvements are being driven by increased automation of mining operations through driverless trucks and trains, remotely operated drilling and blasting, remotely operated crushers and remote train loading.[46]

Rio Tinto's 'Mine of the Future' vision, to deliver technology driven safety and operational efficiency, is becoming a reality with autonomous trucks already operating at mine sites and the impending implementation of their AutoHaul™ automation project. This project aims to have the world's first fully autonomous, heavy haulage, long distance railway network.

BHP Billiton is similarly assessing the benefits of expanding the use of autonomous haul trucks at its Pilbara operations. Fortescue Metals Group has signed a contract with Caterpillar to provide autonomous trucks for its Solomon operation. The success of these autonomous trucks will have a bearing on the overall capabilities of the iron ore freight network and could have a significant impact on the demand for rail capacity. The potential success of this truck automation, coupled with the potential success of Rio Tinto's train automation, could lead to driverless train technology being adopted by all the major rail operators in the Pilbara.

Rio Tinto's Pilbara operations consist of 15 iron ore mines, three port terminals and a 1,500 km rail network. Rio Tinto has an above rail fleet comprising approximately 173 locomotives and 10,500 ore car[47] – these trains travel around 6.2 million kilometres each year. The mines, rail lines and ports are all tightly integrated, so that any expansions to capacity must involve all three elements, as the element with the lowest capacity will determine the maximum capacity of the overall system. Rio Tinto has completed phase one of its port and rail expansions program, giving its Pilbara operations an overall capacity of 290 million tonnes per year. Phase two of the joint port and rail expansion will raise capacity towards 360 million tonnes per year in the first half of 2015.[48]

Owing to the difficulty in securing third party access, many of the junior miners have entered either into offtake agreements at the mine, or into joint ventures with the larger infrastructure owning producers. However, Atlas Iron has made use of road transport to move product from its mines.

45. Queensland Rail paper provided to the audit

46. Engineers Australia (2010b)

47. Rio Tinto's Innovation news, Smart technology helps to develop world-leading rail network, http://m2m.riotinto.com/issue/3/article/innovation-news (accessed 12 May 2014)

48. Rio Tinto in Australia (brochure), http://www.riotinto.com/documents/Rio_Tinto_in_Australia_brochure.pdf, (accessed 12 May 2014)

Figure 19: Bulk freight railway development progression

This has limited Atlas Iron's ability to expand, while miners such as Brockman Resources, due to the location of its mines, have not been able to produce. The key issue is the inability of the junior miners to justify a rail solution in their own right. This has led to recent feasibility studies into construction of another railway for Atlas Iron and Brockman Resources with rail infrastructure operator Aurizon. Without a new third party access iron ore railway, these producers are unlikely to expand, despite the fact that Brockman and Atlas have a combined 50 million tonnes of annual capacity reserved at the future South West Creek development at Port Hedland.

In addition to the existing rail infrastructure that connects to export gateways, additional rail infrastructure from the West Pilbara is required for a number of potential mines to be developed. These mines underpinned the Anketell Point development. Due to the cost of the Anketell Point development, a combined port and rail infrastructure project did not proceed. This may be overcome with a rail development. However, the ability to export is dependent on the ability to secure terminal capacity, or land allocation to develop a new terminal, at one of the existing port facilities.

6.4 Drivers of additional rail capacity

Freight line capacity supporting bulk mineral exports is usually increased to synchronise with mine and port developments or capacity increases and is not undertaken independently. The decision to undertake major step changes to the capacity of freight railway is governed by increases in port capacity, expansion of current natural resource projects and new natural resource projects coming online. The level of passing loops and track duplication is dependent on demand in the systems. In general, the first step is to add more passing loops to a rail line to increase capacity, however at some point this becomes inefficient and there is a need to invest significant capital to convert all the passing loops into duplicated track.

The progression for development of a bulk freight railway is shown in Figure 19.

An important reason for this sequencing is that rail infrastructure can be put in place quicker than port infrastructure. The lead time to build a port is around three years, with five or more years required for regulatory approvals, while the approximate lead time to connect rail infrastructure to a port is often two years. For example, the Wiggins Island Coal Terminal (at the Port of Gladstone) is still under construction, whilst the supporting rail infrastructure is complete and ready for operation. It should be noted that in some cases it may be more economical to truck resources to a nearby existing rail line as opposed to building new rail; in these circumstances much less rail infrastructure development would be required.

Maximum track capacity, for a rail line under demand pressure, is determined by rail sections that are fully utilised, or are at utilisation levels of typically 70 to 75 per cent or more. This level takes account of capacity that is consumed by maintenance activity and fluctuations in daily demand over the course of a year.

Alternatively, capacity can be increased with the express objective of improving service and attracting demand that is deterred by the existing service level. This is a policy driver, rather than a strictly demand-related driver. Investment aimed at shifting freight from road to rail, as with Commonwealth funded upgrading of the Defined Interstate Rail Network over the past 15 years, is of this type. Such an objective would be required to drive investment in the North Coast Line, i.e. to relieve freight pressure on the Bruce Highway, possibly allied to a goal of supporting population growth in northern Queensland through improved passenger transport options.

Rail infrastructure managers also actively pursue rail developments to continuously and incrementally improve the capacity, reliability, performance and safety of rail such that the existing infrastructure is fully exploited to its maximum efficiency.

The underlying economics associated with the provision of rail infrastructure are such that, in many cases, a single well integrated rail network can service demand more efficiently and at a lower cost than two or more separate rail networks. This is the principle behind the National Access Regime, under which third party access to nationally significant infrastructure that cannot be economically duplicated can be sought, pursuant to Part III of the *Competition and Consumer Act 2010*.[49] It is not clear, however, to what extent the regime has served to limit actual rail infrastructure supply requirements. The importance of rail infrastructure as part of a mining company's integrated supply chain and the information asymmetry between regulators considering contested applications for access (and also reviewing courts or tribunals) on the one hand and the company on the other are two major reasons that applications for third party access to date have been largely unsuccessful. Applications also tend to involve extended legal processes, with an associated cost and uncertainty. This situation is especially problematic for junior miners, whose capacity requirements do not support construction of a new railway.[50]

6.5 Future rail demand

Rail bulk freight increased nationally by 5.5 per cent a year over the 20 years to FY10.[51] Coal carried on the Central Queensland Coal Network has grown at around four per cent a year over the last 20 years and at around three per cent a year over the last 10 years.[52]

No information is available from infrastructure managers on future demand growth on the networks. However, wherever networks provide good quality service to customers and are not at risk of losing traffic to alternative modes, growth should be consistent with growth in the source markets. Substantial growth is likely in connection with new and expansion projects, particularly in the Bowen and Galilee basins in Queensland and the Pilbara in Western Australia.

6.6 Rail infrastructure gaps

6.6.1 Improving north-south rail linkages

6.6.1.1 Queensland

Rail is a highly efficient freight transport mode over distances of 1,000 kilometres or more. Notwithstanding short allowable train lengths, slow speeds and poor reliability, the North Coast Line anecdotally carries the majority of freight moving from southern Australia and Brisbane to Townsville and Cairns.

In the longer term, there is a risk that, as the service level of the Bruce Highway improves with progressive upgrading, freight could shift from rail to road, nullifying some of the benefits of the improved road service. Conversely, if the North Coast Line is improved in tandem with the Bruce Highway, rail's natural cost advantage, flowing from its economies of scale relative to a fleet of separate road vehicles, the Bruce Highway freight task might fall, benefitting overall road user amenity. Upgrading of the North Coast Line would also improve northern Queensland passenger transport options, improving the accessibility of the major centres of Mackay, Townsville and Cairns for the populations of their surrounding regions.

6.6.1.2 Northern Territory

The Adelaide-Darwin Railway is a modern railway, providing an efficient rail freight and passenger (tourism) service in Northern Australia's central corridor. Future developments in the Roper mineral province may result in a growth in iron ore and mineral sand shipments along this line. In addition, construction of the Ichthys LNG project and the Darwin Marine Supply base to service the oil/gas sector is expected to positively impact domestic freight volumes in the short term.

There are continual ongoing challenges in firstly increasing capacity through expanding the number of passing loops and secondly, improving the all-weather resilience of the line, given exposure to extreme heat and flooding events (and the impact of the two in combination). Investment in additional passing loops may be necessary to manage train paths, in addition to the already planned extra track through Berrimah freight yard, to facilitate any increase in bulk mineral exports through the Port of Darwin. However this will be dependent on project development.[53] At the port itself, a rail loop or other rail receival solution will be required in the longer term to accommodate mining throughput growth.

Additionally, the Tarcoola to Alice Springs Section (partly south of the Northern Territory-South Australia border) comprises old, substandard track and a light rail section which experienced a derailment in July 2014 and requires upgrading.

49. Productivity Commission (2013)

50. In 2014 Brockman Resources sought access to Fortescue Metals Group Pilbara railway infrastructure. Following granting of access by the Western Australian Supreme Court, Fortescue Metals Group announced it would appeal the decision. See http://www.abc.net.au/news/2014-09-27/brockman-wins-legal-bid-to-access-fmg-rail-infrastructure/5773538.

51. Bureau of Infrastructure, Transport and Regional Economics (2013)

52. Aurizon (2013)

53. Australasia Railway Corporation (2013)

6.6.2 Addressing future resource development

6.6.2.1 Central Queensland Coal Network and Galilee/Bowen basins

Duplication of the Blackwater System is currently being completed, with a program to duplicate the seven remaining sections and to build a passing loop at the Wiggins Island Coal Terminal expected to be finished by 2015.

All other capacity expansion is dependent on future demand resulting from mine expansion and new mine development. Expansion of the Central Queensland Coal Network will be part of a broader infrastructure program, potentially including new rail lines and terminals into the Galilee Basin connecting to Abbot Point. This is subject to mining company decision and action.

The Newlands System requires minor additional work to manage demand of 50 million tonnes per year. Expansions to 110 million tonnes per year and then 210 million tonnes per year are in planning, in line with port expansion and market developments. The Newlands System is constrained by a capacity limitation at 50 million tonnes per year at Collinsville, due to community amenity and the steep uphill and tight curves at Briaba bank, which limit speeds and trunk capacity.[54]

The Goonyella System (140 million tonnes per year committed capacity) is planning for longer term expansion to 220 million tonnes premised on either a new port or expansion of existing terminals (Dalrymple Bay, Hay Point and a future terminal at Dudgeon Point). The Goonyella System is constrained by tight curves at Connors Range, the Praguelands – Jilalan section and the Bolingbroke – Balook section, which limits speed and trunk capacity.[55]

The Blackwater System (97 million tonnes per year) is planning for expansion to 160 million tonnes, for export through the Port of Gladstone. The Blackwater System is constrained by steep uphill grades in two sections (Westwood-Windah and Tunnel-Edungalba), which limit speeds and trunk capacity. There are also capacity limitations at the Callemondah Yard, where train services are provisioned.

The infrastructure requirements to support future coal mine developments in the Bowen Basin will likely be met through enhancement of existing supply chain networks. However, large scale coal mine developments in the Galilee Basin may strain capacity on the Central Queensland Coal Network and may require new infrastructure investment in the supply chain network.

In addition to new infrastructure investment across this network there is a need to ensure that existing infrastructure is performing in an efficient manner. Coal supply chains are made up of a number of participants with disparate business objectives. Each element of the supply chain naturally seeks to optimise its own performance rather than work on improving the performance of the supply chain as a whole. The Central Queensland Growth Analysis Report cites a lack of alignment between participants in relation to optimising supply chain performance and information gaps as the two main underlying causes of failure in relation to coal supply chains. There are significant opportunities available to improve the capabilities of the networks if these issues are adequately addressed.

6.6.2.2 Mount Isa Line and connection to Tennant Creek

In the longer term, it is possible that coal haulage from potential mines in the Northern Galilee Basin could add a coal supply chain to the existing base metals supply chain. Potential nearer term works on the line (subject to commerciality) include a new passing loop at Kimburra, two holding roads at Hughenden, and re-arrangement of port infrastructure at Townsville to improve access to unloading facilities and traffic management.[56]

Following, or in conjunction with, line upgrading, a connection (600 to 800 kilometres) to the standard gauge Adelaide-Darwin Line (at Tennant Creek) could be considered. While noting gauge interface requirements (terminal facilities and rolling stock), this could provide miners and agriculturists in both north west Queensland and the eastern Northern Territory with access to a potential alternative port, i.e. Darwin and Townsville respectively. Given both market and gauge barriers, this is considered less likely within the audit timeframe of FY31 and is not included in the list of critical infrastructure requirements (Section 6.7).[57B]

Potential nearer term works on the line (subject to commerciality) include a new passing loop at Kimburra, two holding roads at Hughenden, and re-arrangement of port infrastructure at Townsville to improve access to unloading facilities and traffic management.[58]

54. Aurizon (2013)

55. Aurizon (2013)

56. Queensland Rail (2013)

57. A Tennant Creek to Mount Isa rail link is included as a development proposal in Joint Select Committee on Northern Australia (2014) and in a submission by the Northern Territory Government (Northern Territory Government 2014b)

58. Queensland Rail (2013)

6.6.2.3 Katherine to Kununurra connection

Expansion of the Ord irrigation scheme and growing resource activity across the top of Northern Australia may require a rail connection, from Kununurra to Katherine, to fully exploit the potential of the region.

This link, to the Adelaide-Darwin railway, would allow Darwin port(s) to serve as an export gateway for agricultural produce from the Ord project and for potential resource activity in the surrounding region. The feasibility of this line will be dependent on agricultural produce hitting a critical mass and value. This line also has the potential to provide greater accessibility to tourists and may facilitate the movement of defence personnel and equipment.

The full supply chain cost of a new rail line could be compared against, for example, development of Wyndham Port to accommodate export growth. Given a range of uncertainties at the present time, development of a rail connection is considered less likely within the audit time frame.

6.7 Rail critical infrastructure requirements

Table 19 sets out critical infrastructure requirements in relation to the infrastructure gaps, together with possible timings. The list reflects the audit's assessment, taking account of public rail planning information and consultation information. Looking beyond the audit timeframe to FY31, rail connections to the Adelaide-Darwin Railway from Mount Isa to Tennant Creek and from Kununurra to Katherine are for future Northern Territory Government feasibility assessment.

Table 19: Rail critical infrastructure requirements

Infrastructure gap	Railway or network	Key infrastructure requirement(s)
Rail expansion or upgrading- resources	Central Queensland Coal Network	Blackwater system – expansion to enable longer trains
		Newlands system – minor works to achieve capacity of 50 million tonnes per year
	Galilee Basin links	Rail links to the Central Queensland Coal Network, with expansion of this network and/or directly to port
	Central West System	Track and signalling, crossing/passing loop upgrades to accommodate Galilee Basin demand
	Mount Isa Line	Passing loop at Kimburra, holding roads at Hughenden, improved unloading facilities at the Port of Townsville
		Line upgrading to improve speeds, train lengths, axle loadings and weather resilience and urban amenity in Townsville (new rail access corridor)
	Pilbara rail systems	Expansion of BHP Billiton, Fortescue Metals Group and Rio Tinto rail systems, development of Roy Hill-Hancock Prospecting railway, possible development of a fifth railway and/or suitable railway access arrangements for junior miners
	West Pilbara (new railway(s))	New rail system(s) connecting to Anketell Port
Rail upgrading – north-south access, mixed traffic	North Coast Line	Line upgrading to improve speeds, train lengths, axle loadings and weather resilience, including overcoming the single track capacity constraint between Beerburrum and Landsborough/Nambour in the Southeast Queensland region
	Adelaide-Darwin Railway	Increased line capacity through additional passing loops and reliability improvement through greater flood-proofing
		Rail loop required at East Arm Port
		A siding needs to be established at Mataranka to facilitate loading of iron ore

Transport – road

7.1 Introduction

The road network in Northern Australia is essential for connecting people and freight with places of residence and economic activity. Servicing a mainly rural population, roads are more often than not a community's lifeline to other residential areas, places of employment or economic activity.

The Northern Australia road network is extensive and characterised by long isolated roads and low daily traffic volumes. The level of service the road network is able to provide is impacted by a number of factors:

- The wet season, December through to April, when the level of service provided by the network is reduced due to road closures and/or significant restrictions
- Short and long term resource projects which intensively use roads during the construction and operational stages of a mine life to transport mining inputs and, in the absence of rail infrastructure, mining outputs
- The configuration of the road (narrow, unsealed, and in some settings, for example where there are timber bridges, weight restricted) which may limit heavy vehicle accessibility and constrain freight network efficiencies.

Urban roads within Northern Australia account for a much smaller proportion of total network traffic than non-urban roads, but provide a vital link between economic generators and export markets e.g. roads connecting highways to ports and airports. The efficient movement of freight and people between areas of economic importance would not be possible without a reliable and well connected urban road network.

7.2 Roads in scope and existing capacity

Roads in scope for the audit have been identified in line with the established critical infrastructure criteria (see Section 2.2). The scope includes all Northern Australia roads that form part of the National Land Transport Network. Additionally, roads of regional and urban importance, which were identified through jurisdiction consultation, are included.

7.2.1 Queensland roads

A total of 32 roads, in Northern Queensland, have been captured within the scope of this audit (see Map 9). These roads provide connections and access to areas of economic activity and links to domestic and international markets and population centres.

Increasing road demand by both light vehicles (on urban roads) and heavy vehicles (on freight roads) has put pressure on government road funding budgets. The Queensland freight task is expected to increase by nearly 90 per cent, from 871 million tonnes in FY11 to over 1,643 million tonnes by FY26. To meet this challenge Queensland's Transport and Main Roads established a 10 year strategy[59] with a broad range of actions which include:

59. Department of Transport and Main Roads (2013)

- Developing investment strategies for key freight corridors
- Improving freight network resistance to floods and natural disasters
- Better collection and analysis of freight data and information
- Continuing to reduce red tape for heavy freight vehicle permits.

The Bruce Highway is Queensland's major north-south corridor connecting coastal population centres from Brisbane to Cairns and supporting 58 per cent of the state population. Traffic volumes along both urban and rural sections of this route have increased rapidly as a result of resource activity and population growth. However, a general lack of capital investment over the years means the road now faces significant safety, flooding and capacity challenges. For example the Bruce Highway, by distance, makes up 7.5 per cent on the national network but accounts for more than 17 per cent of fatalities across the entire national network. A 10 year action plan[60] and program of work to address these challenges is ongoing.

The Flinders and Barkly Highways connect northern Queensland, from the Port of Townsville to the Northern Territory border, to national and international markets and link communities to employment, commerce, essential services and the regional centre of Townsville.

The investment priorities along this corridor are not dissimilar to those of the Bruce Highway and focus on safety, flood immunity and capacity upgrades. Additional investment aims to improve heavy vehicle access and to strengthen vulnerable pavements.[61]

7.2.1.1 Queensland road characteristics

Road closures and availability

Table B.5, in the Appendix, presents an overview of key road characteristics, based on data provided by the Queensland Department of Transport and Main Roads. Data for individual roads are consolidated from count stations along various sections of the road. For roads where several geographically dispersed data collection points exist there may be significant variation between different locations.

Road closure information has been recorded as part of this dataset and, while having limitations,[62] provides an indicator of the road's reliability. Actual road closures can occur for a range of reasons:

- Severe weather (flooding, fire) may limit access to road sections

60. Queensland Government (2012)

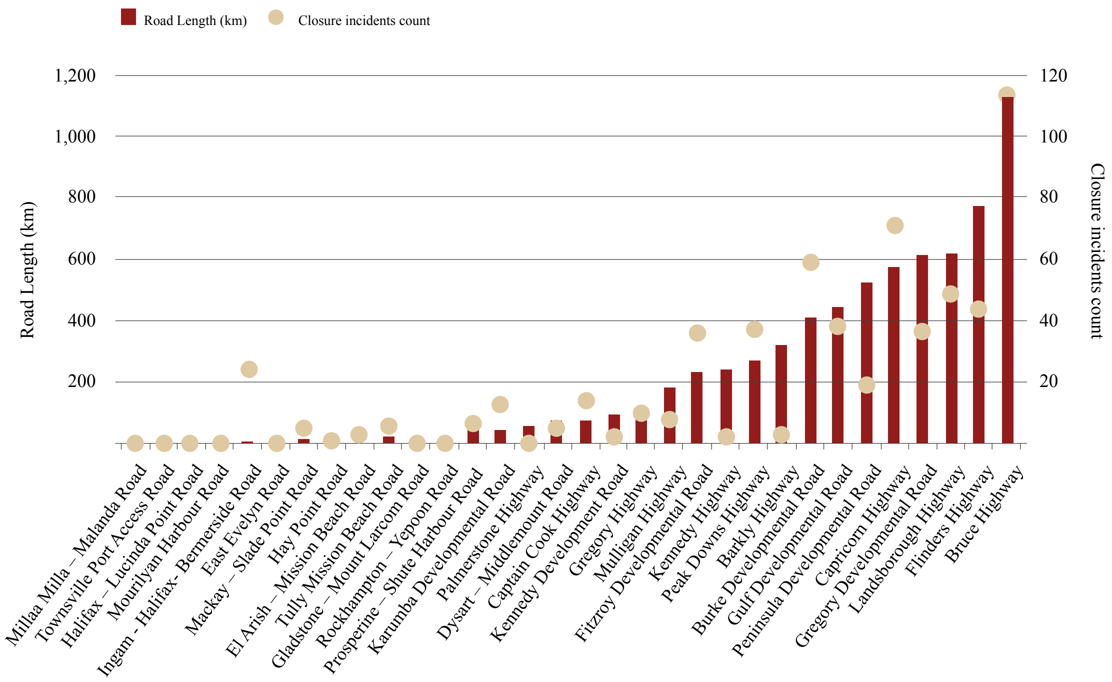
61. Draft Flinders and Barkly Highways Investment Strategy, Department of Transport and Main Roads, Queensland Government, February 2014

62. Road section closure data only records a closure when it is reported. The data is not an exhaustive list of all actual closures across a road network. For example, where a road is not accessible by maintenance inspectors, because access roads to that road are impassable, the road is not necessarily listed as being closed. Similarly, if sequential creek crossings on a particular road are flooded, this is often recorded only as one closure and where the duration of a road closure is short (that is, a number of hours only), then it is possible the closure is not recorded at all.

- Maintenance to ensure the road is of the required standard for reliable travel
- Vehicle accidents and other obstruction causing incidents.

Figure 20 presents the number of road closures for Queensland roads for the five year period between 2010 and 2014.

Figure 20: Queensland road length and section closure incidents, 2010 to 2014

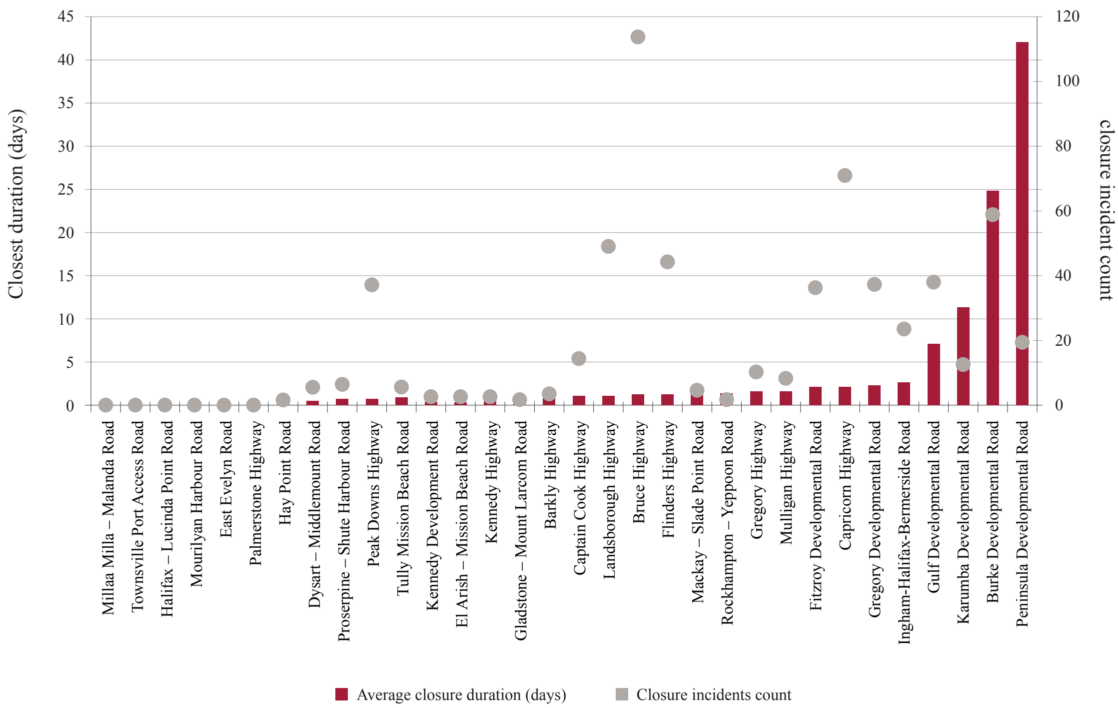


Source: Source: Department of Transport and Main Roads (Queensland) data and GHD analysis

As expected, there is some correlation between road length and the number of closures experienced along the road. The Bruce Highway experienced the largest number of road section closures (114), followed by the Capricorn Highway (71). The vast majority of roads under 200 kilometres in length experienced fewer than 20 closures over the period, with the notable exception of the Ingham–Halifax–Bermerside Road. This road is an important link for the sugar and agricultural industries in that it is a B-double approved route and facilitates the movement of produce through Halifax and on towards Lucinda.

Roads further to the north of the state generally experience a greater number of road closures than those in the south. Many of the developmental roads are problematic, in particular the Peninsula, Karumba and Burke developmental roads which account for the highest average closure durations of all Queensland roads in scope (Figure 21). This provides some indication of the limited reliability and constrained accessibility of some sections of these roads during the wet season.

Figure 21: Queensland road section closure incidents and average duration, 2010 to 2014



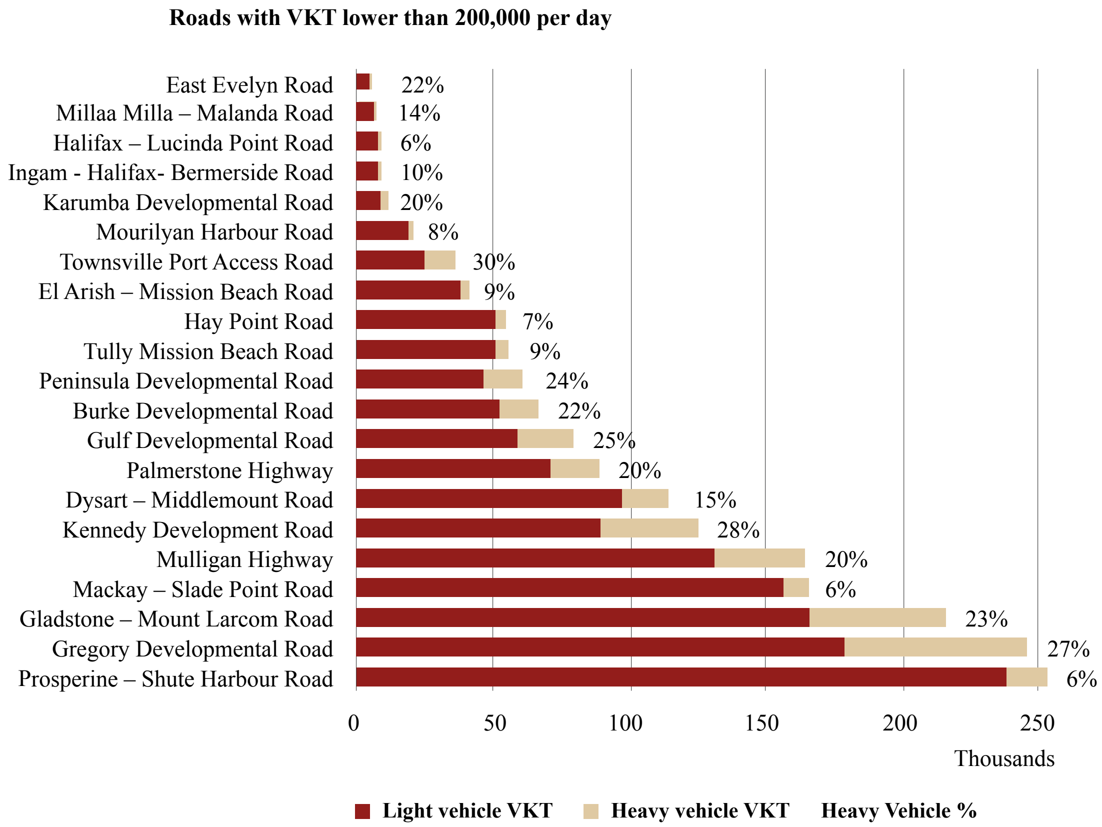
Source: Department of Transport and Main Roads (Queensland) data and GHD analysis

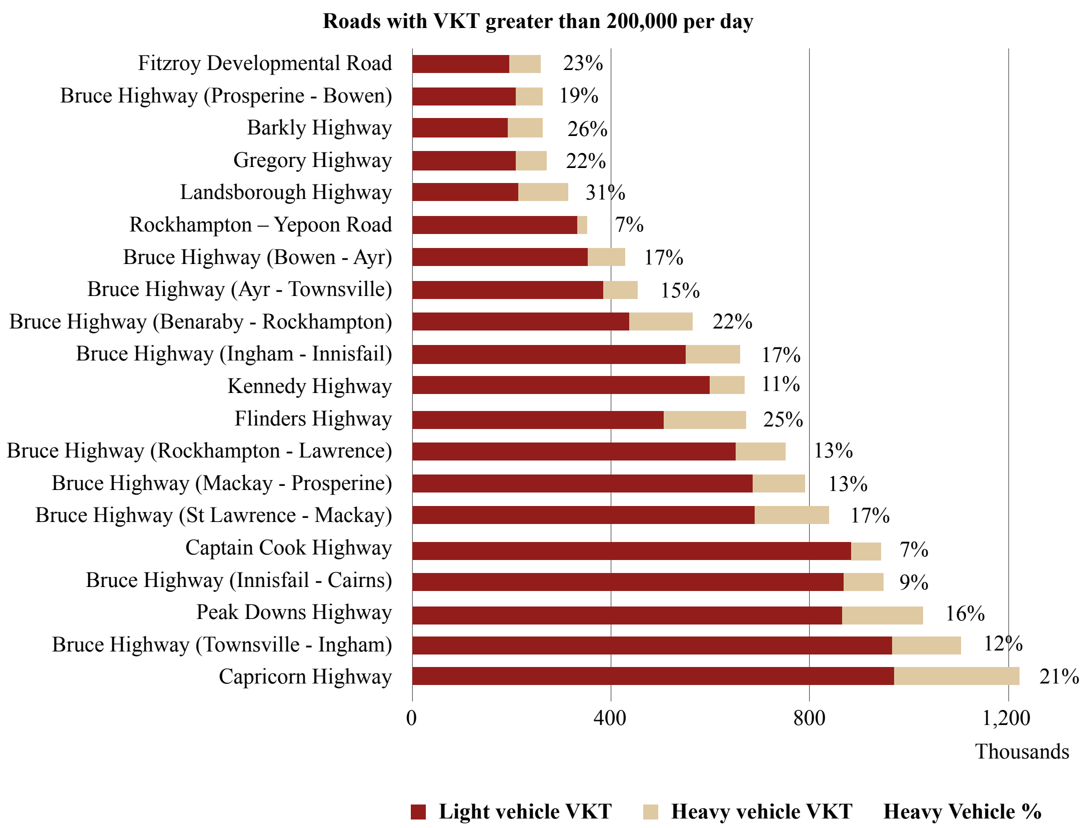
Road traffic and vehicle mix

Figure 22 provides an overview of traffic levels and vehicle mix along the roads in scope. Average Annual Daily Traffic (AADT) recorded along sections of a road was used to calculate a representative VKT (Vehicle Kilometres Travelled) for the whole road. The figure has two panes, one for longer and/or higher volume roads, the other for shorter and/or lower volume roads.

Urban roads generally show evidence of lower heavy vehicle traffic shares (10 per cent or less) than non-urban roads (20 per cent or more). In both settings, effective management of the interaction between vehicle types is important for traffic flow, freight productivity and safety. It is notable that about a third of the total VKT along both the Townsville Port Access Road and the Landsborough Highway is made up of heavy vehicles. In the case of the Townsville Port Access Road, this is due to freight being moved to and from the port while the Landsborough Highway is a key route for moving freight between southern Australia, Brisbane and Darwin.

Figure 22: Queensland vehicle kilometres travelled (VKT) and heavy vehicle use 2012





Vehicle kilometres travelled is calculated based on Road Network Level of Service and Traffic Progression ARMIS extract 30 March 2014.

Source: Department of Transport and Main Roads (Queensland) data and GHD analysis

7.2.2 Northern Territory roads

A total of 17 roads are considered in scope for the Northern Territory and represent a mix of both urban and rural roads (see Map 10). Some of the longer roads, such as the Stuart Highway, have a mixture of both urban and rural sections.

The importance of reliable road links across the Northern Territory cannot be overstated. In many cases, road is the only viable mode to move freight into the jurisdiction and to the destination customer. Additionally, the rural arterial road network is critical for community access (e.g. the Central Arnhem Highway connects Nhulunbuy and other the communities in East Arnhem Land). Severe weather, such as flooding, can force road closures and may leave some of these communities with restricted mobility and limited freight access.

Furthermore, many of the highways located within central Australia (e.g. the Buntine and Plenty highways), provide access and egress for the cattle industry, linking properties to domestic and international markets. The Buntine Highway, for example, facilitates the export of cattle valued at approximately $50 million. At times, the poor condition of the roads can lead to livestock damage, with animal welfare and financial implications.

Tanami Road, located west of the Stuart Highway, provides a link to communities and resource projects as well as access to the Kimberley tourism region. The length of the road and low traffic volumes have led to the difficulties in ensuring the road is maintained to a suitable standard. The road provides the link between Central Australia, Alice Springs, and the Pilbara region in Western Australia, enabling Pilbara products to access the south and east of Australia.

Other key road links include:

- Lasseter Highway and Tjukaruru Road, part of Outback Way when connecting Uluru Kata Tjuta National Park to Western Australia border
- Victoria Highway, adjoining the Katherine and Kununurra regions
- Barkly Highway, running east which connects Mount Isa to the Stuart Highway
- Roper Highway, linking the East Arnhem region to the Stuart Highway
- Carpentaria Highway, linking the growth town of Borroloola to the Stuart Highway.[63]

7.2.2.1 Northern Territory road characteristics

The longest Northern Territory road considered in this audit is the Stuart Highway (2,717 kilometres), which connects Adelaide (in South Australia) to Darwin (in Northern Territory). More than 1,800 kilometres of this interstate highway (Figure 23) fall within the Northern Territory.

Many non-urban roads in scope are typically arterial access roads connecting resource developments and smaller communities/population centres.

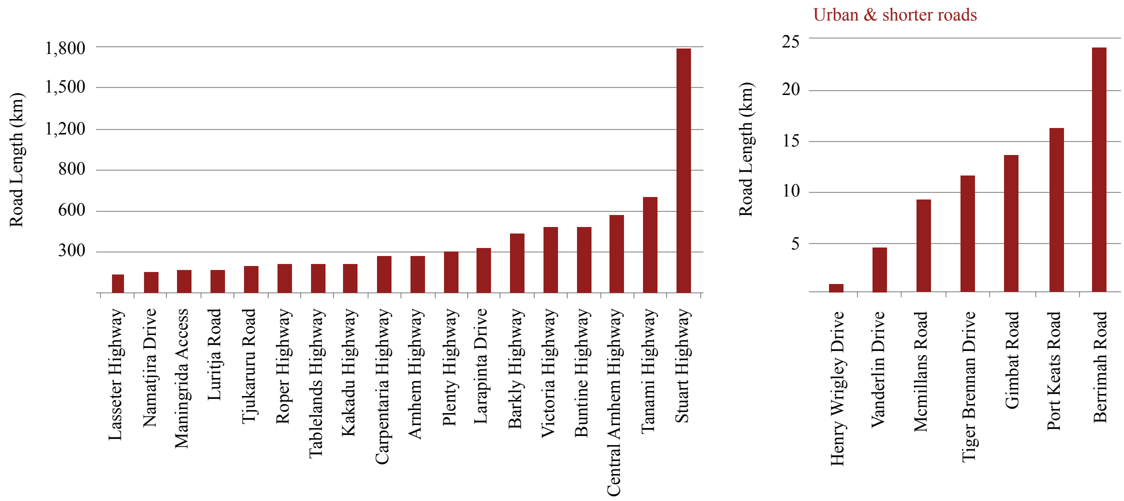
Average Annual Daily Traffic (AADT) for Northern Territory roads is presented in Table B.6 of the Appendix. This is calculated by averaging data from primary count stations for each road during the 2012 calendar year. These count stations are permanent and provide better historical data sets than ‘coverage’ stations which are only temporary and may not record traffic volumes every year. However, a limitation of this method is that the reported AADT only represents traffic volumes on the particular stretch of road where the count station is located, with some risk of under or over reporting. Actual count station locations can be found in the Territory Asset Management Services Annual Traffic Report 2012.

A number of Northern Territory roads are subject to restrictions and/or closures for sometimes significant portions of the year. Closures typically occur when a road is impassable or unsuitable for any vehicle to travel on it. Closures are typically much shorter in duration than restrictions, lasting perhaps only for two to three days.

Restrictions typically place limitations on vehicles accessing the roads. Restrictions normally occur in the form of lower mass/axle limits, or alternatively forbid access for certain vehicle classes. These restrictions typically occur due to safety implications for vehicles or the potential for additional damage to the road. Restrictions can also lead to unintended consequences. For example, transport operators may still be obliged to fulfil their contract because the road has not been officially closed. Restrictions of this kind may require the operator to complete the task using smaller, less efficient vehicles which they may not have in their fleet. Decreased payloads result in an increase in the number of required trips, increasing operational costs and placing pressure on drivers.

63. Northern Territory Government (2008)

Figure 23: Road length – Northern Territory



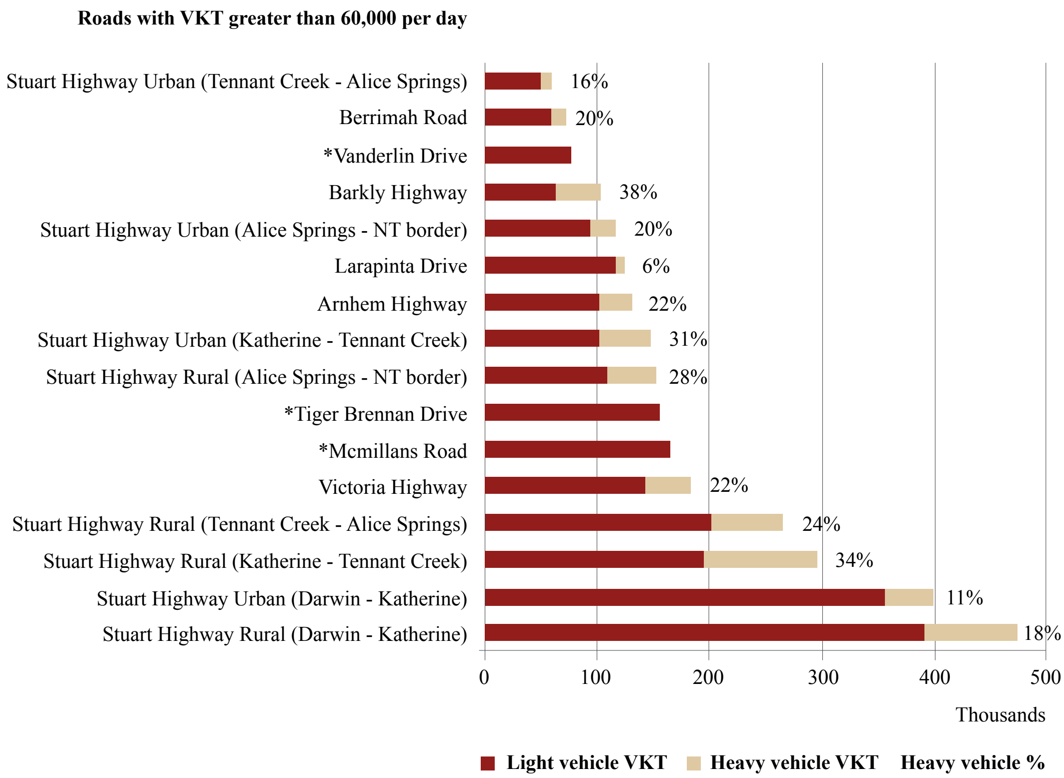
Source: GHD analysis

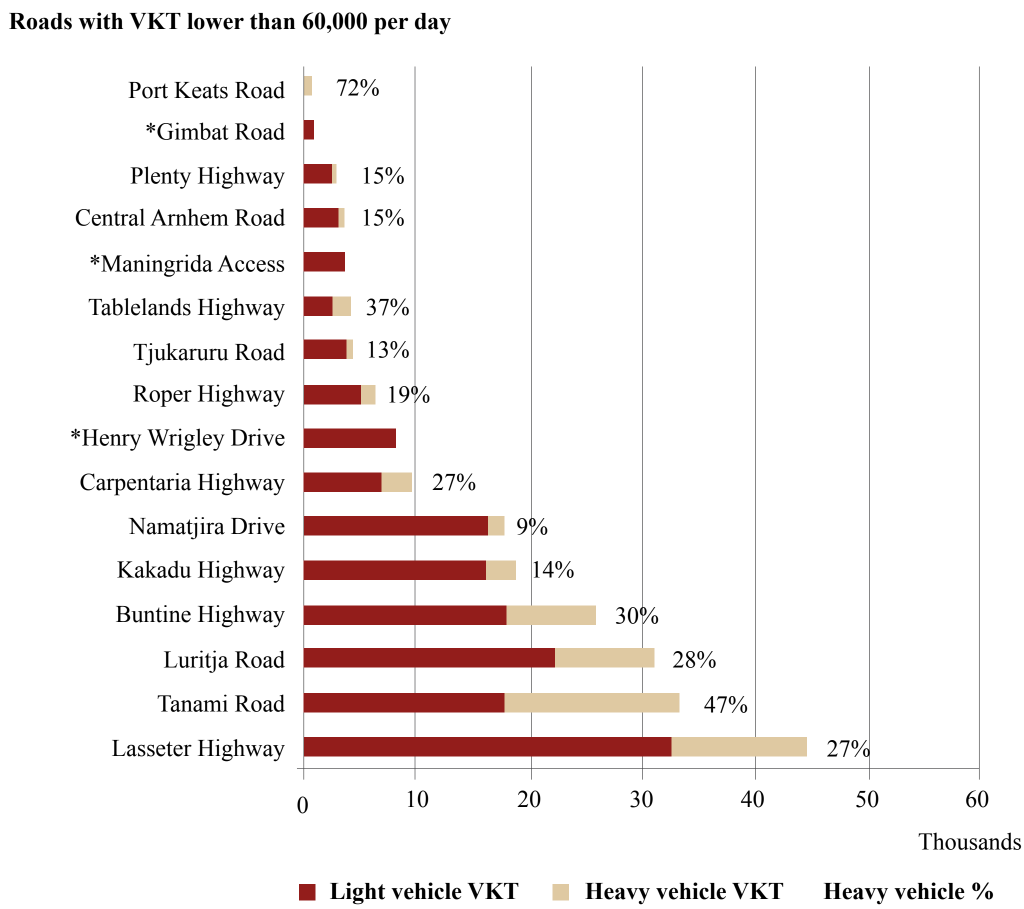
Data for 2012 indicate that, of the counting stations examined, closures occurred on two roads, the Buntine and Plenty highways. The Buntine Highway was closed for four days in March due to the road being classified as impassable. The Plenty Highway was also closed in March for five days due to flooding.

Significant restrictions were in place on the Tablelands Highway during 2012. No vehicles requiring over mass permits were permitted access to the road from January through to December 2012. These restrictions were exacerbated in March 2012 when the road was subject to 'four wheel drive only' restrictions that lasted 16 days and 'proceed with caution restrictions' that lasted 46 days (April to May 2012), due to water on the road. These road conditions relate to a data collection point one kilometre north of the Barkly Highway.

Historical AADT data from 2012 were used to calculate Vehicle Kilometres Travelled (VKT) and heavy vehicle usage (Figure 24). Data outlining heavy vehicle use indicate that roads located to the east of the Stuart Highway experienced the highest heavy vehicle use in 2012. The VKT data show that, with the exception of main road assets such Stuart Highway, Victoria Highway, Arnhem Highway and other suburban and urban arterial roads (e.g. Mcmillans Road, Tiger Brennan Drive, Larapinta Drive), Northern Territory roads present relatively low daily total traffic volumes.

Figure 24: Vehicle kilometres travelled on Northern Territory roads 2012





*No heavy vehicle use data are available for Gimbat Road, Henry Wrigley Drive, Maningrida-Ramingining, Mcmillans Road, Tiger Brennan Drive and Vanderlin Drive.

Source: Territory Asset Management Services (2012) and GHD analysis

7.2.3 Western Australian roads

The 23 roads in scope in Western Australia (see Table B.7) are almost wholly located within non-metropolitan areas. The roads vary significantly in type with some routes being 100 per cent sealed, such as the Great Northern Highway. This road provides the main link between northern and southern Western Australia, while traffic is growing strongly on the North West Coastal Highway, due to the more direct connections it offers to ports and many mining project locations.

A large proportion of the roads are affected by a significant increase in traffic due to economic development. Western Australia accounted for 46 per cent of Australia's merchandise exports in FY11 mostly generated from mining. With more than 500 commercial mineral projects, almost all of which operate outside metropolitan areas,[64] the stress on the regional road network is significant and is likely to increase.

Regional road and freight strategies cite three main issues:

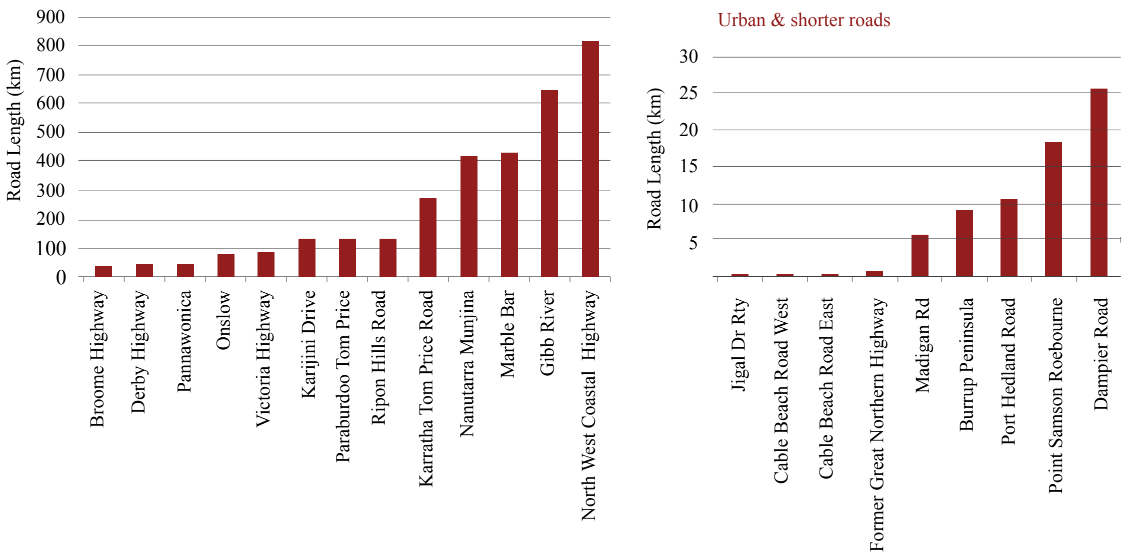
- Flooding during the wet season causing prolonged closures on roads such as the Marble Bar and Nanutarra-Munjina roads
- Increases in traffic due to economic activity intensifying the conflict between light and heavy vehicles
- Inadequate maintenance due to lack of funding and/or resources.[65]

Challenges also vary between regions within the state. Regional road strategies imply that road projects in the Kimberley region are more likely to have flooding issues as the rationale for road upgrades. In contrast, Pilbara region road improvements are driven by economic development – specifically resource projects.

7.2.3.1 Western Australia road characteristics

The longest route in the Western Australian road network is the Great Northern Highway which is 2,452 kilometres in total length (Figure 25) and connects Perth in Western Australia to the Northern Territory. It is a vital link to economic resource regions including the Pilbara and the Kimberley. Besides linking other remote and agricultural areas between southern and northern Western Australia, the Great Northern Highway provides alternative access to Port Hedland and Wyndham (Map 11).

Figure 25: Road length, Western Australia



*Great Northern Highway (2,452 kilometres) is not shown.

Source: Main Roads Western Australia

64. Department of Transport (2012)
65. Regional Road Network Plan – Pilbara Region (2012)

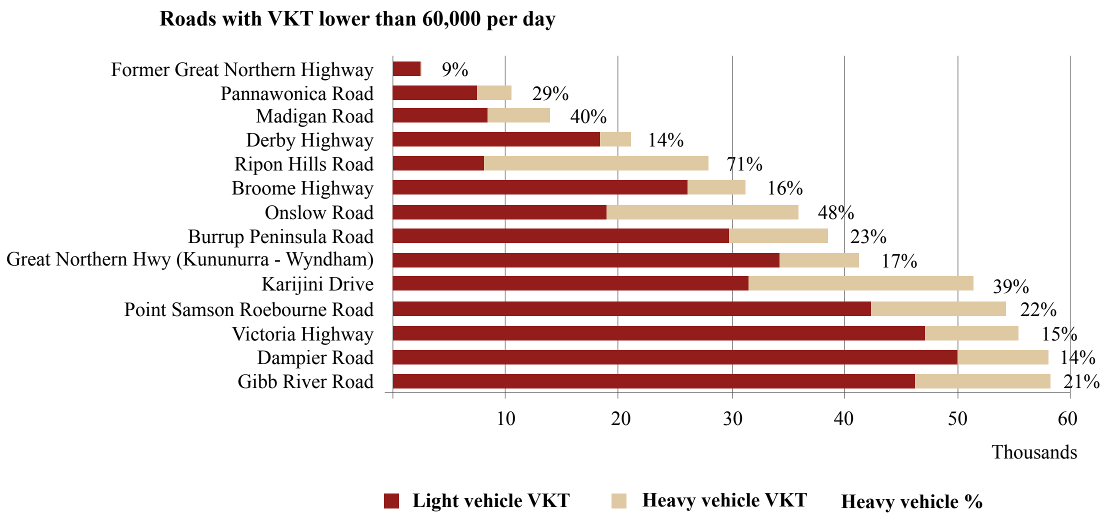
The Derby Gibb River Road remains closed for three to four months a year due to flooding. Over previous years improvements have been made to allow road train access. This provides some productivity benefits to industries located along the road, but does not provide an all-weather route for communities. The Great Northern Highway is the only sealed link between Perth and the north of the state. Any road closures isolate it from the rest of Australia, impacting agricultural and resource industry supply chains.

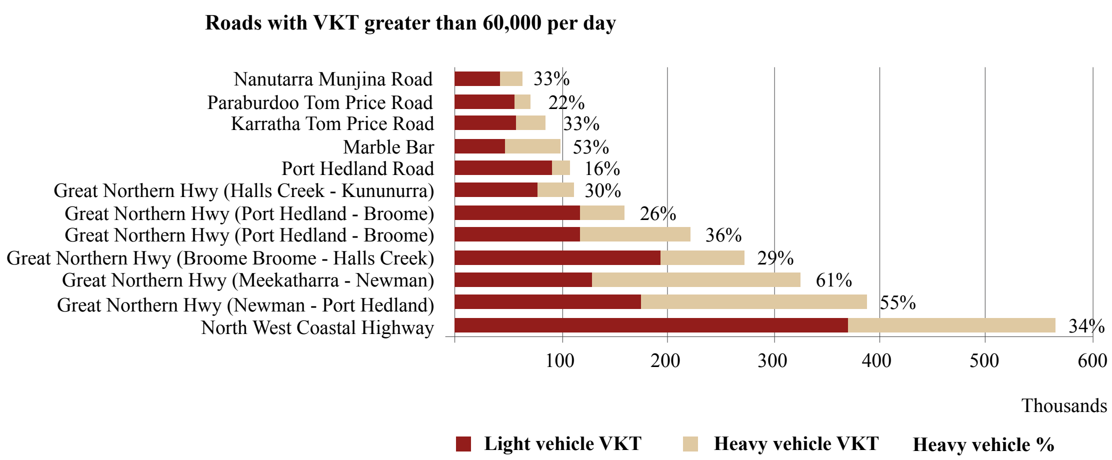
After Ripon Hills Road, Marble Bar Road is the second most heavily used regional road link, particularly by industry and freight. Marble Bar Road is not fully sealed, causing significant issues for the private road owner. Pavement deterioration is more rapid than expected, making it problematic for the road owner to maintain an adequate level of service. The Pilbara region road network plan indicates that seven of the eight high priority projects within the region are located on Marble Bar Road.

Urban roads such as Port Hedland Road are under pressure due to rapid increases in traffic volumes and a growing mix of heavy haulage and light vehicles. Treatments such as road duplication are proposed solutions.

Western Australian roads evidence the highest heavy vehicle traffic shares in Northern Australia. Three roads (Onslow Road, Madigan Road and Karijini Drive) with heavy vehicle shares of around 40 per cent or higher (Figure 26). Further information on Western Australian roads is at Table B.7.

Figure 26: Western Australia vehicle kilometres travelled and heavy vehicle road use 2012





Source: Government of Western Australia, Main Roads Western Australia, IRIS data and GHD analysis

7.3 Drivers of increased road capacity

Additional and/or improved road capacity is driven by a range of factors, including population growth, economic growth, safety and climate considerations.

7.3.1 Population

Population growth in Northern Australia will drive the need for greater connectivity within and between regions. Queensland is expected to experience the highest population growth of the Northern Australia study states between 2011 and 2031 (Figure 27).

Figure 27: Population growth 2011 to 2031

Source: PWC (2014) Population Forecasts

Governments have developed strategic visions that look to increase the regional populations in Northern Australia. The Western Australian Government has developed the Pilbara Cities' Vision which looks to increase total regional population to 140,000 by 2035; a population of 50,000 in Karratha, 50,000 in Port Hedland, 15,000 in Newman and 25,000 across other regional areas. The Queensland Government's 30 year vision for Queensland, The Queensland Plan, anticipates that by 2034 half of Queensland's population will live outside South East Queensland.

Larger populations are likely to result in an increase in light vehicle use within and between urban areas. This will put additional pressure on road infrastructure. Larger populations will also drive a larger freight task, with an associated increase in heavy vehicle road use.

7.3.2 Economic development

Economic development in Northern Australia centres to a significant extent on the resources industry. Prospective investment has an implied impact on the road network. Although a significant proportion of mining output is transported via rail to export markets, required inputs for the construction, operational and decommissioning stages of mines are likely to be transported by road. Increased over-size over-mass vehicle movements are likely, as well as an increase in general traffic bringing supplies and employees to the development.

Agriculture is also a contributor to gross regional product in Northern Australia. The expansion of the industry, or change in the operational structure of the industry, will impact the road network. The introduction of a new agricultural sector (e.g. forestry), is likely to see the relevant road network experience greater wear and tear, or climatic conditions such as drought may require stock to be moved more frequently between grazing lands. Road reliability is of paramount importance to the agricultural industry. The ability to access markets when the price is right and the produce is ready is essential for financial success.

7.3.3 Safety

Consultation has highlighted the drive across multiple government and industry organisations for general infrastructure improvements across the region. However, with the size of the networks, it is difficult to undertake all desired improvements within budgetary constraints.

Single lane highways can be challenging and dangerous for heavy vehicles and road trains. These vehicles may pull over to allow the safe passage of a light vehicle and get bogged, resulting in significant time delays and financial penalties.

This emphasises the link between safety and productivity. Scarce rest bays on remote highways may also be used by tourists, making them unsuitable for heavy vehicle use, thereby putting pressure on drivers' fatigue management.

During consultation it was noted that road deaths and injuries in the Northern Territory are above that in other jurisdictions – over 3.5 times higher than the national average. Over the past decade, 75 per cent of Northern Territory road fatalities occurred outside the greater Darwin area. Out of 12,462 crashes in the Darwin area, 746 involved heavy vehicles, with nine fatalities.

7.3.4 Climate

Climatic conditions can have direct and indirect impacts on the road network. Greater rainfall may lead to increased intensity and frequency of flooding. Data provided by the Northern Territory Department of Transport show that, apart from road works and accidents, flooding and water over roads is the largest cause of road closures and restrictions. These closures and restrictions vary significantly in duration. Higher rainfall levels will see a higher number and longer duration of road closure and restriction events. Adverse conditions on weather-affected roads can also be intensified by the behaviour of drivers.

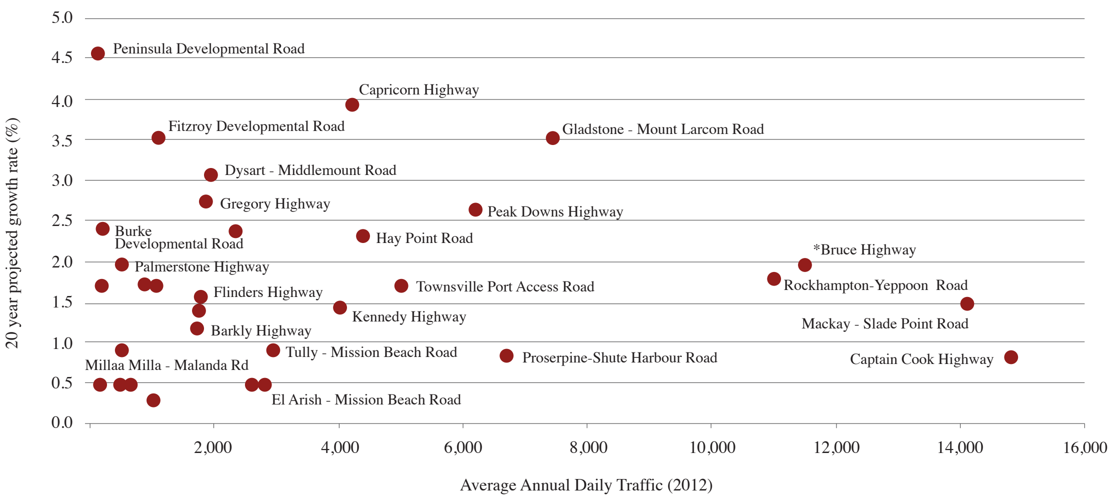
7.4 Future road demand

7.4.1 Queensland road demand

Figure 28 shows projected future demand for the Queensland roads in scope. Queensland Transport and Main Roads provided projected road demand data for 2012, 2022 and 2032, for the roads in scope for this study (see Table B.8).

Roads with the highest projected growth rates are the Peninsula Developmental Road (4.6 per cent), the Capricorn Highway (average of 4 per cent per year over 20 years) and the Fitzroy Developmental Road (3.5 per cent). Development of the Galilee Basin, particularly the central Galilee Basin, is likely to generate significant light and heavy vehicle traffic on a number of road links including the Capricorn Highway, Peak Downs Highway and Gregory Highway and Gregory Development Road.

Figure 28: Queensland roads – projected 20 year traffic growth rates and current traffic volumes



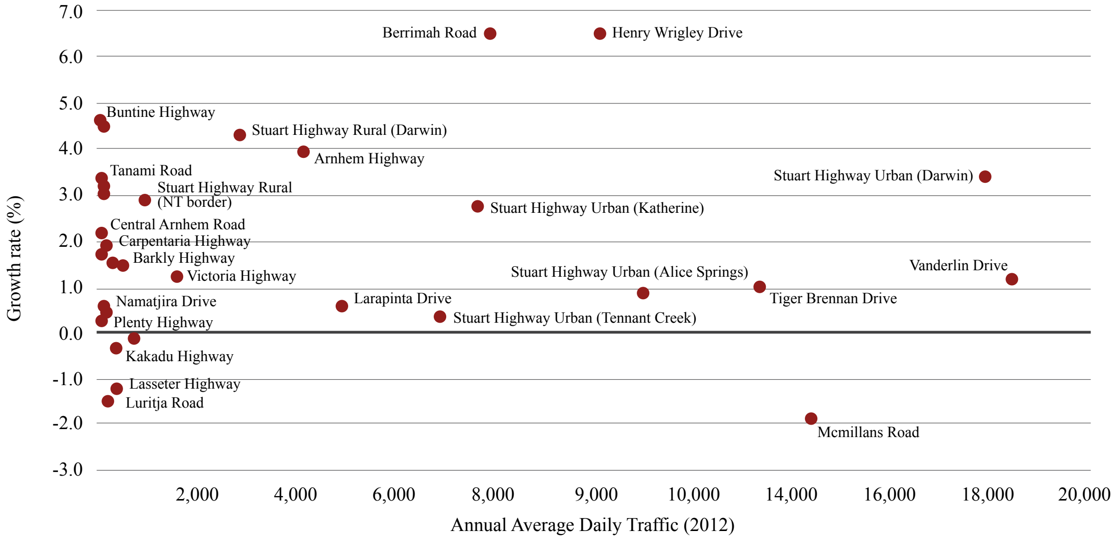
* Bruce Highway highest traffic volumes are around Rockhampton, Mackay, Townsville and Cairns. Lowest volumes are around St Lawrence, Proserpine, Bowen and Ingham.

Source: Department of Transport, Main Roads projections and GHD analysis

7.4.2 Northern Territory road demand

Figure 28 shows historical (eight year) annual average growth traffic volumes and growth rates for roads in scope (see also Table B.6). Urban roads in Darwin, Tiger Brennan Drive (road to port) and Henry Wrigley Drive (road to airport) have the highest traffic volumes and some of the highest historical traffic growth rates. Non-urban road growth rates are greatest on the still low volume Central Arnhem and Roper highways and on the Arnhem Highway.

Figure 29: Northern Territory roads – historical (8 year) traffic growth and volumes



Source: Northern Territory Department of Transport data and GHD analysis

Future Northern Territory traffic growth

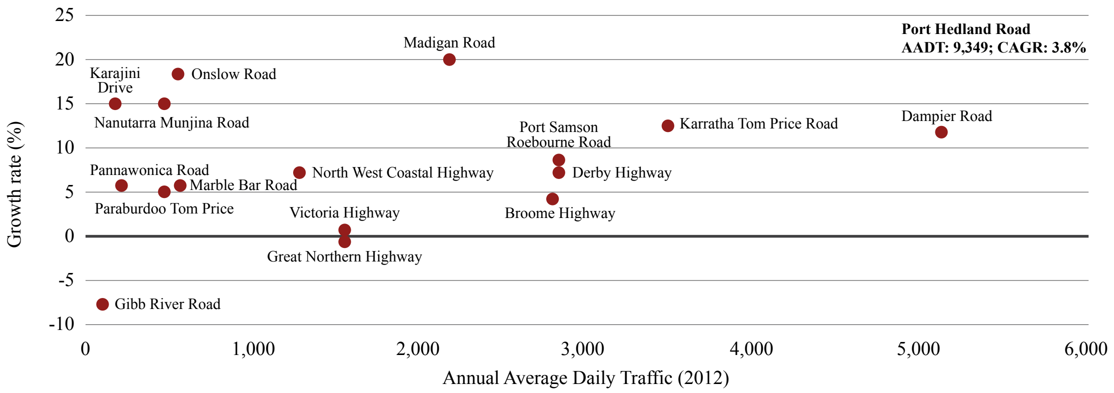
No forecasts are available for Northern Territory roads. With strong construction-linked economic growth expected to continue in Darwin and with mining-related construction activity in the Roper/McArthur River region, recent growth rates may continue for several years before tapering on routes such as the Arnhem Highway, the Central Arnhem Highway and the Roper Highway.

7.4.3 Western Australian road demand

Past Western Australia traffic growth

Figure 30 illustrates annual average traffic growth rates based on data from 2003 to 2012. Port Hedland Road and Dampier Road have the highest traffic volumes rates and considerable traffic growth. Roads experiencing the highest traffic growth rates are the still comparatively low volume Nanutarra Munjina, Onslow and Madigan roads.

Figure 30: Western Australia roads – historical (9 year) traffic growth and volumes



Source: Government of Western Australia, Main Roads Western Australia, IRIS data and GHD analysis

Future Western Australian traffic growth

Traffic forecasts are not available for Western Australian roads. With continued resource project development and with large resource sector production, recent growth rates may continue for several years before tapering.

7.5 Road infrastructure gaps

Gaps in road infrastructure are driven by increasing populations and expanding economic development, as well as the need for these regions to be connected to other regions, areas of residence, national and international markets and to renew life-expired infrastructure.

7.5.1 North – south access

Linking Northern Australia to the southern part of the continent – and linking the three jurisdictions of the north – is essential for the region's economic development. The relevant routes are the Bruce Highway in Queensland, the Stuart, Barkly and Victoria highways in the Northern Territory and the Great Northern and North West Coastal (Port Hedland-Perth) highways in Western Australia.

The Bruce Highway faces challenges of safety, flooding and capacity, with safety prioritised under the Bruce Highway Action Plan,[66] in response to a recent deteriorating severe crash trend.

On the Stuart Highway, flood immunity works at only a small number of locations could yield a route with year round weather reliability. The Stuart Highway also forms an important part of the urban and peri-urban road networks of the cities it connects, particularly Darwin and Alice Springs, resulting in a need for capacity expansion in response to residential and industrial development.

The Victoria Highway, in some contrast to the Stuart Highway, has lower flood immunity and weak pavement strength due to age, despite recent widening (to two lanes). The Northern Territory Government notes that a new Department of Defence fleet of vehicles, with axle loads 90 per cent above statutory loads, will challenge the jurisdiction's pavements, particularly the Stuart, Victoria and Arnhem highways.

In Western Australia, strong resource-related traffic growth on the narrow and sub-optimally aligned North West Coastal Highway limits road freight productivity and affects safety.

7.5.2 Hinterland road links to major northern centres

Links between major urban centres and hinterland areas can be very important for economic activity. These areas often provide input into industries located in urban areas.

The Arnhem Highway, located to the east of Darwin and linking the city to Jabiru and Arnhem Land, is one such link. The growing construction industry in Darwin is increasingly moving towards a year round industry, rather than one that pauses during the wet season. This results in a more consistent demand for construction materials throughout the year. Construction materials for projects based in Darwin are generally sourced from quarries located along the Arnhem Highway,

66. Queensland Government (2012)

which was not built for significant construction vehicle traffic. As a result, the highway can be a dangerous and busy stretch of road, especially when shared with a growing tourism industry.

Complications are compounded during the wet season when restrictions are put in place. These may include restrictions such as reduced weight limits and/or vehicle type. Restrictions still allow access to both communities and city, and are more commonly applied than closures. However, anecdotal evidence suggests that restrictions can do more commercial damage to certain users of the highway (e.g. transport operators) than closures. For example, a transport operator contracted to supply the construction industry with material is still contractually obligated to honour this agreement in time and volume, even though a road may have severe restrictions in place. The operator may be required to use smaller vehicles or reduced loads, resulting in more journeys, increased costs and complications regarding managing driver fatigue.

Other important Northern Australia hinterland routes include the Capricorn, Flinders and Peak Downs highways and the Karratha Tom Price and Marble Bar roads.

7.5.3 Resource region links

The resources industry has been the main recent driver of infrastructure development for much of Northern Australia. Resource developments are commonly clustered in regions, with their cumulative impact ranging from moderate to very large. Interaction and implications for the road network depend on a number of variables, which include the size of the developments and the methods by which inputs/outputs will be transported. Impacts will also be determined by the nature of arrangements between government and proponent and the extent to which the proponent must mitigate or rectify any adverse impacts on the road network that the development may trigger.

Many of the large resource development regions, including the Galilee Basin (Queensland) and the already developed Pilbara (Western Australia) are, or will be, supported by substantial rail infrastructure. Although this will remove some pressure from the road network, it will not remove all impacts. The rail systems are primarily designed to move bulk product from the mine to export markets, not to transport break bulk to the mine. A large proportion of mining inputs during the construction, operational or decommissioning stages are commonly moved via the existing road network. Large items of machinery or significant quantities of fuel will have short, medium and long term impacts on road pavements, ancillary infrastructure, permit request systems and piloting services. Conflicts with other economic and social road uses therefore need to be managed.

Resource industry employment will in some cases require the use of roads for employees to access their place of work. Although FIFO operational structures will reduce the pressure of light vehicle traffic and reduce the mix of heavy and light vehicles on the road, the volume of traffic on the road will still increase. When multiple developments occur in close proximity, the cumulative effect on the road network can become substantial. Urban movements of road trains, for example to the Port of Port Hedland, are a source of conflict between vehicle types, which road upgrading (bypasses) can address.

The Roper region in the Northern Territory, approximately 400 kilometres south of Darwin, is a resource development area smaller in scale than those located in the Galilee Basin and Pilbara. The area is still in its infancy with regard to mining exploration and has the potential to expand significantly. There is currently no rail infrastructure to support the developments, resulting in all inputs/outputs being transported via the road network. The Roper Highway is a sealed single carriageway not entirely suitable for the large, oversize requirements of the mining industry. Consultation for this project has suggested that the proponents have expressed an interest in hauling 30 metre road trains and are considering the construction of a haul road parallel to the existing highway.

7.5.4 Agricultural industry road links

The agricultural industry is a significant player in the Northern Australia economy with the region making up half of Australia's pastoral land.[67] Pastoral farms, in particular cattle, are typically found in the central region.

Cattle are solely moved via the road network, often from relatively remote areas to export markets or between grazing sites. The extent of the movement depends primarily on weather conditions, with drought often resulting in greater stock movements. Road conditions are critical in allowing stock owners to be able to move cattle exactly when the market is right. Delays due to road closures may result in stock not obtaining the best market rate, or pastoralists not being able to sell when the animals are in the best condition. Road closures may also impact animal welfare should it occur midway through a journey – although such situations are not a common occurrence.

The Buntine Highway, the Barkly and Murranji stock routes, Duncan and Buchanan highways, linking Carpentaria Shire in Queensland to the Stuart Highway in the Northern Territory's Barkly and Victoria River regions, then west to the Kimberleys and south to South Australia are core

67. ABARES (2013)

arterial routes for northern beef producers.[68] Other Northern Territory roads including the Plenty Highway (single lane bitumen and unsealed) and Tanami Road (two lane bitumen, single lane bitumen and unsealed) are also critical in the efficient movement of stock. These roads experience low traffic volumes and connect sparsely populated areas of central Australia. While investment has been low, the deterioration of such roads can lead to significant productivity losses. Anecdotally, a 250 kilometre trip on the Tanami Road may take a heavy vehicle driver 14 hours to complete, due to the severe corrugations.

The Ord agricultural region in the Kimberley region of Western Australia is a significantly sized seasonal arable farm development. Historically, fruit and vegetables have been the dominant crops, due to the large irrigated areas; however in recent years, forestry products have expanded. The transportation of fruit and vegetables to domestic and international markets is wholly reliant on the road networks. Reliability is the key, ensuring farmers are able to access markets, which is all the more critical due to the perishable nature of the goods. Forestry products, as non-perishable items, will not experience the same time sensitive pressures. However, forestry products present the road network with a different set of challenges due to their heavy nature. Pavement damage may occur at a quicker pace with road maintenance implications for the road owner, and road/vehicle restrictions may impact the productivity of the transport industry.

7.5.5 Maintenance

Road maintenance comprises rehabilitation of the pavement's structure and surface and routine maintenance, including repairs, drain and culvert clearing and grading of unsealed roads. While key to road condition and the road's load carrying capacity, maintenance funding appears not to have kept pace in recent years with requirements. Queensland notes that while the network has expanded, largely due to safety-related road widening, over the past decade, maintenance expenditure has remained stable.[69] This is a likely contributor to the maintenance backlog phenomenon. There is also an anecdotally reported tendency for road freight vehicles to operate more intensively than previously during the wet season, with resulting greater road damage.

Over 55 per cent of the Queensland Northern Australia network exceeds the theoretical design life and a third of network seals today are older than the target optimum, compared with only 10 per cent in 2003. Queensland notes a pavement rehabilitation and programmed maintenance requirement in Northern Queensland of $700m over the next five years, $318m of which represents backlog.[70]

The Northern Territory notes that its national highway roads are on average receiving around 60 per cent of the required budget calculated on a whole of life cost basis (national highways 59 per cent, Territory roads 57 per cent).[71] In 2009 the Western Australian Auditor-General found that maintenance activity had declined over the previous ten years, with the proportion of the whole of state network overdue for resurfacing having increased from 20 to 27 per cent and with the proportion of pavements aged over 40 years and with increased risk of failing having risen from 14 per cent to 30 per cent.[72]

Maintenance backlogs can threaten the ability to open and retain access to Higher Mass Limits (or larger) vehicles, increase the likelihood of temporary load restrictions being imposed during wet weather conditions and also limit capacity when lengthy road repair periods become necessary. Flood recovery works and safety prioritisation (notably involving widening seals and improving road shoulders) also constrain maintenance budgets.

7.5.6 Bridge condition and strength

Bridge condition and strength can represent limiting factors in road route serviceability in Northern Australia as elsewhere, given industry pressure to increase vehicle mass limits. There are 724 bridges on the North Queensland roads in scope, 18 of which are timber. The Department of Transport and Main Roads has undertaken an assessment of bridge strength through a range of scenarios from general mass limits (GML) at 42.5 tonnes up to a Heavy Load Platform at 320 tonnes. The costs of the load-based scenarios range from $86m to $911m, with higher costs for size-related scenarios (48 tonne and 80 tonne cranes).[73]

Improving the flood resilience of bridges is important in all three jurisdictions, with a need for high level bridges identified in a number of locations, for example at Big Horse Creek and Little Horse Creek on the Victoria Highway.

68. Joint Select Committee on Northern Australia (2014), p.73

69. At a whole of state level, network capacity has increased by 21 per cent as measured by the area of surfaced lanes including new roads, urban capacity expansion projects, widening of narrow roads to two lanes, e.g. Gregory Developmental Road and upgrading unsealed roads to a sealed standard, e.g. Kennedy Developmental Road (Queensland Transport and Main Roads input to the Australian Infrastructure Audit maintenance study).

70. Queensland Transport and Main Roads input to the audit

71. Northern Territory Government input to the Australian Infrastructure Audit maintenance study

72. Auditor General Western Australia (2009),pp.15-16

73. Queensland Transport and Main Roads input to the audit

7.5.7 Urban road and public transport links

The capacity and condition of urban arterial road links will impact the overall performance of the road network and are critical for the economic and social needs of growing urban centres.

A well maintained highway providing access to areas of economic development 500 kilometres inland has limited value if the product is not able to be moved from the port to the highway or vice versa ('last mile' and 'first mile' considerations). These disconnects can occur in the form of weight restrictions (i.e. no higher mass limit vehicle access) or limits on the type of vehicles that can use the infrastructure.

Several Queensland centres have experienced bus patronage growth in excess of population growth over the past decade and will benefit from public transport upgrading to reduce congestion and improve accessibility for these centres as they grow. Patronage has increased, in some cases, despite poor service frequency in urban growth regions.

Bus priority measures on high frequency corridors in Cairns and Townsville would reduce the impact of peak period congestion on service reliability and on-time running. As these measures may involve a reduction in parking and road space for private vehicles, advance planning and careful timing is particularly important. Townsville's new City Plan which focuses on urban densification along the current high frequency corridor, between the CBD and the university, is likely to result in increased public transport patronage.

Access roads to some areas of the city, such as Townsville Hospital and James Cook University, may face significant congestion over the next 20 years. Targeted public transport investment could attract more users away from private transport and thereby defer or remove the need for substantial investment in widening of bridge and road infrastructure. In addition, improved ticketing and bus information systems would reduce boarding times and improve service quality. Bus interchange (Cairns) and bus stop or station upgrades (Cairns, Townsville, Mackay, Rockhampton) are also in view over the period to FY31.[74]

Under the Western Australian public transport service model the state owns the depots, ticketing systems and buses (in metropolitan and larger centres). It is anticipated that the realisation of the Pilbara Cities initiative will require investment in bus depots and upgraded ticketing systems to serve the additional population in Karratha and Port Hedland.

7.6 Road critical infrastructure requirements

Improvement priorities for the Barkly, Bruce, Capricorn, Flinders and Gregory highways (and at a somewhat more general level for the Galilee Basin) are addressed in a range of Queensland Government strategy documents.[75] Similarly, specific priorities for the Victoria and Great Northern highways and the Gibb River Road (all Kimberley Region) and for the North West Coastal Highway are set out in Western Australian road network plans.[76] The Northern Territory is currently undertaking a regional infrastructure study which will identify road upgrading priorities.

More generally, from information provided, the audit's assessment is that all of the roads in scope feature at least several of the following key improvement requirements:

- Widening narrow seals (e.g. of less than 8 metres) that, in a context of increasing use of larger, heavier vehicles, entail both safety and maintenance concerns, the latter particularly due to edge damage from heavy vehicles and from overtaking light vehicles
- Pavements that require renewal, having neared or exceeded their design life, a challenge exacerbated in some regions by weak, expanding soil conditions
- Bridges that require upgrading (single lane, low strength, e.g. timber, or in some cases both)
- Road realignments, to address steep grades and horizontal and vertical curves, improving both safety and heavy vehicle productivity
- Improved flood immunity at targeted locations, benefitting all-weather reliability and also availability, by limiting lengthy periods of recovery road works
- Capacity expansions on higher volume roads, e.g. duplication in urban and peri-urban locations, to improve both vehicle flow and safety (in view of traffic conflicts between heavy and light vehicles) and overtaking and truck stopping lanes in non-urban locations
- Other safety related improvements in high traffic volume locations, e.g. intersection upgrading, wide line
- Sealing of roads in sparsely populated regions of the Northern Territory and north Western Australia in particular, to respond to and encourage resource and other industry development and improve overall accessibility.

In addition, while the information cited relates to only one of the three jurisdictions, addressing road maintenance backlogs and ensuring that they

74. Queensland Transport and Main Roads input to the audit

75. All documents are listed in Section 14 References

76. See Regional Road Network Plan Kim berley Region (2012) and Regional Road Network Plan Pilbara Region (2012). This plan is currently being updated.

do not recur and addressing bridge condition and strength are further critical road infrastructure requirements.

Finally, urban public transport upgrades (Cairns bus priority, ticketing/information systems) and bus stop/station upgrades (Cairns, Townsville, Mackay, Rockhampton) are also critical.

Table 20: Road critical infrastructure requirements

Infrastructure grouping	Location	Primary infrastructure gap(s)	Key infrastructure requirement(s)
North-south and inter-jurisdictional links	Barcaldine to Cloncurry, QLD (Landsborough Highway, NLTN)	Demand, service standard	Upgrades to address ageing and narrow pavements, structures, flooding (reliability) and safety (with vehicle mix including Type 2 road trains and tourist vehicles) and capacity (e.g. overtaking lanes and shoulders)
	Beneraby to Cairns, QLD (Bruce Highway, NLTN)	Demand, service standard	Safety (including seal widening, sealed shoulders), flooding immunity, capacity (including pavement rehabilitation, duplications, Mackay Ring Road (see Queensland Government (2012))
	Townsville to Mount Isa, QLD (Barkly and Flinders highways, NLTN)	Demand, service standard	Upgrades to address ageing and narrow pavements and structures, flooding (reliability) and safety (with vehicle mix including Type 2 road trains and tourist vehicles) and capacity (e.g. overtaking lanes) (See Department of Transport and Main Roads 2014a, for Townsville to Mount Isa)
	Darwin to the South Australian border, NT (Stuart Highway, NLTN)	Demand, service standard	Address safety pavement and structure strength, flood mitigation and industrial/suburban duplications (Hughes near Darwin abattoir and residential development and Alice Springs road to the airport addressing residential and industrial development)
	Darwin, NT to Kununurra, WA (Victoria Highway, NLTN)	Demand, service standard	Address safety, pavement strength and width (e.g. Halls Creek section connecting to Great Northern Highway and Victoria Highway), high level bridges (e.g. bridges such as Big Horse and Little Horse River/Creek and on the Victoria Highway), for flooding resilience (e.g. Kununurra Diversion Dam Bridge route)
	Tennant Creek to Flinders, NT (Barkly Highway, NLTN)	Demand, service standard	Address safety (narrow pavement and structures), pavement and structure strength
	Tobermorey to Stuart Highway, NT (Plenty Highway – Outback Way)	Service standard	Address unsealed pavements and structures, flooding (reliability) and lane capacity upgrade to improve livestock flow efficiency
North-south and inter-jurisdictional links	Kununurra and Wyndham to Perth, WA (Great Northern Highway, NLTN)	Demand, service standard	Address safety (narrow pavement and vehicle mix conflict e.g. Wyndham Spur, duplication of single lanes, e.g. Erskine – Blina), pavement and bridge strength, culvert rehabilitation and flooding resilience
	North West Coastal Highway, WA	Demand, service standard	Address pavement and steel culvert rehabilitation, seal widening (e.g. Minilya to Barradales), capacity/congestion (Karratha to Roebourne link) and demand linked regional including west Pilbara region growth (e.g. Anketell Port, Cape Preston, and Northern Carnarvon Basin).
	North West Coastal Highway, WA	Demand, service standard	Upgrades to strengthen pavements and ease freight and road users' interaction by providing extra passing lanes and sealed shoulders
Resource, agriculture, tourism and community links	Cairns to Boulia, QLD (NT border) (Kennedy Developmental Road/Hann Highway – Outback Way)	Service standard	Address unsealed sections, narrow pavement (largely single lane near NT border)
	Charters Towers to Cairns, QLD (Gregory, Kennedy Developmental roads, Kennedy Highway	Demand, service standard	Address safety (narrow pavement and structures), pavement and structure strength, flooding resilience, slow traffic movement (Atherton, Mareeba)

Infrastructure grouping	Location	Primary infrastructure gap(s)	Key infrastructure requirement(s)
Resource, agriculture, tourism and community links	Clermont to Charters Towers, QLD (Gregory Highway, Developmental Road)	Demand, service standard	Address safety (narrow pavement and structures), pavement and structure strength, flooding resilience
	Cloncurry to Dimbulah, QLD (Burke Developmental Road)	Demand, service standard	Address safety (narrow pavement and structures), pavement and structure strength
	Dingo to Mount Flora, QLD (Fitzroy Developmental Road)	Demand, service standard	Address safety (narrow pavement and structures), pavement and structure strength, flooding resilience
	Innisfail to Ravenshoe, QLD (various roads)	Demand, service standard	Address safety and freight efficiency (widen seal)
	Lakeland to Weipa, QLD (Peninsula Developmental Road)	Demand, service standard	Address safety (narrow pavement and structures), road sealing and flooding resilience to alleviate prolonged wet season closures
	Mackay to Clermont, QLD (Peak Downs Highway)	Demand, service standard	Upgrades to strengthen and widen narrow pavements, replace load-limited timber bridges and upgrade the Eton Range winding alignment (west of Walkerston), improve flood resilience (See Department of Transport and Main Roads 2014c)
	Mareeba to Lakeland, QLD (Mulligan Highway)	Service standard	Address safety and freight efficiency (widen seal) and structure strength
	Normanton to Mount Garnet, QLD (Gulf Developmental Road)	Demand, service standard	Address safety (narrow pavement and structures), pavement and structure strength
	Rockhampton to Barcaldine QLD (Capricorn Highway	Demand, service standard	Safety and capacity upgrades, including extensive seal widening, overtaking lanes, targeted pavements strengthening, bridge and culvert upgrades, duplication (Rockhampton to Gracemere), flood immunity improvements (See Department of Transport and Main Roads (2014b))
	Alice Springs to Yulara, NT (Red Centre Way)	Opportunity, service standard	Seal the Mereenie Loop Road Hermannsburg to King's Canyon) and upgrade Lasseter Highway to King's Canyon spur, assisting tourism development
	Alice Springs, NT to Halls Creek, WA (Tanami Road)	Opportunity, cost, service standard	Address pavement sealing and widening of single lane sections and sealing of unsealed sections.
	Barkly Highway to Borroloola, NT (Tablelands Highway)	Demand, service standard	Address single lane and pavement widening
	Daly River to Wadeye, NT (Port Keats Road)	Service standard	Address unsealed road flood resilience for community and resource sector access
	Jabiru to Pine Creek, NT (Kakadu Highway)	Demand, service standard	Address safety (narrow pavement and structures), pavement and structure strength and flooding resilience to cater for the mixed traffic of tourists with caravans and heavy transport.

Infrastructure grouping	Location	Primary infrastructure gap(s)	Key infrastructure requirement(s)
Resource, agriculture, tourism and community links	Katherine to Nhulunbuy, NT (Central Arnhem Highway)	Demand, service standard	Phase pavement sealing through strategic links (i.e. Stuart Highway to Bulman, Bulman to Nhulunbuy and connection to Melville Bay Road) including bridging of river/creek crossings
	Mataranka to Numbulwar, NT (Roper Highway)	Demand, service standard	Address pavement sealing and widening of single lane sections and sealing of unsealed sections and flooding resilience and bridges (e.g. Wilton Crossing)
Resource, agriculture, tourism and community links	Stuart Highway to Borroloola, NT (Carpentaria Highway)	Demand, service standard	Address safety (narrow pavement and structures), single lane pavements and pavement widening and strengthening
	Stuart Highway, NT to the WA border (Lasseter Highway, Tjukaruru Road – Outback Way)	Demand, service standard	Address safety (narrow pavement and structure), pavement and structure strength to cater for the mix of tourists with caravans and heavy transport
	Derby to Broome, WA (Derby Highway)	Demand, service standard	Address safety, improve access to Derby city, pavement sealing and seal widening when connecting to Great Northern Highway
	Derby to Wyndham, WA (Derby Gibb River Road/ Gibb River Road/ Gibb River Wyndham Road)	Demand, service standard	Address pavement sealing, seal widening (Derby to Fairfield-Leopold), flood resilience including remote monitoring to improve information to road users
	East Pilbara mines to Marble Bar Road, WA (Ripon Hills Road)	Demand, service standard	Address pavement rehabilitation and flooding resilience
	Karratha to Tom Price and Paraburdoo, WA (Karijini Drive)	Demand, service standard	Address freight efficiency (steep alignment)
	Kununurra to Keep River/Legune Station, WA (Weaber Plains Road extension)	Opportunity	Extend road to support Ord Stage 3 agricultural development
	Nanutarra, WA (on North West Coastal Highway to Munjina, WA (near Paraburdoo)	Demand, service standard	Address safety (road geometry), bridge strengthening and widening, pavement sealing, flood mitigation, (e.g. Oakober River Floodway, Nullagine River Floodway and Shaw River Floodway upgrade/repair)
	Pannawonica to North West Coastal Highway, WA (Pannawonica Road)	Demand, service standard	Address freight efficiency (narrow pavement)
	Paraburdoo to Tom Price, WA (Paraburdoo Tom Price Road)	Demand, service standard	Address narrow pavement and bridge strength
	Strelley, WA (on Great Northern Highway) to near Newman, WA (Marble Bar Road)	Demand, service standard	Address pavement sealing, road geometry, bridge strength, flood resilience

Infrastructure grouping	Location	Primary infrastructure gap(s)	Key infrastructure requirement(s)
Resource, agriculture, tourism and community links	Victoria Highway to Nicholson, WA (Buntine Highway)	Demand, service standard	Address unsealed sections and single lane pavements (Kalkarindji to Victoria Highway)
Access to ports, airports and tourism locations	El Arish to Mission Beach Road, QLD	Service standard	Address safety (narrow pavement)
	Gladstone to Mount Larcom, QLD (Gladstone Mt Larcom Road)	Demand, service standard	Address safety (narrow pavement, limited overtaking)
	Halifax to Lucinda Point Road, QLD	Service standard	Address safety (narrow pavement)
	Ingham to Halifax-Bemerside Road, QLD	Demand, service standard	Address safety (narrow pavement)
	Mackay-Slade Point Road, QLD	Demand, service standard	Address safety (mixing of heavy vehicle and passenger traffic)
	Tully – Mission Beach Road, QLD	Service standard	Address safety (narrow pavement)
	Berrimah to East Arm Port Access, NT (Berrimah Road)	Demand, service standard	Address duplication to port access infrastructure and mixed traffic through urban links (e.g. Export Drive)
	Borroloola to Bing Bong Port, NT (Carpentaria Highway, Robinson Road)	Demand, service standard	Address safety, seal width, pavement design and strengthen for heavy vehicles traffic
	Humpty Doo to Jabiru, NT(Arnhem Highway)	Demand, service standard	Address bridge repairs and maintenance (e.g., Mary River, Wildman River, and East Alligator Rivers), safety (narrow pavement and structures, vehicle mix conflicts), pavement and structure strength, rehabilitation and flooding resilience (e.g. Adelaide River)
	Dampier – Burrup Road, WA	Demand, service standard	Address safety and capacity through duplication to Dampier Port facilities and intermodal access (e.g. Burrup Peninsula Logistics Hub)
	Port Hedland, WA (Gilbert Street/ Wilson Street)	Demand, service standard	Address safety (narrow pavement and structures, vehicle mix conflicts), pavement and structure strength and rehabilitation)
	Robe River loading facility to Roebourne, WA (Point Samson Roebourne Road)	Demand, service standard	Address safety (shoulder width, road geometry, vehicle mix conflicts)
Urban including public transport	Bus interchange and other upgrades, QLD (Cairns, Townsville, Mackay, Rockhampton)	Demand	Bus interchange (Cairns) and bus stop or station upgrades (Cairns, Townsville, Mackay, Rockhampton) can improve service and help attract patronage, limiting urban congestion growth over the period to 2031
	Bus priority measures, QLD (Cairns, Townsville)	Demand	Bus priority measures to reduce the impact of peak period congestion on on-time running and service reliability, together with improved ticketing and bus information systems
	Cairns to Mossman, QLD (Captain Cook Highway)	Service standard	Address safety (vehicle mix conflicts), delays through Cairns, flooding (reliability)

Infrastructure grouping	Location	Primary infrastructure gap(s)	Key infrastructure requirement(s)
Urban including public transport	Dysart to Middlemount, QLD	Demand, service standard	Address safety (narrow pavement), flooding resilience
	Proserpine to Shute Harbour, QLD	Service standard	Address safety (vehicle mix conflicts), urban delays
	Rockhampton to Yeppoon, QLD	Demand, service standard	Address safety (vehicle mix conflicts), urban delays
	Darwin International Airport, NT (Henry Wrigley Drive)	Demand	Address duplication and increase capacity of airport link
	Tiger Brennan Drive, NT	Demand	Address safety (vehicle mix conflicts), urban delays and capacity through complete duplication from Darwin to Berrimah
	Dampier Highway to North West Coastal Highway, WA (Madigan Road, Karratha)	Demand, service standard	Address seal width, seal shoulders, pavement rehabilitation, strength and lane duplication
	Jigal Drive, WA (Broome Road – Gubinge Road)	Service standard	Address safety (vehicle mix conflicts) and freight efficiency through urban area
	North West Coastal Highway to Karratha, WA (Dampier Road)	Demand, service standard	Address safety (narrow pavement and structures, vehicle conflicts) and capacity/congestion (e.g. Balmoral Road West to Burrup Road)
	Onslow to North West Coastal Highway, WA (Onslow Road)	Demand, service standard	Address safety (road geometry), seal width, pavement design for increasing traffic and heavy vehicles

Energy – electricity

8.1 Introduction

Northern Australia is served by four major electricity networks that are each supplied by two or more power stations. These networks cover, roughly speaking, the eastern third of north Queensland with the exception of Cape York, the Mount Isa region, a narrow strip between Darwin and Katherine in the Northern Territory and a limited part of the Pilbara in Western Australia. Beyond these networks a number of localised distribution systems or stand-alone generating plants exist to supply the needs of remote mining and minerals processing sites.

There are numerous Indigenous communities across northern Australia located at long distances from each other, existing power networks or fuel supply pipelines and only a handful of these communities have more than 1,000 residents.

8.2 Electricity infrastructure in scope

The major networks have been included and described as single non-separable entities, as they are critical to the current operation and future development of almost all economic, cultural and leisure activity. Additional isolated demand centres are included only if they fit the critical infrastructure definition. However, isolated mines that generate their own power with no connection outside the site are generally excluded. The networks and demand locations specifically covered in this audit are shown in Table 21 and mapped in Map 12.

Table 21: Electricity networks and significant demand centres in Northern Australia

Queensland	Northern Territory		Western Australia
National Electricity Market North Queensland	Darwin-Katherine Interconnected System		North-West Interconnected System
Mount Isa	Alice Springs		**Other Western Australia:**
Other Queensland:	Tennant Creek		Broome
Boulia	**Other Northern Territory:**		Camballin/Looma
Burketown	Alpurrurulam	Lajamanu	Derby
Camooweal	Amunturangu	Milyakburra	Fitzroy Crossing
Coen	Areyonga	Nauiyu	Yungngora
Doomadgee	Elliott	Nyirripi	Kalumburu
Gununa Mornington Island	Epenarra	Orwaitilla	Kununurra/Wyndham/ Lake Argyle
Lockhart River	Galiwinku	Papunya	Warmun
Mapoon	Gapuwiyak	Peppimenarti	Marble Bar
Weipa	Gove	Pine Gap	Nullagine
	Groote Eylandt	Ramingining	Onslow
	Hermannsburg	Tara	Exmouth
	Ikuntji	Umbakumba	
	Imangara	Walangkura	
	Jabiru	Wutungurra	

Note: 'Other Queensland', 'Other Northern Territory' and 'Other Western Australia' only include locations within the scope of this audit. Southern Queensland and Western Australian locations are excluded, as are some locations in north Queensland and the Northern Territory that neither meet the minimum population criterion nor lie within geographical areas defined as 'economically significant'.

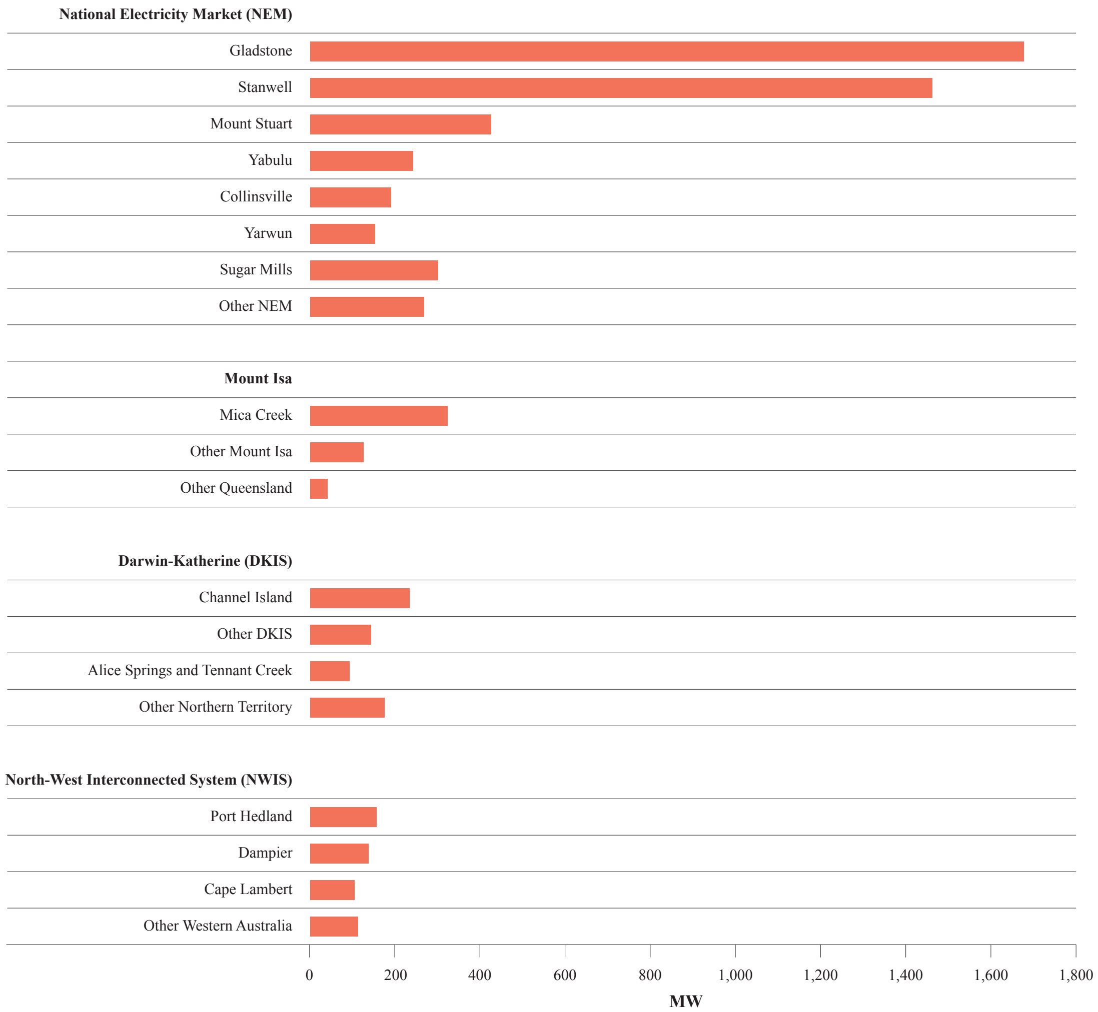
8.3 Existing electricity capacity

8.3.1 Base year capacity

The nameplate, or nominal registered capacities and fuel types for major power stations across Northern Australia existing in FY11 are presented in Figure 31 and detailed in Table B. 9. A major part of generation capacity actually located in the north is provided by two large power stations in the Gladstone-Rockhampton vicinity. Additional capacity is available to the east coast of Queensland through the interconnected National Electricity Market which provides shared access to generation sources further south in Queensland and stretching to encompass Tasmania and South Australia.

The nameplate capacity of a power station is unlikely to be available continuously, either because of interruptions to fuel supplies or network flow constraints, or due to scheduled maintenance or unscheduled breakdowns. However, for those generating units connected to a network that are available to operate in any given dispatch period, the market operator ensures that units are dispatched in order of lowest bid up until demand on the system is met.

Figure 31: Capacity of Northern Australia electricity supply systems in FY11



8.4 Drivers of additional electricity capacity

8.4.1 Recent and prospective capacity changes

Recent changes to generation capacity shown in Figure 31 are as follows:

- Australian Energy Market Operator (2014) reports that capacity at Barcaldine, Collinsville and Yabulu power stations has been taken off-line resulting in a reduction in Queensland National Electricity Market capacity of 220 megawatts (MW)
- Australian Energy Market Operator (2014) reports that Collinsville and Mackay GT power stations will be retired in 2016 and Mount Stuart power station will be retired in 2023. By 2023 capacity in northern Queensland will be reduced by a total of 647 MW
- Projects with announced completion dates may bring 387 MW of renewable energy to north Queensland before June 2018
- AGL and APA jointly announced that the new natural gas Diamantina and Leichhardt power stations together supplying 302 MW to Mount Isa are being progressively commissioned during 2014. This coincides with the closure of around 76 MW of capacity at the existing Mica Creek power station[77]
- Utilities Commission (2012) reported that Berrima power station was removed from regular service during FY11 and recent additions of 90 MW of capacity at Channel Island power station and further additions to Wedell and Katherine has brought the Darwin-Katherine system total capacity to 499 MW
- New capacity at Alice Springs and retirement of two units at Ron Goodin leave Alice Springs with a total capacity of 86 MW. Further units at Ron Goodin will be withdrawn from service progressively until 2021, although this will be offset to an extent by commissioning new units at Owens Springs
- Horizon Power (2014) reports that, since FY11 additional capacity of 20 MW has been added to NWIS at Karratha, 67 MW will be operating at South Hedland before FY16 and a commercial agreement on an additional 150 MW capacity (South Hedland stage 2) has recently been announced by the State Government and is expected to be in service by FY21. Associated transmission works by Horizon Power in the Karratha and Port Hedland areas will support this new generation capacity.

8.4.2 Indications of capacity shortfalls

Table 22 shows reserve margins and capacity factors for electricity systems in Northern Australia. The reserve margin — calculated as one minus peak demand over capacity — indicates the excess of capacity over demand, which may be an indication of relative reliability when comparing two similar large systems.

Reserve margins for networks are likely to be lower than for stand-alone generating sets due to the possibility of using alternative sources of supply. However networks by definition have alternative interconnected sources of supply and can therefore share some degree of redundancy. A common method of assessment of relative capacity shortfall is through the use of an 'N-X' standard. Using this method, reserve is measured as 'capacity in excess of the planned-for peak demand after withdrawal of an amount of X units of supply. For X=1, the withdrawn capacity is the largest generating unit on the system; for X=2, the withdrawn capacity is the largest two units on the system, and so on. Meanwhile the planned-for peak demand is often defined as the peak demand with a chance of being exceeded one year in every 10.

The system capacity factor — calculated as annual energy over capacity times the number of hours in a year — is an indication of the persistence of the load on an electrical system, comparing the energy that was actually produced over a period with the amount of energy that would be produced if all generating units ran continuously at maximum capacity.

The capacity factor thus shows how hard the average generating unit works. In practice there is likely to be a great deal of variation between different individual generating units connected to the same system, with base load units working harder than peaking units or intermittent generation sources, such as seasonally-dependent bagasse burning generating units or wind turbines which only operate when the wind speed is within a given range. Variation in capacity factors will also occur in response to demand variation, with growing demand leading to higher capacity factors, if generation capacity remains constant.

Within the in-scope section of the National Electricity Market in north Queensland, around three quarters of the available generation capacity is concentrated in just two power stations located at Gladstone and Stanwell in the south. This leaves a large deficiency in northern generation relative to demand which is made up by power transfers from the south via the National Electricity Market network. This means that part of the demand for electricity by customers in northern Queensland is generally able to be met by generators located throughout south-eastern Australia because they are interconnected.

77. Townsville Bulletin, http://www.townsvillebulletin.com.au/business/gas-fired-plant-on-network/story-fnjfzyqo-1226738715029, accessed 7 May 2014 – GHD estimation of MW capacity is based on overall Mica Creek capacity of 302 MW and retirement of 3 out of 12 units.

Table 22: Reserve margins and capacity factors

	Reserve margin FY11 (%)	Capacity factor FY11 (%)
National Electricity Market North Queensland	42.4	50.6
Mount Isa	22.8	56.4
Darwin-Katherine Integrated System	21.8	46.5
Alice Springs	24.4	34.5
Tennant Creek	61.1	18.4
Darwin-Katherine, Alice Springs and Tennant Creek	21.8	46.5
North-West Integrated System*	14.2	43.5

** Based on Horizon Power load and power stations that supplied that load. Additional generation capacity in the interconnected system is largely devoted to the BHP and Rio Tinto iron ore operations that own them.*

Source: GHD analysis

8.4.3 Network performance

The National Electricity Market network in North Queensland is operated by Powerlink Queensland and supplies the majority of the lower voltage Ergon Energy distribution network. The in-scope network consists of a number of zones running from Gladstone to north of Townsville and from the coast west as far as Barcaldine. The direction of power flow is generally northwards and there are notable transfer limits within this northern grid section between central Queensland and the north.

Powerlink Queensland advises that growing levels of transmission congestion are anticipated in this section, with increases in demand which will result in constraint of northern Queensland generators. Development of any of the proposed coal mines in the Galilee or Bowen Basins or upstream gas liquefaction in the Bowen Basin would cause network limitations. Transmission augmentation solutions are under review by Powerlink.

Table 23: Electricity network performance

Network reliability measures for FY11	
Powerlink constraint times	0.0
Powerlink system events > 0.2 min	0.0
Ergon performance in excess of Minimum Service Standards (SAIDI)	135.0
Ergon performance in excess of Minimum Service Standards (SAIFI)	2.9
Darwin and Katherine performance in excess of Minimum Service Standards (SAIDI)	10.0
Darwin and Katherine performance in excess of Minimum Service Standards (SAIFI)	4.0
Alice Springs performance in excess of Minimum Service Standards (SAIDI)	-137.0
Alice Springs performance in excess of Minimum Service Standards (SAIFI)	-1.1
Tennant Creek and Alice Springs performance in excess of Minimum Service Standards (SAIDI)	-185.0
Tennant Creek and Alice Springs performance in excess of Minimum Service Standards (SAIFI)	-2.4
Horizon Power performance in excess of Minimum Service Standards (SAIDI)	130.0
Horizon Power performance in excess of Minimum Service Standards (SAIFI)	3.5

Source: Target and performance figures published by Powerlink Queensland (2012), Ergon Energy (2013), Utilities Commission (2012) Horizon Power (2011) and GHD analysis

Table 23 shows that there were no constraints on the central to north Queensland grid section during FY11. Power transfer from southern to northern zones is an important contribution to the reliability of supply to northern electricity customers. Network constraints are acceptable at certain times (and usually do not cause any interruption to supply) if the cost of overcoming them exceeds their value to customers. Powerlink Queensland has primary responsibility for planning to ensure that south-north power flow constraints remain at an acceptable level. Table 23 also shows the reliability of distribution networks, which generally set reliability targets in terms of customer interruptions. The System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI) are commonly used as standard measures of the duration and number of interruptions respectively. In Table 23 these measures are shown at a whole of network or organisation level rather than being confined to the study area. Numbers shown are actual performance compared with ex-ante targets; therefore positive numbers show performance exceeding the target while negative numbers show the target was not met. The reasons for not meeting the target may reflect adverse weather conditions or other anomalies in the year under consideration, although the data usually exclude extreme events. In the first instance therefore, negative numbers in Table 23 reflect reference year problems in maintaining the system to previously agreed standards of reliability.

8.5 Future electricity demand

Around 80 per cent of existing demand for electricity in Northern Australia comes from Queensland and around 30 per cent from Gladstone in particular. Under a 'business as usual' scenario for Northern Australia, Queensland's demand share is expected to decline slightly in the next 20 years, while the Pilbara region of Western Australia is expected to almost double its share through higher growth. A single customer, the Boyne Island aluminium smelter, currently accounts for around 20 per cent of electricity demand in Northern Australia.

Figure 32 and Figure 33 show peak demand and annual electrical energy consumption forecasts respectively. Further details of the forecasts are at Tables B.10 and B.11. Annual energy and peak demand in FY11 both reflect the weather that occurred in that particular year (and particularly on the day of peak demand), as well as the economic circumstances pertaining to each region and the resident population. The forecasts shown as shaded areas compile information published by the relevant authorities in each jurisdiction. These forecasts are generally based on the continuation of historical trends in energy intensity modified for the impact of large committed projects. The additional demand impact of all publicly announced coal, iron ore, port expansion and railway projects that are likely to proceed within the timeframe of the audit is shown as 'Possible new loads not yet committed'.

8.5.1 Future Queensland electricity demand

Ten year forecasts for the National Electricity Market in Queensland were last updated by Powerlink Queensland in February 2014.[78] The North, Ross, Far North, Central West and Gladstone zones cover the area in scope and these forecasts have been extrapolated to FY31. The Powerlink forecasts are based on comparable assumptions to 'most likely' forecasts for eastern Australia published by most other network organisations and the Australian Energy Market Operator. The forecasts below do not allow for potential new coal mines in the Galilee Basin whose development has not yet proceeded to a stage of sufficient certainty. These possible developments could add another 1,000 MW to the forecasts. Other possible loads in northern Queensland identified by Powerlink Queensland could add a further 600 MW.

Mount Isa forecasts are based on the more conservative of two scenarios that were published by Queensland Department of Mines and Energy in 2008, with capacity data sourced from the 2009 Sims Review.

Estimates of energy consumption and peak demand for isolated communities in Queensland and the Northern Territory are calculated from known generating unit capacities and assumed reserve margins and load factors (which determine annual energy as a proportion of peak demand sustained for an entire year). The known reserve margin for isolated Western Australia is 46 per cent, which is substantially higher than for small networks such as Mount Isa (23 per cent) or Darwin-Katherine (22 per cent), possibly because the Western Australian capacity data includes some supply to unmetered on site consumption. Erring on the side of higher consumption, reserve margins of 20 per cent (similar to Mount Isa) have been assumed to calculate isolated communities'

78. Forecasts of electricity demand throughout Australia have generally been revised downwards in recent years and, in line with AEMO's updated forecast published in June 2014, it is possible that Powerlink's next forecast will be lower again.

demand. Known load factors for the National Electricity Market in north Queensland, Mount Isa, Darwin-Katherine, Alice Springs and Tennant Creek and Western Australia range from more than 80 per cent to less than 50 per cent. A load factor of 75 per cent has been used to calculate energy demands for isolated communities in Queensland and the Northern Territory, which is similar to Mount Isa.

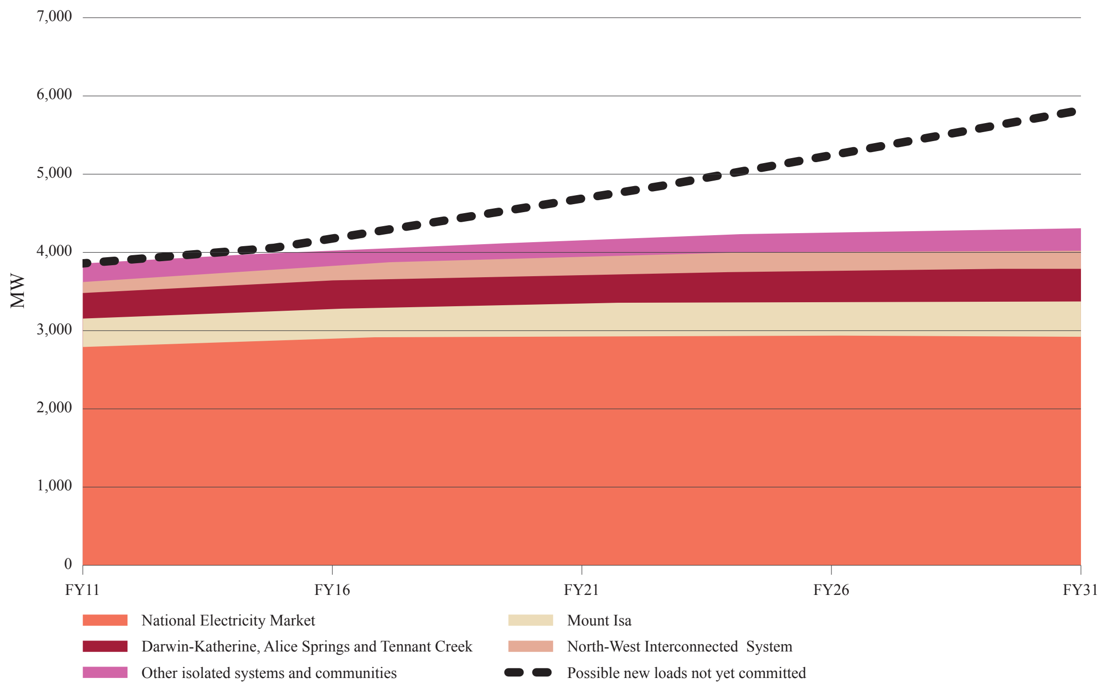
Isolated Queensland communities' demand is generally forecast by the audit at around one per cent a year. This results in minimal change after keeping existing mining operations constant and accounts for population growth of around two per cent a year and some additional adoption of rooftop solar panels to offset demand for non-renewable generation.

8.5.2 Future Northern Territory electricity demand

Northern Territory major centres' forecasts (for Darwin-Katherine, Alice Springs and Tennant Creek) were produced by Power and Water Corporation and published by the Utilities Commission for ten years, while Western Australian forecasts were published by Horizon Power for five years.

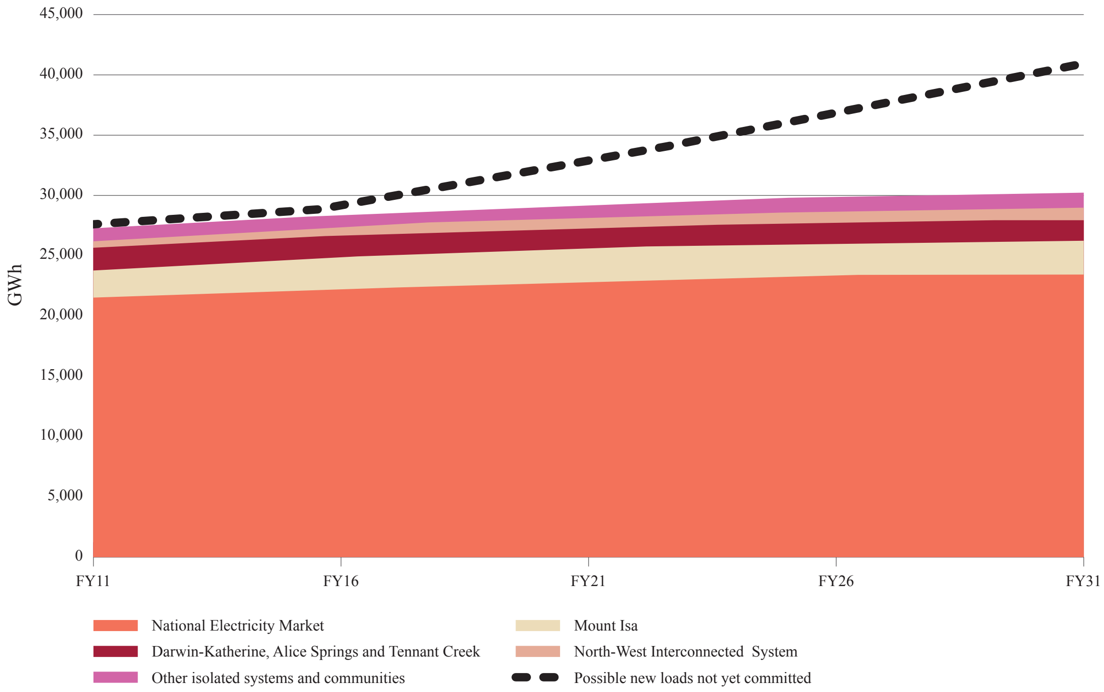
In the absence of published detailed forecasts, demand in isolated communities (locations outside the major centres) in the Northern Territory is assumed to grow by six per cent a year until FY16, reflecting recent growth and a program of upgrading community facilities. In light of Indigenous Essential Services demand management programs and regional household composition, demand growth from FY16 until FY31 is assumed to be around half population growth of approximately two per cent a year. These assumptions do not apply to existing mining and minerals processing facilities, whose loads are assumed to remain constant, with the exception of the Gove alumina refinery which was closed down in 2014.

Figure 32: Base year peak demand and 'business as usual' forecasts



Source: Powerlink Queensland, Sims Review (2009), Power and Water Corporation and Horizon Power

Figure 33: Base year annual energy consumption and 'business as usual' forecasts



Source: Powerlink Queensland, Sims Review (2009), Power and Water Corporation and Horizon Power

8.5.3 Future Western Australian electricity demand

Demand forecasts for each in-scope location in Western Australia were provided by Horizon Power. Analysis for northern Western Australia is divided between the North-West Interconnected System, covering the majority of energy demand in the Pilbara, non-interconnected systems in both the Pilbara and the Kimberley and the local supply to Exmouth.

8.6 Electricity infrastructure gaps

This section discusses baseline infrastructure gaps. As with other regions of Northern Australia, options to supply the rising demand for electricity in northern Queensland will need to be considered within the study period. However the existence of large coal resources in Queensland (where none exist in the Northern Territory or the top end of Western Australia) still presents the theoretical option of building coal-fired power stations to supply plentiful energy at a relatively cheap cost (even taking into account a potential requirement for carbon capture and storage). In general the most appropriate supply option will be determined by the relative cost of the energy that can be provided, the specific location of major demand growth and the regulatory environment that allocates the cost of major power infrastructure. In these respects the following developments will be key:

- Rising domestic gas prices in line with increasing export prices captured by new LNG opportunities will reduce the incentive to build new gas-fired power stations and the extent of operation of existing capacity
- Uncertainty over future climate change policies — especially the price of carbon emissions and support for renewable alternatives — will obviously impact on the cost of new coal-fired power stations and the ability to build them, relative to gas and renewable sources of power
- Cooperative arrangements (including market rules) that will continue to determine in large part the cost of connecting to networks in remote mining locations or the alternative of self-supply.

8.6.1 National Electricity Market north Queensland

Infrastructure gaps within a large electricity network such as that extending into north Queensland are traditionally thought of as either:

- Supply deficiency, caused by demand for electricity exceeding the existing generation capacity to reliably supply that demand, at the time it occurs
- Network deficiency, caused by a reduced carrying capacity of the network to ensure power can flow from where it is generated to where it is used.

These types of deficiencies may be resolved through:

- Provision of physical infrastructure including additional generation units and network components
- Reductions in demand per customer, peak-shifting changes in demand or distributed, customer self-generation
- Realigning reliability levels (in some cases), such that the costs of an equipment update that would reduce power failures is less than the collective cost to consumers of those failures.

8.6.1.1 The industry development role of electricity infrastructure

Deficiencies of either generation or network within the northern Queensland section of the National Electricity Market may be signalled in various robust forward planning processes, but are unlikely to actually eventuate, precisely because of those processes. Firstly, since northern Queensland has strong interconnections with southeast Queensland, a deficiency of northern generation capacity relative to demand (as has historically existed) can be readily supplied from anywhere in the interconnected network. Secondly, a robust process exists to ensure that Powerlink Queensland and Ergon Energy maintain, and where necessary, augment their respective networks in a timely manner to ensure electricity consumers in northern Queensland continue to enjoy an acceptable level of reliability. Thirdly, reliability standards are under review, which may reduce the obligation to supply high cost, low intensity areas such as the mid-west of northern Queensland. Fourthly, very large individual customers have historically undertaken their own network investment when the regulated network providers have been unable to respond to their time or cost requirements. This includes, for example, the significant networks built and owned by coal miners in the Bowen Basin during its expansion in the 1970s and 1980s. Large mining customers continue to supplement the work of Powerlink Queensland by offering to build their own transmission lines, such as the 250 kilometre Galilee Transmission Line proposed by the Adani Group to connect the proposed Carmichael mine with Powerlink's Strathmore substation.

For all the reasons above, an outright deficiency of generation, inability to connect or the possibility of blackouts are all unlikely to emerge as major issues for electricity consumers in north Queensland. However the wider consequences of network development and customer connection, and in particular its impact on the already high cost of electricity in north Queensland, is a significant issue for new investors in mineral resources.[79] Northwest Queensland from the Mount Isa area to the Gulf of Carpentaria is known to be rich in mineral resources while the Galilee Basin coalfields and mid-northwest shale and renewable resources have immense energy potential. North Queensland's potential for irrigated agriculture is similarly underdeveloped, particularly in the non-coastal areas. Continually increasing energy costs may also reduce the sustainability and productivity of irrigated agricultural businesses as farmers choose to apply less irrigation water to minimise pumping costs with a flow-on consequence of reduced yields. This is a significant issue for industry, particularly in Queensland, where sugarcane producers have already flagged their concern.[80] Furthermore, rising energy costs increase the difficulty of meeting targets to double agricultural production.

The majority of Queenslanders pay the same price for electricity due to the Queensland Government's tariff equalisation policy, under which Ergon Energy offers tariffs throughout regional Queensland that are similar to those in the southeast, with the difference between Ergon's costs and revenue paid for by public funding. Although pricing for large mining, irrigation and industrial customers in northern Queensland is cost-based and efficient, these customers face some of the highest electricity prices in Northern Australia.

8.6.1.2 A northern Queensland electricity price comparison

To illustrate the difference between electricity costs for north Queensland customers and electricity costs elsewhere, including other areas of Northern Australia, we have calculated some hypothetical power bills for FY15. The applicable charges for residential customers are shown in Figure 34 and for industrial customers that have access to the shared network in the National Electricity Network, Mount Isa, Darwin-Katherine and the Pilbara in Figure 35. These charges are compared to those in southeast Queensland and Perth as reference points. Estimates of ongoing charges for larger mining projects, based on specific Queensland proposals, are shown in Figure 36. This illustrates the wide variability of those charges according to location. None of these ongoing charges account for the capital costs of initial connection to the respective shared networks which in themselves may be prohibitive. Collectively these figures illustrate for each of the

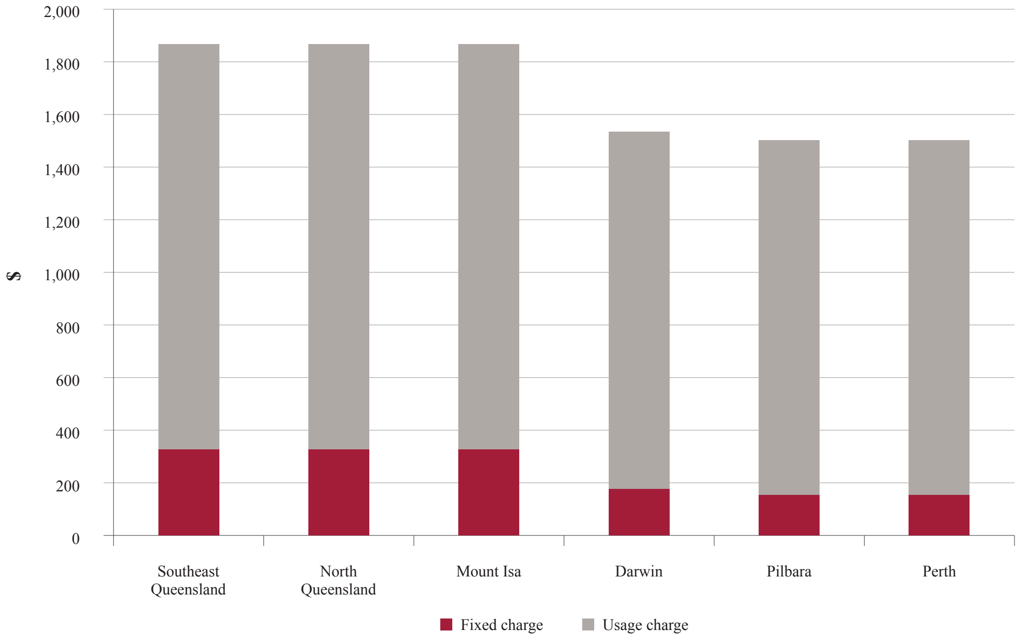
79. See, for example, the discussion in Townsville Enterprise (2014).

80. ABC Rural (2014) "Canegrowers call for national summit to halt power price hikes", http://www.abc.net.au/news/2014-10-09/canegrowers-want-power-price-relief/5802532, accessed 13 October 2014.

three classes of customer the extent of exposure to electricity price differences due to their location.

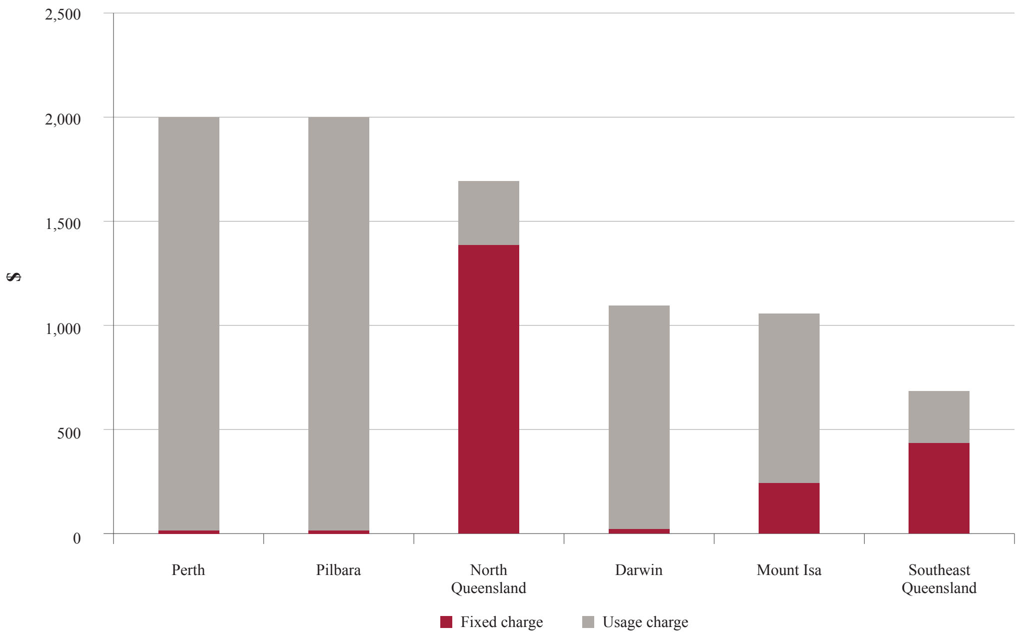
Residential power bills in Figure 34 are for a consumer using 5,000 kWh a year at various Northern Australian locations. There is limited disadvantage to households in the cost of power to living in mid-northwest Queensland, as opposed to anywhere else in Queensland, due to the uniform tariff policy. The regulated price sets a cap for southeast Queensland households and is discounted by retailers. North Queenslanders therefore pay no more than southeast Queenslanders, as they are subsidised to a significant extent by the Queensland Government. However, northern Queensland residential electricity consumers pay more for power than other Northern Australian residents in Darwin and the Pilbara who use a similar amount of power. Whether this is a genuine reflection of the costs of provision — particularly of networks — or relatively greater inefficiencies in Queensland power networks is uncertain.

Figure 34: Comparison of residential power bills for a household consumption of 5,000 kWh p.a.



Source: Published tariff schedules and GHD analysis

Figure 35: Comparison of power bills for large industrial customers up to 2 MW



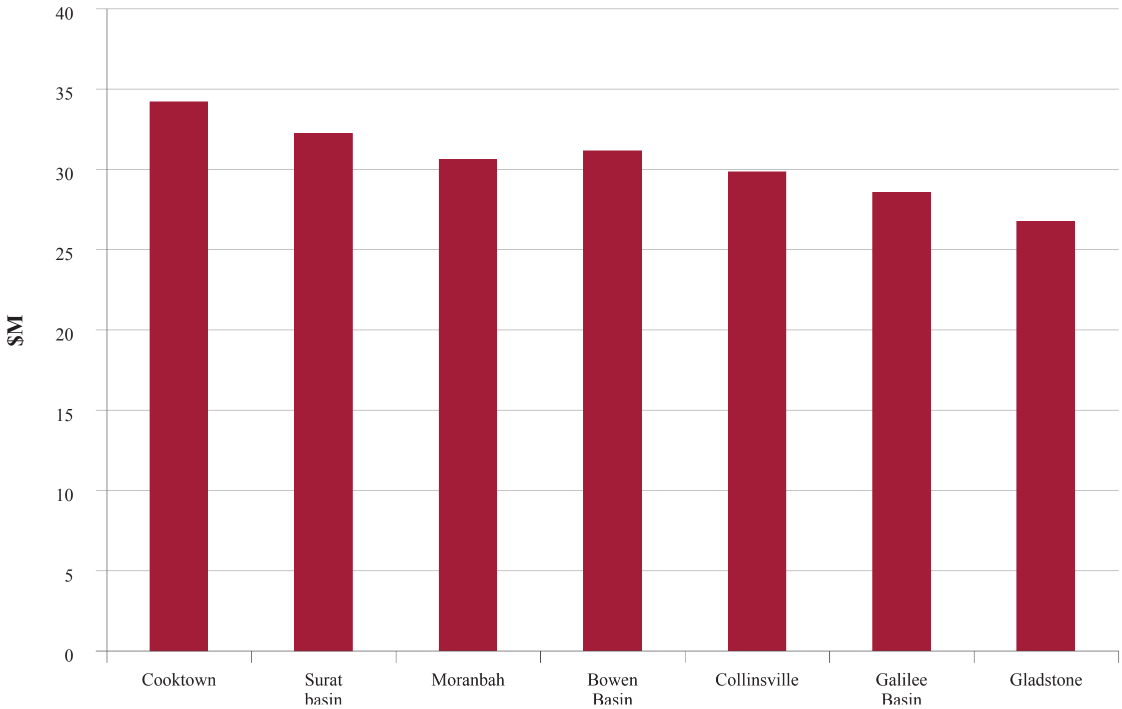
Note: Charges for Queensland assume pass-through of an average wholesale energy price of $45/MWh for the National Electricity Market. An energy price of $146/MWh is assumed for Mount Isa, based on the relative marginal cost of gas CCGT versus black coal steam turbine generation plus gas transmission costs. Source: Published marginal loss factors and transmission charges and GHD analysis

Figure 35 shows power bills for a hypothetical industrial customer drawing maximum power of 2 MW each month and with energy consumption of 13 GWh a year. Within Queensland, variation is due to locational network pricing. The Mount Isa treatment is dealt with separately below. For the Northern Territory and Western Australia, published tariff schedules include an energy price component. The National Electricity Market in mid-northwest Queensland is clearly the second most expensive location in Northern Australia after the Pilbara. In the National Electricity Market, network charges exceed the energy cost for our hypothetical customer, whereas the predominance of isolated systems elsewhere ensures relatively low network costs.

Mount Isa is an isolated system where there is no real market for electricity because there is an effective monopoly supplier. All major supply contracts are bilateral and the generator requires electricity consumers to pay for the cost of the fuel, the cost of the fuel transport and the cost of the generation plant – all on a long term contract with appropriate financial security. In effect a load greater than 2 MW would almost certainly be too large to connect to the network and would have to pay for an investment in generation, the associated gas and gas pipeline capacity on a long term take or pay contract and the operations and maintenance costs of the facilities. The lack of both generator competition and access to a market for supply, results in a substantial financial commitment for new loads that cannot be supplied under standard Ergon Energy regulated arrangements.

Figure 36 draws on information about the sample of proposed energy projects in northern Queensland identified in the Energy Scenario described in Table C.6 in Appendix C. Power bills will vary between each project due to large variations in project size, with associated variation in energy consumption. Therefore power bills were calculated for a representative project using 8 MW, 500 GWh a year of electricity, based on a common wholesale energy price but location-based marginal loss factors and transmission price elements (and excluding up-front connection charges). The comparison shows a difference of up to $7 million a year or 25 per cent between the lowest cost location (Gladstone) and the highest (Cooktown); and that, generally speaking, the further north the project, the higher the cost.

Figure 36: Comparison of power bills for a large Queensland 8 MW energy project within the National Electricity Market



Note: Calculations based on 8 MW maximum demand, 500 GWh energy consumption, an average wholesale energy price of $45/MWh and marginal loss factors and transmission prices

Source: Powerlink Queensland and GHD analysis

All of the above price comparisons are based on published network tariffs for currently connected customers where possible. However, all the non-residential load examples shown would also have significant connection costs, which vary according to individual circumstances, especially the location of the load relative to the existing shared network. The capacity of existing networks (except in southeast Queensland) is very limited in their ability to take a new connection of more than 2 MW.

The capital costs of connection (irrespective of whether paid by the new customer or shared among all network customers) may far outweigh the ongoing charges. In particular, access to the National Electricity Market more than 30 kilometres west of Charters Towers would likely require the cost of a new high voltage connection back to Milchester. The cost of access to a network in the Mount Isa or Darwin-Katherine areas or in the Pilbara would roughly be priced in proportion to the distance from the limited amount of network that is available. The alternative to network connection is on-site self-generation, including capital costs, a possible gas pipeline connection and on-going fuel contract costs (either piped gas or delivered diesel) which is usually significantly more costly.

8.6.1.3 Reasons for high electricity prices in north Queensland

For large electricity users in northern Queensland, prices paid broadly reflect the costs of supply as allocated by the National Electricity Market; however prices for domestic electricity users and other small users are subsidised by the Queensland Government. It is important to understand the difference between the costs of energy supply in northern Queensland and the prices charged (either via market mechanisms or the regulated retail electricity tariff). The costs to deliver electricity to the north are largely determined by the physical structure of the electricity system, particularly the southern location of most Queensland generation, the long distances over which power is transmitted and the market rules for allocation of network charges.

The location of generation in Queensland is largely the result of historic central planning decisions, availability of fuels and the allocation of costs for use of the shared network. The wholesale price for electricity in the Queensland region of the National Electricity Market applies to all areas of Queensland connected to the national grid. The delivered cost is a combination of:

- Wholesale price as determined in the market in each settlement half-hour
- Marginal loss factor (MLF), an economic signal related to the impact of incremental load on losses which is used to mark up the wholesale price differently for each supply location within Queensland
- Allocation of network costs, a portion of which is equally allocated across Queensland and a portion of which is related to the usage attributed to different locations across the State.

North Queensland electricity costs are adversely impacted by:

- High MLFs, due to the location's remoteness from the notional Regional Reference Node, which is used to calculate MLFs
- High locational network charges due to low customer density
- Distribution of shared transmission network costs among all Queensland customers, despite the fact that most of the network exists to supply customers in the southeast.

Additionally, quite aside from the ongoing costs of using the shared network, large customers also often need to consider the initial cost of connecting to the network, which in northern Queensland can entail the individual customer shouldering the considerable cost of building several hundred kilometres of high voltage transmission line.

High connection costs are a critical issue for new loads and generators that are located at a significant distance from the existing grid. This is a disincentive for the development of the proposed coal mines in the Galilee Basin, potential new power stations using the wind and solar resources in the mid-north west and any significant new loads west of Charters Towers. Regulators have recognised the problem of developing major new network into areas that do not have transmission capacity, because an efficient network for a developing region places too much cost onto the first user of the new network. The Scale Efficient Network Expansion rule was seen as a way to allow a number of projects locating in a similar remote region to manage connection costs while having the project proponents carry the risk of the investment rather than all consumers. However, no such projects have yet progressed.

8.6.2 Mount Isa

Future mining expansion is likely to result in electricity demand exceeding the base year FY11 Mount Isa system capacity. Since the base year FY11 forecast, APA and AGL have decided to jointly construct and operate the Diamantina Power Station, expected to provide (together with the adjacent Leichhardt Power Station) up to 302 MW of power by FY15. Units at the power station are being progressively commissioned during 2014. Meanwhile three units at the existing Mica Creek Power Station will be decommissioned, leaving a net capability to adequately supply expected business as usual demand for the next 20 years.

The construction of Diamantina diminishes any immediate opportunity to source future power supplies for the Mount Isa region via interconnection with the National Electricity Market. With recent decisions on Dugald River Mine and changes to Glencore operations, there is likely to be a reduction in generation at Mica Creek once Diamantina Power Station is fully commissioned. Although there is sufficient generating capacity for some load growth in the area there is no market in which to negotiate competitive supply terms. This is further reinforced by the absolute reliance on gas for fuel and the forecast low availability and high prices for domestic gas in Queensland in the medium term. The supply structure in the Mount Isa region is dominated by long term bilateral contracts which make it very difficult if not impossible for new generation including smaller conventional or renewable generation to find a market.

The alternative to interconnected electricity supply is the potential for integrated renewable and diesel standalone generation and energy storage. The capacity of new technology energy storage is providing an option for maximising the value of renewable resources such as wind and solar. This will have application in some specific circumstances of isolated load in the northwest where access to the east coast market remains uneconomic.

The development of additional sources of energy in the northwest will rely on significant load development coincident with the end of existing long term contracts for supply for the major existing loads. Access to a market for both new generation and current and future loads would stimulate as yet uncommitted development of the Carpentaria minerals province including the development of additional sources of power supply. Potential new mining loads in the area together with opportunities for renewable or non-renewable generation in the Mount Isa – Townsville – Collinsville triangle could be supplied by isolated generation systems, an extension of the Mount Isa network or even a connection of Mount Isa to the National Electricity Market. To enhance the development of north Queensland, some degree of coordinating vision is called for to establish the most efficient solution to the area's energy needs, assist new mining loads to develop and achieve a lower cost of electricity in the region for established customers.

The option of building a transmission line to connect Mount Isa to the National Electricity Market has been assessed previously. A transmission line west of Townsville into the Galilee Basin and mid-northwest has some potential to facilitate generally lower prices in northern Queensland by:

- Facilitating the development of multiple generation options along the route with consequential benefits of lower loss factors in the north generally
- Stimulating the development of major mining operations in the northern Galilee Basin
- If extended to Cloncurry, by increasing energy competition in Mount Isa itself.

Benefits may flow from an east-west transmission system for northern Queensland as a result of a significant increase in generation which changes the role and utilisation of the existing north-south transmission system, which is currently used purely to supply energy into northern Queensland.

8.6.3 Northern Territory

Territory Generation and Power and Water Corporation will continue to plan to ensure adequate generation and network capacity is available throughout the Northern Territory.

According to the Utilities Commission of the Northern Territory, the major power system failure that occurred in Darwin in early 2014, which shut down the entire system requiring a black start,[81] was not considered to be caused by system design or capacity shortfalls. Rather, the root cause appears to have been Power and Water Corporation's operational response to a circuit breaker failure. This episode is indicative of the relatively poor level of reliability of electricity supply in the Territory, even when generation capacity is adequate.

The Utilities Commission also reports that the Darwin-Katherine system is expected to have

81. Black Start is the procedure to recover from a total or partial shutdown of the transmission system which has caused an extensive loss of supplies. This entails isolated power stations being started individually and gradually being reconnected to each other in order to form an interconnected system again.

sufficient generation capacity to maintain supply under a 'business as usual' demand scenario through to FY20, given the commissioning of an additional generating unit at Weddell power station in 2013. 'Sufficient' in this context means that expected capacity will, to a high degree of probability, exceed forecast maximum demand by more than the size of the largest two generating units in the system (an N-2 standard). The Commission also assumes that an additional unit will be added to Katherine power station in 2016, but the need for this unit is related to local issues at Katherine rather than overall capacity requirements on the Darwin-Katherine system. Finally, the Commission advises that additional capacity may need to be planned to come on line in FY20.

The Alice Springs system is expected to have sufficient generation capacity in the medium and long term to meet forecast peak demand under a 'business as usual' demand scenario with planned capacity additions. The timing of new plant in the Alice Springs system is influenced far more by the timing of decommissioning of capacity at Ron Goodin Power Station than by load growth.

The generation supply-demand balance in the Tennant Creek system is adequate until at least FY22 (the end of the current detailed planning outlook period). For the period beyond FY22, maintenance of generation and network adequacy is expected to continue to be catered for by Territory Generation and Power and Water Corporation.

8.6.4 Western Australia

8.6.4.1 North-West Interconnected System

Horizon Power expects sustained high load growth in the Pilbara region over the next 20 years, deriving from population growth, new loads, the Western Australian Government's Pilbara development initiatives and growth in the mining sector. However all these factors are essentially underpinned by growth in iron ore extraction to supply export markets. Power infrastructure development is led by Horizon Power and underpinned by the Pilbara Planning and Infrastructure Framework[82] and the vision of the Pilbara Cities program.[83]

A number of projects are in train to secure new generation and upgraded network capacity in the region to cater for load growth. These include an additional 67 MW of generation capacity at Port Hedland (South Hedland) prior to FY16 and the 150 MW South Hedland stage 2 project due to be completed prior to FY21, with additional generation capacity expected to be required before FY31. Specific network upgrades are planned to support the additional generation. An undergrounding project, largely intended to increase reliability under cyclonic conditions, has also been active in replacing overhead lines with underground cable connections in the major Pilbara cities of South Hedland, Roebourne, Karratha and Onslow.

Under these existing planning arrangements, actual capacity shortfalls are unlikely to eventuate. However, current planning arrangements are likely to entail an increasingly unsustainable cost to existing electricity customers, the Western Australian Government and potential new mining connections. In the Pilbara, dispersed industry has generally provided its own power generation and transmission infrastructure, with Horizon Power filling in the gaps by ensuring power supply both to the cities and remote communities. This has left a legacy generation capacity in the Pilbara that is not connected to the North-West Interconnected System. Resource project and location-specific self-generation and the relative lack of an integrated electricity system inhibits the more efficient sharing of resources that may be facilitated by a network and can result in under-utilised generation capacity and higher than necessary costs.

Although electricity tariffs for residential and small business use in the Pilbara are comparable with eastern capital cities, the cost of provision is subsidised by the Western Australian Government's uniform tariff policy, currently costing Western Australian taxpayers in the order of $370 million a year. Typical consumption in the region is already relatively high and energy subsidies provide a barrier to increased efficiency and to investment in roof-top photovoltaic installation.

Horizon Power has previously proposed an East Pilbara link between Port Hedland and Newman, connecting nearby Fortescue Metals Group and Rio Tinto Iron Ore operations and completing a network ring linking Dampier, Wickham, Port Hedland, Newman, Paraburdoo and Pannawonica. The benefits of such a coordinated development, when combined with a single network operator operating on a market basis, would include reduced electricity supply capital and operating costs, saving of scarce water resources, greater opportunities to harness disparate renewable energy sources and reduced barriers to entry for junior mining resource holders. However,

82. Planning Western Australia (2012)

83. Pilbara Development Commission (2014)

until sufficient aggregate demand exists and/or energy costs rise substantially, these benefits will not exceed the costs of such a project. Without coordinated planning of a strategic nature, the net benefits of large-scale system development such as the East Pilbara link are unlikely to change, as new mining operations will continue to invest in their own on-site generation capacity.

The key strategic infrastructure constraint is therefore connected with the cost of extending the network to connect potential new isolated loads as mining expands. Unconstrained, future fuel price levels will tend towards the prices available in export markets. Any relaxation of the Western Australian Government's domestic gas reservation policy would therefore likely result in higher gas prices. The provision of electricity to supply demand growth in the region at lowest cost will become increasingly important if gas prices do increase, thereby driving up the cost of electricity generation. As the number and scale of mining loads in the region grows, the cost of developing the integrated system will reduce further relative to the cost of increasing the number of isolated generating units.

8.6.4.2 Non-interconnected system

In the absence of opportunities to integrate with an expanded North-West Interconnected System in the Pilbara, there are no significant electricity infrastructure gaps outside that system. However, this does not mean that significant investment is unnecessary. The planning responsibilities allocated to Horizon Power provide an orderly process for replacement, upgrading and new additions to electricity infrastructure for the period up to and including FY31. A number of projects entail additional generation, either built or contracted from third parties by Horizon Power. Increases in embedded renewable energy capacity could defer investment requirements in certain locations.

Pilbara

Marble Bar and Nullagine

Marble Bar and Nullagine are separate service centres for agriculture and remote communities in the Pilbara. They both have significant installed renewable photovoltaic farm generation capacity, albeit with a relatively low proportion of that capacity dependably available to meet maximum demand (since they rely on sunlight). The photovoltaic farms are therefore backed up by diesel gensets and short-term flywheel storage systems. Capacity is considered adequate, although using Horizon Power's N-2 criterion there is currently no capacity for load growth. Renewed load growth at either location would therefore imply a need to install additional generation.

Onslow

Horizon Power forecasts significant demand at Onslow from BHP Billiton's Macedon and Chevron's Wheatstone off-shore gas and on-shore processing projects. Immediate needs for an expansion of generation capacity are being addressed by Horizon Power by FY16. An additional 1 MW capacity has been installed since FY11. Meanwhile, a new 9 MW power station is being designed and built by Chevron before being handed over to Horizon in conjunction with new connection equipment built by Horizon Power.

Incremental additions to the new power station may be made before 2021 if demand growth continues. Dispersed renewable generation would defer the need for such additional increments.

Kimberley

Kununurra/Wyndham/Lake Argyle

Horizon Power expects demand growth in this region to be related to Ord agricultural scheme expansion and increased mining and tourism.

This system lacks redundancy as it is based on a single transmission line connecting the main power hydro station to Kununurra and Wyndham. The Ord hydro power station, which is operated by Pacific Hydro, provides 60 per cent of Horizon Power's system capacity but at present can only provide that capacity in full 86 per cent of the time.

The load rejection scheme at the power station only operates under complete loss of power flow on a single transmission line, rather than continuously monitoring the balance of load and supply on the line. It would be desirable for Horizon Power's customers if the load rejection scheme were upgraded by Pacific Hydro in tandem with network upgrades planned by Horizon Power.

Warnum

Warnum is a service centre for local agricultural and remote communities. Generation is contracted by Horizon Power for the town and the power purchase agreement will need to be renewed by 2021.

Broome

Horizon Power expects continued high demand growth in the Broome area as a result of Browse basin oil and gas development and related on-shore processing, growth in tourism and associated resident and non-resident population growth.

Existing generation is unreliable and the distribution system will need to be augmented to cater for major new block loads. Additional generation capacity will be needed as load in the area grows, with uncertain timing. Dispersed renewable generation can defer additional diesel or gas generation.

Derby

The new Derby prison is a significant addition to load in the area. Low reliability is mainly caused by equipment failure. Continuing high load growth will need to be addressed by additional generation capacity of perhaps 1 MW. Dispersed renewable generation can defer additional diesel or gas generation.

Cambollin/Looma

The two nearby towns of Cambollin and Looma are joined electrically and share generation capacity. The existing power purchase agreement will need to be renewed by FY21. Additional generation capacity is unlikely to be required before FY31 unless demand growth recurs.

Fitzroy Crossing

Fitzroy Crossing is a service centre for agriculture and remote communities in the area. The existing power purchase agreement will need to be renewed by FY31. If demand continues to grow at recent rates, additional generation of at least 1 MW will be required by FY31. Dispersed renewable generation can defer additional diesel or gas generation.

Exmouth

Growing electricity demand is forecast at Exmouth, driven by fishing, manufacturing and tourism. A single high voltage customer, Watercorp, accounts for a maximum of 0.055 MW of the current peak demand of around 6 MW. Horizon Power plans incremental average increases in generation capacity for the town at the rate of 0.87 MW every two years. Horizon Power advises that a power purchase agreement renewal will be necessary before FY31; and that hosting capacity for dispersed renewable generation was exceeded in 2012.

8.7 Electricity critical infrastructure requirements

A reliable and efficient supply of energy is essential if the full potential of Northern Australia — including tourism, agriculture and services to support a higher resident population, as well as mining — is to be realised. Strategic reviews of north Queensland and the Pilbara need to be undertaken to determine the most suitable framework within which new supply capacity may be provided to cater for as yet unrealised resource development opportunities. Even areas currently in the planning stage such as the northern Galilee will require a degree of coordinated development of enabling electricity, rail and water infrastructure. Meanwhile there are many smaller locations throughout Northern Australia that will continue to need electricity supply on an isolated basis and replacement and updating of these assets, incorporating renewable generation sources where efficient.

Energy – gas pipelines

9.1 Introduction

Australia produced 2,030 petajoules of gas in FY11, of which around 53 per cent was for the domestic market. The coal seam gas (CSG) share of production for the domestic market rose during FY11 to 21 per cent, with the remainder sourced from traditional porous rock formations. All of Northern Australia's current production of CSG comes from Queensland and considerable known reserves remain in the Bowen Basin.

Around half of Australia's gas production is sourced from offshore basins in Western Australia and the Northern Territory and is exported as liquefied natural gas (LNG). This ratio is increasing with the development of major new LNG projects in Queensland and Western Australia. The major share of domestic gas — particularly in Australia's north — is consumed by electricity production.

This section focuses on the handful of critical gas transmission pipelines that supply primary energy for electricity production, and gas pipelines connected to export LNG facilities in the Northern Australia study area. The most critical new infrastructure development under consideration is likely to be the linking of northern with eastern gas markets.

9.2 Gas pipelines in scope

Gas pipelines in scope are listed in Table 24, mapped in Map 13 and discussed below.

Carpentaria gas pipeline

The Carpentaria gas pipeline allows gas to flow northward from the South West Queensland pipeline and Ballera to supply the Mica Creek Power Station, as well as Cannington mine and Mount Isa town.

North Queensland gas pipeline

The North Queensland gas pipeline allows coal seam gas to flow north from Moranbah in the Bowen Basin to the Yabulu power station and large industrial customers in Townsville. Unlike other pipelines in Queensland, it is not connected to any other pipelines in the eastern Australian gas network.

Queensland gas pipeline

The Queensland gas pipeline begins at Wallumbilla in southeast Queensland and ends at Gladstone on the Queensland coast. The pipeline supplies large industrial users and gas distribution networks in Gladstone and Rockhampton, as well as a gas distribution network in Wide Bay. Gas is sourced through pipeline connections at Wallumbilla or from the Bowen Basin coal seam gas fields along the pipeline's route.

Amadeus and Bonaparte gas pipelines

Historically the Amadeus-Bonaparte gas pipeline system has been supplied from either end, both from central Australia (the Amadeus Basin) and from the Timor Sea (Bonaparte Gulf). Amadeus Basin supply to Power and Water Corporation ran out in 2012 and was replaced by Blacktip in the Bonaparte Gulf, for which a 25 year contract will provide adequate supply until 2034. Alternative sources are also available as back-up (including Darwin LNG and liquid fuels, owing to the dual-fuel capacity of many generating units). Power and Water advised FY12 gas demand was 56.7 terajoules (TJ) per day (half current supply capacity).

The Amadeus gas pipeline transports gas to Darwin, Katherine and other locations principally to fuel electricity generation in the Northern Territory. When it was built, gas flowed northwards to Darwin from the Palm Valley and Mereenie gas fields in the Amadeus Basin. However, since 2008 natural gas from the Blacktip gas field in the Bonaparte basin has been fed through the Bonaparte gas pipeline into the Amadeus gas pipeline . This gas flows north to Darwin and south to Alice Springs.

The Bonaparte gas pipeline carries natural gas from the Eni Gas Plant at Wadeye to the Amadeus gas pipeline at Ban Ban Springs, thus allowing that pipeline to be supplied from the Blacktip gas field in the Bonaparte basin.

Daley Waters to McArthur and Palm Valley to Alice Springs river pipelines

These pipelines supply natural gas from the Amadeus gas pipeline to, respectively, the McArthur River Mine and the Alice Springs area.

Dampier to Bunbury natural gas pipeline

The Dampier to Bunbury natural gas pipeline transports gas from the North West Shelf gas fields near Dampier to customers in the southwest of Western Australia. It consists of a mainline and several laterals (the total length of laterals is 339 kilometres). The pipeline capacity has been expanded at various stages with looping and upgrades to compressors.

Goldfields gas pipeline

The Goldfields gas pipeline transports gas from gas fields in the Carnarvon basin and the North West Shelf to mining customers in the Pilbara, Murchison and Goldfields regions of Western Australia for industrial use and power generation.

Karratha to Cape Lambert pipeline

The Karratha to Cape Lambert Pipeline is a transmission pipeline operated by Robe River Mining Company. It transports gas from the Dampier to Bunbury natural gas pipeline at Karratha, to Cape Lambert where the gas is used for power generation.

Pilbara pipeline system

The Pilbara pipeline system is a free flowing transmission pipeline that transports gas from the Carnarvon basin from Karratha to Port Hedland and Wodgina. It is connected to the Dampier to Bunbury natural gas pipeline, the Telfer Gas Pipeline, the North West Shelf Dampier processing plant and the Karratha power station.

Telfer gas pipeline

The Telfer gas pipeline connects to the Pilbara pipeline system and transports gas to mine sites in the Great Sandy Desert. As a secondary pipeline, its customers are reliant on the availability of capacity on the Pilbara pipeline system. Telfer gas pipeline capacity is understood to be fully contracted to the Telfer gold mine and the Nifty copper mine.

9.3 Existing gas pipeline capacity

Base year existing gas pipeline capacities are shown in Table 24. The Australia Pacific Liquefied Natural Gas Pipeline (APLNG) is currently under construction to supply the APLNG export facility at Gladstone from gas sources in south Queensland. It is expected to commence gas flow in 2015 with a capacity of 1,250 TJ per day.

The Arrow-Bowen pipeline is an announced project to transport coal seam gas from the Bowen Basin to export facilities at Gladstone. It is proposed to commence in FY17 with a capacity of 490-1,000 TJ per day. There have also been suggestions of connecting Galilee basin gas sources with export markets and to nearby power stations.

APA Group is currently undertaking a feasibility study into connecting Northern Territory gas pipelines with eastern Australia; details are in Section 9.4.

Table 24: Characteristics and FY11 capacity of in-scope gas pipelines

	Electricity supply area	Length (km)	Capacity (TJ/day)
Carpentaria Pipeline	Mount Isa	840	119
North Queensland Gas Pipeline	Townsville	391	108
Queensland Gas Pipeline	Gladstone	629	142
Amadeus Gas Pipeline	Darwin-Katherine	1,512	104
Bonaparte Gas Pipeline	Darwin	287	80
Daley Waters to McArthur River pipeline	McArthur River	330	16
Palm Valley to Alice Springs Pipeline	Alice Springs	140	27
Dampier to Bunbury Natural Gas pipeline	Perth	1,854	869
Karratha to Cape Lambert pipeline	Cape Lambert	57	
Goldfields Gas Pipeline	Mount Newman iron ore mine and Newman township	1,427	150
Pilbara Pipeline System	Karratha-Port Hedland-Dampier	219	188
Telfer Gas Pipeline	Telfer Gold Mine	443	25

Source: Australian Energy Regulator (2011)

9.4 Drivers of additional gas pipeline capacity

Forecasts of Queensland gas pipelines' maximum utilisation rates in the next 10 years are reported by AEMO as follows: Carpentaria Gas Pipeline 91.4 per cent; Queensland Gas Pipeline 98.6 per cent; and North Queensland Gas Pipeline 28.7 per cent. These maximum utilisation rates are generally reached in 2018 and then fall, so it is unclear to what extent demand-based capacity limitations are likely to be reached prior to FY31.

Comprehensive data on utilisation of gas pipelines in Western Australia and the Northern Territory are not published.

Gas consumption in existing Northern Australia locations is driven by electricity generation and new mining loads. Newly developed gas sources in north Queensland, in particular, but also in the Canning Basin in Western Australia, may drive additional connections to export markets.

Whether new transmission pipelines are built largely depends on the location of future mining loads and the relative cost of gas versus new electricity transmission infrastructure. Recent exploration in the Galilee Basin has not yet resulted in conclusive plans for development of new CSG production. For such production to be feasible, a new pipeline would very likely be required to connect the new sources of gas to eastern gas or export markets via the North Queensland Gas Pipeline. Nevertheless, export gas prices and policies affecting domestic prices such as the Western Australian Government's 15 per cent domestic reservation policy may be key to understanding future gas demand and infrastructure needs. In this respect the recently initiated campaign for a national gas reservation policy should be noted.[84]

The Northern Territory Government proposes connecting its gas fields with eastern gas markets by constructing a pipeline from Alice Springs to Moomba, or via a possible alternative route from Tennant Creek to Mount Isa.[85] This would be a major undertaking, costing up to $1.3 billion which would open up opportunities for flows in either direction to fulfil both overseas exports and domestic needs. A link of this type would also drive development of potential new sources of gas from the Amadeus Basin. APA Group announced a $2 million feasibility study of the project in February 2014. In October 2014, the Northern Territory Government granted major project status to the proposed pipeline.[86] COAG has agreed that connecting the northern and eastern gas markets will contribute to the development of a more national and competitive domestic gas market, helping to improve supply security.[87] An expression of interest process for construction commenced in late 2014.[88]

Eleven companies were invited in December 2014 to submit initial proposals. The companies are scheduled to submit proposals by March 2015.[89]

9.5 Gas pipeline critical infrastructure requirements

A summary of identified infrastructure gaps, their causes and consequent requirements is shown in Table 25.

Table 25: Gas pipeline critical infrastructure requirements

Infrastructure grouping	Location	Primary infrastructure gap(s)	Infrastructure requirements
Link to eastern gas markets	Alice Springs to Moomba, or Tennant Creek to Mount Isa	Demand, opportunity	Gas pipeline link

84. http://www.abc.net.au/am/content/2014/s4096305.htm, accessed 8 October 2014
85. Northern Territory Government (2014)
86. http://newsroom.nt.gov.au/#mediaRelease/10370, accessed 18 October 2014
87. COAG communique 10 October 2014
88. http://minister.industry.gov.au/ministers/macfarlane/speeches/announcement-northern-territory-eastern-australia-gas-pipeline, accessed 18 October 2014
89. http://newsroom.nt.gov.au/mediarelease/10370?y=2013&=3

Water

10.1 Introduction

Access to reliable water resources is essential to the further development of Northern Australia. This is especially so given that the industries with the strongest natural advantages include water-intensive agriculture, aquaculture and mining.

Water is a common resource, ownership of which is vested in the Crown. The sharing of this common resource is stipulated in the water resource planning framework in each state and territory and geared towards sustainable management and development of the resource. Therefore, the provision of water services and the operation of water infrastructure assets are subject to the amount of water resource that is identified as available for consumptive use. This section commences with an overview of the water resource planning frameworks of the three jurisdictions, before addressing infrastructure capacity, future water demand and an assessment of infrastructure gaps in the areas of water for urban use and bulk (industry) use.

In addition, a number of jurisdictions have recently or are currently reviewing their water legislation which may impact the existing regulatory arrangements discussed in the following sections.

Whilst specific water legislation may have a lead agency/department, the regulation of Australia's water sector is highly fragmented with multiple agency involvement and flow-on impacts to economic, social and environmental regulation. This can also impact approval processes for water service infrastructure in terms of complexity translating to time and cost pressures.

10.2 Water resource planning framework

10.2.1 National Water Initiative

In 2004, the Council of Australian Governments signed the National Water Initiative (NWI) agreement, which included objectives, outcomes and agreed commitments across eight inter-related elements of water management.[90] The NWI is a shared commitment by governments to increase the efficiency of Australia's water use, leading to greater certainty for investment and productivity, for rural and urban communities, and for the environment. Under the NWI, governments made commitments to:

- Prepare water plans with provision for the environment
- Deal with over-allocated or stressed water systems
- Introduce registers of water rights and standards for water accounting
- Expand the trade in water
- Improve pricing for water storage and delivery
- Meet and manage urban water demands.

Progress on NWI to date has been less advanced in the north, largely due to the smaller number of water users (lower population) and lesser perceived urgency in the north compared to the south. While there has been progress in recent years, it will be important to ensure that future increases in demand are met by sustainable provision of the resource and efficient water

90. Tasmania and Western Australia signed the agreement in 2005 and 2006 respectively.

infrastructure.[91] Notwithstanding this, major new multi-generational enabling or transformational water infrastructure may be challenged with principles of cost reflective pricing and willingness and capacity to pay issues. Assessing the net economic benefits of such assets is also challenging as many of the future users and sources of economic benefit are uncertain on day one, leading to potential benefits not being readily quantifiable in economic assessments.

10.2.2 Queensland water resource planning

In Queensland, the overarching legislation is the *Water Act* 2000, which describes how the state's water resource should be managed through its water resource planning process (the Act has recently been reviewed).

Water resource plans are subordinate to the *Water Act* 2000 and have been developed through technical and scientific assessment as well as extensive community consultation, to determine the right balance between the economic, social and environmental demands on the state's water resources. Each plan covers a catchment and describes the surface water and/or groundwater available within the catchment, general and ecological outcomes, performance indicators and water available for consumptive purposes.
It also defines the amount of water (if any) that is available for future allocation (unallocated water).

Finalised water resource plans are implemented through resource operations plans. Each operations plan describes the details of water releases from dams, distribution to users, environmental flow requirements, and water trading rules with regard to temporary (seasonal) and permanent trade of water allocations. The Water Act 2000 has recently been reviewed to streamline delivery of water resource services, with a water reform bill passed by the Queensland Parliament in November 2014.[92]

10.2.2.1 Catchments

There are 22 catchments in Queensland. The location and boundaries of these catchments are shown in Map 14. All catchments except Cape York[93] have gone through the resource planning process and have water resource plans and resource operational plans. Of the 22 catchments, 13 catchments fall within the boundary of Northern Australia: Boyne River Basin, Calliope River, Fitzroy, Pioneer Valley, Whitsunday, Burdekin, Barron, Wet Tropics, Mitchell, Cape York, Gulf, Georgina and Diamantina and Cooper Creek.[94]

10.2.2.2 Unallocated water

In some catchments, unallocated water can be made available for future consumptive use without compromising the environment or the security of existing supplies. Table 26 provides a guide to the amount of unallocated water reserved for general purpose, strategic and infrastructure upgrades

91. Green Paper on Developing Northern Australia

92. See https://www.dnrm.qld.gov.au/water/catchments-planning/water-reform, accessed 9 January 2015

93. The Gulf WRP and ROP are currently undergoing amendments. The draft ROP amendment proposes greater flexibility for existing water licences to support development in the Flinders and Gilbert river catchments by making licences permanently and seasonally tradeable (transferable). As well as proposing rules and assessment criteria for licence transfers, the draft ROP amendment is also updating unallocated water release provisions.

94. Note that currently there are no major water infrastructure assets in the Georgina and Diamantina and Cooper Creek catchment areas.

that may be available for further distribution in each catchment. It is important to note that some catchments may not have identified unallocated water when the water resource plan or resource operational plan was prepared, if there was no need at the time to investigate the potential of further consumptive use of water resource in the catchment in the future.

Table 26: Unallocated water (reserved for future allocations)[1] as at June 2012

Catchment	Strategic reserve[2] (ML)	General reserve (ML)	Infrastructure reserve (ML)
Barron	4,000	-	-
Gulf[3]	58,000	119,900	-
Mitchell	10,000	55,000	-
Burdekin	35,000	200,000	308,744
Fitzroy	20,950	89,750	222,400
Boyne	200	2,443	19,000
Whitsunday	1,500	28,500	-
Pioneer Valley	10,500	4,000	-

Notes:
1 The unallocated water identified here may not be available uniformly across the catchment area identified.
2 Projects need to meet the criteria outlined in the WRP/ROP in order to be able to access water from the Strategic Reserve.
3 The draft Gulf ROP amendment is currently undergoing hydrological assessment to update unallocated water resources available for consumptive use
Source: Queensland Department of Natural Resources and Mines

10.2.3 Northern Territory water resource planning

In the Northern Territory, the overarching legislation is the *Water Act* (NT), which provides for the investigation, allocation, use, control, protection, management and administration of the Territory's water resources. The *Water Act* allows for enhanced water resource management in certain areas through the declaration of Water Control Districts. Water control districts have been declared for the Alice Springs, Daly Roper, Darwin Rural, Gove Peninsula, Great Artesian Basin, Tennant Creek, Ti-Tree and Western Davenport regions. Water allocation plans can be declared under the *Water Act* within water control districts to allocate water resources to various uses. There are currently four water allocation plans declared and five in progress within the territory, as shown in Map 15.

10.2.4 Western Australia water resource planning

In Western Australia, a range of legislation governs the State's water resource planning, allocation, management and regulation. Management of water abstraction from both surface and groundwater sources involves the issuing of water licences under the *Rights in Water and Irrigation Act 1914* (WA).

10.2.4.1 Water allocation plans

Within the Northern Australia boundary, there are currently three water allocation plans – the Ord River surface water plan and the La Grange groundwater plan in the Kimberley region and the Pilbara groundwater plan (Maps 16a and b). These plans are at an ongoing implementation and evaluation stage.

The State's water legislative framework is currently undergoing reform. The aim is to simplify and streamline the legislation, which at present is spread across six different Acts,[95] into a single new Act. A key feature of the new framework is the introduction of statutory allocation limits and plans, which will ensure that the amount of water drawn from a groundwater aquifer is sustainable and is done in a way that provides certainty for users. Figure 37 details the key features of the new framework and how they relate to existing arrangements.

95. *Rights in Water and Irrigation Act 1914* (WA) – the principal legislation for the allocation and management of water resources; *Country Areas Water Supply Act 1947* (WA) – provides for the protection of public drinking water source areas in rural areas and the regulation of clearing control areas; *Metropolitan Water Authority Act 1982* (WA) – authorises the provision of certain drainage works and coordinates drainage services; *Metropolitan Water Supply, Sewerage and Drainage Act 1909* (WA) – provides for the protection of public drinking water source areas in the metropolitan area; *Water Agencies (Powers) Act 1984* (WA) – provides many of the works and other powers of the Minister for Water and the Department of Water; *Waterways Conservation Act 1976* (WA) – provides for the conservation and management of certain waters and associated land and environment.

Figure 37: Western Australia's new water resources legislative framework

	Existing framework	New water resource management framework	
		Improved licensing and management	Water access entitlements
Instruments	A licence to take a works permit	A licence to take and a works permit	Water access entitlement and abstraction arrangements
Duration of tenure	Usually 10 years	Up to 40 years	Perpetual
Nature of access right	Volumetric, with limited flexibility to vary take to match water availability	Volumetric with a mechanism to vary the take depending on how much water is available	Share of a consumptive pool with periodic allocations determined in accordance with available water in the pool
Planning	Non-statutory water allocation plans	Statutory allocation limits and statutory water allocation plans	Statutory water allocation plans are mandatory
Licensing of take from farm dams	Authorisation required to construct a farm dam and volumes may be licensed	No change to existing	Farm dams that currently require a licence to take water can be given a water access entitlement
Trades and transfers	Licensed entitlements are tradeable and licenses are transferable following assessment	Simplified mechanism for trading and transfer of licensed entitlements	Tradeable water access entitlements
Administration	Full assessment for all licence and permitting applications	Simplified, risk-based permitting and assessment	Implementation through statutory water allocation plan

Source: Western Australia Department of Water

10.2.4.2 Unallocated water

As at June 2012, the amount of groundwater and surface water allocated and committed is summarised in Table 27 below.

Table 27: Water resources and availability status[1]

Region	Allocation volume[2] (GL/year)	Percentage of allocated and committed water resource
Kimberley		
Ord River and Tributaries	905	0 – 70%
Canning basin (groundwater)	308	0 – 70%
Bonaparte basin (groundwater)	7	0 – 70%
Pilbara		
Pilbara coast	29.4	71 – 100%
Surplus mine dewater	160	n/a
Remainder	142	0 – 100%
Gascoyne		
Carnarvon basin (around Onslow)	15	0 – 99%

Notes:
1. Information compiled from Water resources inventory 2014, *Figures 1 and 2.*
2. Allocation volume represents the combined allocation limits for surface water or groundwater sources within the area
Source: Western Australia Department of Water (2014)

10.3 Water infrastructure in scope

10.3.1 Queensland water infrastructure

10.3.1.1 Bulk water services

The supply of freshwater begins with the large scale water storages that capture and store the water resource in stream within the catchment. Queensland structures its bulk water supply network based on the hydrology of the catchment and the geography of the stream system and the site of the water storage. Water supply schemes then distribute water through pipelines or channels (gravity fed or pumped) to bulk water users. The main bulk water service provider in Queensland is SunWater. Map 17 maps the major water infrastructure and Table 28 lists the critical bulk water supply networks that are in scope.

Table 28: Critical infrastructure supplying bulk water

Catchment	Water supply scheme	Main water storages	Main use	Operator/Owner
Barron	Mareeba-Dimbulah	Tinaroo Dam	Irrigation[1]	SunWater
	Cairns-Mulgrave	Copperlode Falls Dam	Town	Cairns RC
Gulf	Mount Isa Water Board	Lake Moondarra Dam	Town, mining, industrial	Mount Isa Water Board/ Xstrata
		Julius Dam		Mount Isa Water Board/ SunWater
	Other	East Leichardt Dam, Corella Dam	Currently not being used	Department of Natural Resources & Energy
Mitchell	Not applicable	Lake Mitchell Dam	Not available	Private company
Townsville sub region	Ross River Paluma-Crystal	Ross River Dam, Black School Weir, Paluma Dam, Crystal Creek Weir	Town	Townsville Water
Burdekin[2]	Burdekin Haughton	Burdekin Falls Dam, Clare Weir, Gorge Weir	Irrigation and town	SunWater
	Bowen Broken	Eungella Dam, Bowen River Weir	Mining and town	SunWater
Fitzroy	Nogoa Mackenzie	Fairbairn Dam, Selma Weir, Bedford Weir	Town, mining and irrigation[3]	SunWater
	Lower Fitzroy	Eden Bann Weir	Power generation, town and irrigation	SunWater
	Fitzroy Barrage	Fitzroy Barrage	Town	Fitzroy River Water
Boyne River	Awoonga Callide, Gladstone Area Water Board	Awoonga Dam	Town and industrial	SunWater/Gladstone Area Water Board
Whitsunday	Proserpine River	Peter Faust Dam	Town, sugarcane and sugar mill	SunWater
Pioneer Valley	Pioneer River	Teemburra Creek Dam, Dumbleton Weir	Town and irrigation	SunWater
	Eton	Kinchant Dam	Sugarcane	SunWater

Notes:

1. Sugarcane (main crop), mangoes, bananas, pawpaws, various citrus, avocados, tobacco, general horticulture, tea-trees, coffee and other garden industry products (grasses and legumes for seed production) as well as irrigation for pastures for livestock farming.

2. Mining use in the Bowen Coal Basin. The weather in Burdekin allows for double-cropping of many field crops. It is the largest sugar producing region in Australia, complemented by a wide variety of horticultural crops, which include melons, mangoes (one-third of the national mango harvest), plums, bananas, tomatoes, capsicums, chillies, beans, pumpkins, eggplants and cucumbers.

3. Main crops: cotton, citrus (mandarins, oranges and lemons) and grapes; other crops: wheat, pulse crops, sorghum, maize, lucerne, oats, barley and sunflowers.

Source: Australian Bureau of Statistics, SunWater, local government councils and Department of National Resources and Mines

10.3.1.2 Urban water and wastewater services

The distribution of treated potable water is mostly provided by water service business units within local government councils. Table 29 identifies the water service providers, their main source of water supply and the key urban centres and localities (UCLs) that receive their service. Consistent with the audit criteria, the list excludes UCLs with fewer than 3,000 people.

Table 29: Water service providers supplying urban water and wastewater services

Water service provider	Major UCLs	Main source of water supply
Burdekin Regional Council	Ayr Burdekin	Groundwater (recharge from Burdekin)
Cairns Water and Waste	Cairns and Gordonvale Port Douglas-Craiglie	Copperlode Falls Dam and Behana Creek Rex Creek (Mossman Gorge)
Cassowary Coast Regional Council	Innisfail, Tully	South Johnstone River
Central Highlands Regional Council	Emerald Blackwater	Fairbairn Dam and Emerald Weir Bedford Weir
Charters Towers Regional Council	Charters Towers	Burdekin River, Charters Towers Weir and groundwater
Fitzroy River Water (Rockhampton)	Rockhampton and Gracemere Yeppoon and Emu Park	Fitzroy River Barrage Waterpark Creek and connection to Rockhampton reticulated network
Gladstone Regional Council	Gladstone, Tannum Sands – Boyne Island, Calliope	Awoonga Dam
Hinchinbrook Shire Council	Ingham	Herbert River & groundwater
Isaac Regional Council	Moranbah Middlemount Dysart Nebo	Eungella Dam, Burdekin Falls Dam Fairbairn Dam BMA’s Calvert’s Dam Groundwater
Longreach Regional Council	Longreach	Thomson River Weir and groundwater
Mount Isa City Council	Mount Isa	Lake Moondarra Dam and Julius Dam
Tablelands Regional Council	Atherton and Mareeba Kuranda	Tinaroo Falls Dam Barron River and groundwater
Townsville Water	Townsville	Ross River Dam and Paluma Dam / Crystal Creek, connection to Burdekin Haughton Water Supply Scheme
Water and Waste Services (Mackay)	Mackay Sarina Walkerston	Teemburra Creek Dam and weirs on Pioneer River Middle Creek and groundwater Dumbleton Weir
Weipa Town	Weipa	Groundwater
Whitsunday Regional Council	Bowen, Airlie Beach – Cannonvale Proserpine, Collinsville	Peter Faust Dam and groundwater Peter Faust Dam and groundwater Bowen River Weir and groundwater

Source: Australian Bureau of Statistics, SunWater, local government councils and Department of National Resources and Mines

10.3.2 Northern Territory water infrastructure

10.3.2.1 Urban water and wastewater services

The main water source for most of the Northern Territory regions is groundwater, with all centres relying on groundwater for all or part of their supply. Darwin River Dam provides about 85 per cent of current water needs, or 37,000 mega litres per year, with the balance drawn from the McMinns and Howard East borefields.[96]

Power and Water Corporation is the main water service provider and provides mostly treated potable water, with the exception of minor non-potable supplies for urban irrigation and a major recycled water scheme in Alice Springs. Irrigation water users are managed by the Department of Land Resource Management. Map 18 maps the major infrastructure and Table 30 lists the critical bulk water supply networks that are in scope.

Table 30: Critical water infrastructure in the Northern Territory

Major UCLs	Main source of water supply	Main use
Alice Springs area	Roe Creek Borefield	Town
Darwin area	Darwin River Dam (85%) McMinns, Howard East Borefields (15%)	Town
Katherine	Donkey Camp weir, groundwater	Town
Nhulunbuy	Groundwater	Town
Tennant Creek	Cabbage Gum / Kelly Well Borefields	Town

Source: Power and Water

Power and Water Corporation owns and operates wastewater treatment plants in all of the Northern Territory's five major centres and five of the minor urban centres. The wastewater infrastructure assets are mostly in good condition, however most plants are about 20 to 30 years old. The issue in wastewater services is not just capacity but also the level of treatment, which with a change in environmental water quality would require a step change to infrastructure.

Existing sewerage treatment plants in the Darwin region are progressively being upgraded on a priority basis to improve treatment outcomes. Since the $20 million Ludmilla wastewater treatment plant upgrade project was completed in April 2013, the highest priority upgrade currently is the Leanyer/Sanderson treatment plant, which services the northern suburbs of Darwin, followed by East Arm treatment plant to support growth in the industrial precinct. Since the FY11 base year, a $6 million upgrade of the Katherine wastewater treatment plant has been completed. The plant is now positioned to cater for significant growth in the township for years to come.

10.3.3 Western Australia water infrastructure

10.3.3.1 Urban water and wastewater services

The Water Corporation of Western Australia is the main water service provider and mainly provides treated potable water to residents and fit-for-purpose freshwater to some industrial users. While some service hubs may be larger than some towns, they are not currently connected with a licensed water service provider. The smaller communities (fewer than 50 people) are generally 'self supplied' in terms of water services. The main water source for most of Western Australia's (in-scope) regions is groundwater, with the exception of the Ord River Scheme in Kununurra, Moochalabra Dam in Wyndham and the Harding Dam near Roebourne. Map 19 maps the major water infrastructure and Table 31 lists the critical bulk water supply networks that are in scope.

96. Power and Water Corporation (2014), p.18

Table 31: Critical water infrastructure in Western Australia

Major UCLs	Main source of water supply	Main use
Broome	17 bores	Town (residential 2,337 MLpa)
Derby	5 bores	Town (residential 574 MLpa)
Karratha	10 bores (Millstream borefield) plus Harding Dam	Town (residential 2,673 MLpa)
Kununurra	4 bores	Town (residential 786 MLpa)
Newman	Private supply	Town (residential 1,106 MLpa)
Port Hedland	10 bores (Yule borefield) plus 11 bores (DeGrey borefield)	Mining (3,897 MLpa)
Tom Price	Private supply	n/a

Source: Water Corporation of Western Australia

10.3.3.2 Bulk water services

The Ord Irrigation Co-operative, licensed by the Department of Water, manages irrigation water users. Outside of these major centres, several large Indigenous communities operate as service hubs. The Ord River Dam was built in the 1970s to provide a reliable water supply to the Ord River Irrigation Area and manage flood risk. The dam captures highly variable runoff from the catchment each wet season. The storage enables water to be released year-round to generate hydro-electricity, supply irrigation and sustain the lower Ord River environment. The storage capacity to full supply level is 10,760 GL, 2.5 times mean annual inflow. The dam wall is high enough to capture significant flood storage, which is gradually discharged through a narrow spillway.

10.3.3.3 Water monitoring infrastructure

The Department of Water has 976 surface water or groundwater monitoring assets in Northern Australia, of which 463 are currently monitored. Details are shown in Table 32.

Table 32: Water monitoring infrastructure in Western Australia

Region	Water resource	Department of Water assets	Currently monitored
Kimberley	Groundwater	474	196
	Surface water	256	52
Pilbara	Groundwater	191	191
	Surface water	55	24
Total		976	463

Source: Water Corporation of Western Australia

10.4 Existing infrastructure capacity

Maximum water infrastructure capacity can be limited by a number of factors, specifically the:

- Amount of sustainable yield at the source of water supply
- Processing capacity of treatment plants
- Distribution capacity of the network for a given time
- Condition of the asset.

Infrastructure needs for storage, extraction and transmission vary depending on the source of water supply – surface water versus groundwater.

In Queensland, yield is linked to performance/reliability of the water product. For example, a storage that holds 300,000 megalitres (ML) may be able to yield 30,000 ML per annum at 100 per cent reliability (high priority), or 72,000 ML per annum at 90 per cent reliability.

Information on yield is researched during the water resource planning stage through extensive modelling of the long term catchment hydrology. Processing and distribution capacity determines the maximum supply limit for peak day demand. To some extent, augmentation and improvement to these facilities are more attainable in a short timeframe, whereas securing a new water source may sometimes require up to ten years of lead time before a dam can be ready to supply water.

In most parts of Western Australia and Northern Territory, water supply comes from groundwater aquifers. Groundwater is susceptible to saltwater intrusion near coastal unconfined systems, is highly saline in the deeper confined aquifers near coastal areas and is of variable quality at depth inland.[97] Information on the quality and quantity of available groundwater resource is researched during the investigation stage of water resource planning, which may take up to five to ten years of research and monitoring before an aquifer may be developed into a water supply source.

In addition, the presence of water restrictions may indicate an issue of water security due to drought or capacity, or may also reflect a policy decision where a water service provider chooses to use water conservation measures as a demand management strategy.

Tables B.12 and B.13 provide key infrastructure capacity and usage information for northern Queensland, the Northern Territory and northern Western Australia.[98]

10.5 Drivers of additional water infrastructure capacity

Drivers of additional water infrastructure capacity may include:

- **Service standards:** Adequacy of infrastructure capacity is dependent on the level of service standards prescribed. When new and higher service standards are required, existing capacity becomes inadequate under new service standards. In Northern Australia, this is likely to be driven by health standards and water quality standards that may better match the more stringent requirements similar to major cities in the southern part of Australia. While there is currently no regulatory enforcement of compliance with the Australian Drinking Water Guidelines (ADWG), the guidelines are designed to provide an authoritative reference to the Australian community and the water supply industry on what defines safe, good quality water, how it can be achieved and how it can be assured.[99] The ADWG has generally been advocated by the members of the Water Services Association of Australia (WSAA) as best practice drinking water supply performance indicators. According to the most recent National Performance Report for FY13, out of the Northern Australian water service providers that provided data to the National Water Commission,[100] all achieved microbiological compliance for 100 per cent of the population they served.
- **Ageing assets:** The need to replace ageing assets to maintain current infrastructure capacity requires asset owners to plan and implement an asset renewal program, including data requirements. While larger corporations may have a good understanding of their asset renewal needs, it is likely that some local councils may not have a full picture of the assets they own. Furthermore, information about asset life and asset management requirements may not be readily available to facilitate forward planning of capital works and scheduled maintenance.
- **Climate change/variability:** With a potential for climate change to increase climate variability and possibly the severity of Australian droughts, by raising temperatures and increasing evaporation, a given amount of inflow will no longer yield the same amount of water, due to a higher evaporation rate. Research indicates that an average annual warming of Australia by 1 degree Celsius by 2030 can be further broken down into a 0.7 degrees Celsius to 0.9 degree Celsius average warming in coastal areas and a 1 to 1.2 degree Celsius warming across inland areas.[101] The maximum and minimum temperatures and the number of hot days and nights are also likely to increase. Thus dam size alone may not guarantee sufficient water supply. On the other hand, climate variability may also increase the level of rainfall but with greater intensity during storm events, with risks to infrastructure assets from damage during extreme weather events and other climate changes (such as sea level rise). The overall impact is likely to increase the cost of service provision and impacts on service reliability for urban water users, water-using industries and water-dependent ecosystems.[102]
- **Population growth:** Population change is the most important driver of demand for urban water supplies. Strong population growth has been projected to occur in most of the current major urban centres, which will require supply augmentation and demand management strategies to ensure services can be maintained. However, the preferred water supply solution

97. Department of Water (2010)

98. Data from Western Australia is being sought.

99. National Health and Medical Research Council

100. Power and Water Corporation (for Darwin and Alice Springs), Cairns Water and Waste, Fitzroy River Water (Rockhampton), Water and Waste Services (Mackay), Gladstone Area Water Board, and Townsville Water

101. Centre for Australian Weather and Climate Research (2011), Water Services Association of Australia (2012)

102. National Water Commission (2012)

will be dependent on cost of supply and development patterns in spatial and temporal terms. Consideration should also be given to the security of supply requirements of proposed customers of a water supply source, coupled with the source's hydrology and other factors, such as need for continuity of supply and the ability to respond to supply failures.

- **Commodity prices:** Developments in the mining and agricultural sectors are heavily reliant on world prices for hard and soft commodities. These exogenous drivers have profound impacts on local industry development, employment requirements, residential arrangements and the subsequent water supply needs of locations.
- **Mine dewatering surplus:** There are currently significant amounts of surplus water from mine dewatering processes in a number of mine sites, whereby an aquifer is dewatered in order to access the resource below the water table. While this water may be recycled to supplement water use during mining operations, a large amount of surplus water often remains and requires further treatment before being discharged back into the environment. If there are nearby agricultural precincts, this surplus water may be more efficiently utilised for irrigation purposes, or other fit-for-purpose town water supplies. Alternative uses of surplus water will require pipelines from mine sites to the destination of demand. However, treatment cost and environmental considerations would form a core element in investment decisions.

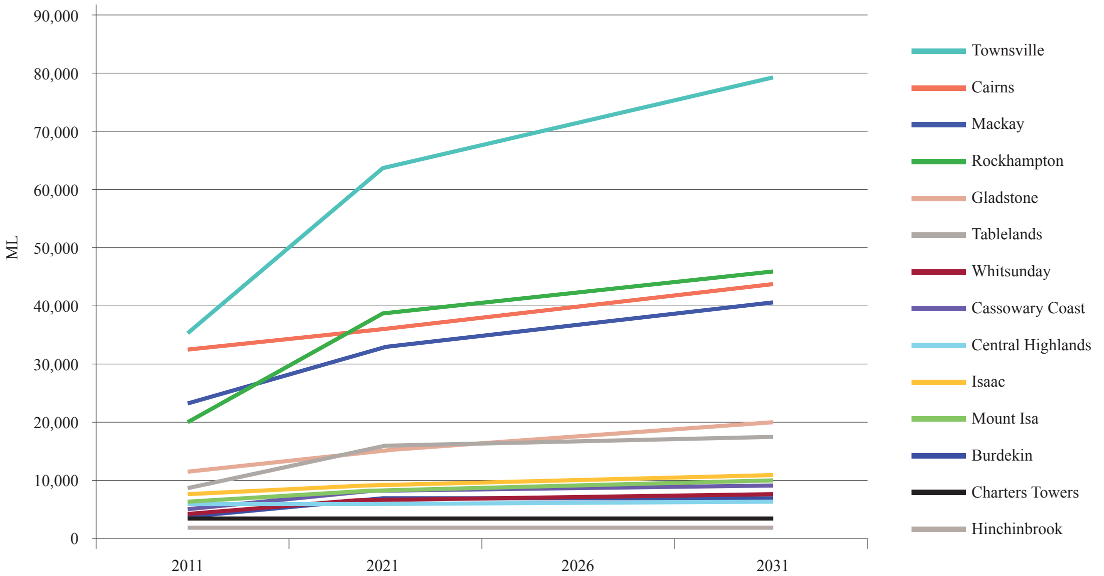
10.6 Future water demand

10.6.1 Urban water

Population growth in the region is forecast to increase by an aggregate amount of between 31 and 43 per cent in Northern Territory and between 22 and 87 percent along the major Queensland coastal centres over the next 20 years. Notably, population growth in the Gladstone LGA is expected to grow by approximately 87 per cent and the other four major centres (Rockhampton, Mackay, Townsville and Cairns) are expected to grow by between 46 and 58 per cent over this period. In Broome, aggregate growth is estimated to be as high as 118 per cent, with most population centres in the Pilbara region expected to grow moderately (between 25 and 47 per cent over the 20 year period).

Demand projections driven by population growth (based on average historical water usage rates)[103] for the next 20 years are shown for the three jurisdictions in Figure 38 (Queensland) and Figure 39 (Northern Territory and Western Australia). These demand projections are intended to provide a ballpark measure of possible demand, based on historical water usage levels and without the aid of climate and hydrological studies. See Table B.14 for underpinning data and the notes to the table for a description of the methodology employed in calculating future water demand projections.

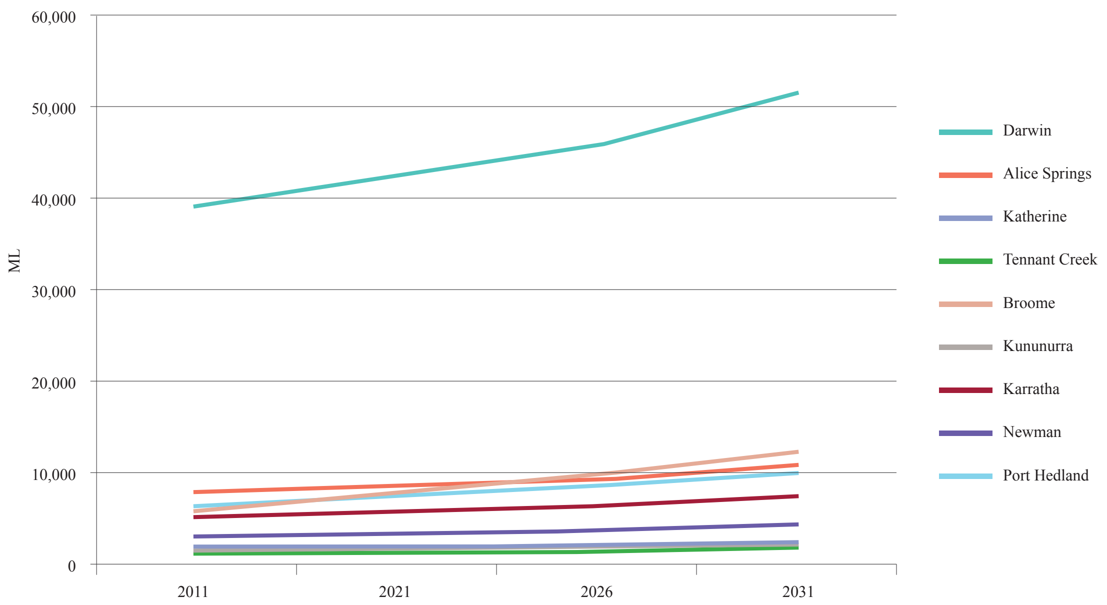
Figure 38: Urban water demand projections, Queensland



Source: Australian Bureau of Statistics, National Water Commission, local government councils, Queensland Department of National Resources and Mines, PwC Analysis and GHD Analysis

103. Average historical water usage rates have been calculated based on available population and water usage data published by the water service providers for the years between FY10 and FY13

Figure 39: Urban water demand projections, Northern Territory and Western Australia



Source: Australian Bureau of Statistics, National Water Commission, Power and Water Corporation, Water Corporation of Western Australia, PwC Analysis and GHD Analysis

10.6.2 Northern Australia bulk water demand

10.6.2.1 Irrigation user demand

A large variety of irrigated crops is grown across Northern Australia. The irrigation requirement for crops varies significantly dependent on climatic conditions, soil types, irrigation water availability, strategic or full irrigation, irrigation technology employed on-farm (surface, spray or trickle) and the efficiency of the on-farm irrigation system. It is difficult to forecast irrigation water demand without all of these information inputs, which are in turn linked to market demand for the commodity. Presently, planning and investigation work (in terms of soil testing/profiling, water resource planning, market sounding and investor appetite gauging) are underway for a number of regions in Northern Australia.

Sugarcane production dominates irrigation cropping on the east coast with irrigation requirements ranging from zero ML per hectare in rain-fed areas of the wet tropical coast, to three to four ML per hectare in the Mackay region (with supplementary irrigation), to 10 ML per hectare in the dedicated full irrigation areas of the Mareeba and Burdekin Irrigation Areas.

Irrigated banana production extends from the wet tropical coast to Lakeland Downs, Atherton Tableland, Northern Territory and the Ord, with the irrigation water requirement varying from nine to 12 ML near the coast to 11 to 13 ML per hectare in the other areas. The higher than anticipated water use can be largely attributed to fertigation activities (i.e. fertiliser being applied through irrigation systems). Banana cropping is currently displacing lower value crops and driving further expansion in the Lakeland Downs area (west of Cooktown), as growers seek to reduce cyclone related risk on more exposed coastal growing areas.

Fruit trees such as mangoes are also extensively grown from the east coast, the Gilbert River/Georgetown area, Katherine/NT and through to the Ord and, as with other fruit and tree crops, use in the order of four to six ML per hectare for irrigation. The Katherine-Mataranka region is one of the case study regions in the CSIRO and ABARES Northern Australia Food and Fibre Supply Chain Study for groundwater based horticulture. Although the actual supply of water is not a huge problem with aquifer well allocated, Mataranka aquifer is close to its full allocation.

Whilst cotton crops have been trialled in the Mareeba Dimbulah Irrigation Area, Richmond region and the Ord, production across Northern Australia remains centred on Emerald.

The irrigation water requirement for cotton in this area is in the order of six to seven ML per hectare.

Pastures also demand a large volume of irrigation water. However, the irrigation usage varies significantly depending on the actual crop (e.g. rye grass, sorghum, lucerne etc.) and intended use e.g. maximising the number of 'cuts' achieved from an irrigated lucerne crop where up to 10 ML per hectare may be used to 1.5 ML per hectare where the crop is used to augment grazing opportunities. The pastoral industry contributed about 48 per cent of the total value of the Northern Territory rural industries and fisheries production in FY13. The Katherine-Douglas-Daly area has been used for irrigated fodder and cell grazing since 1990 with production systems of 2,200 hectares still evolving. The area has also been used for perennial horticulture with small areas of field crops (e.g. maize, peanuts, fodder).[104] There is also further agribusiness potential in the Katherine area, with the possibility of setting up an agricultural precinct given there is access to good water and significant underutilised land.

Indian sandalwood currently dominates irrigated cropping in the Ord Irrigation Area (i.e. approximately 60 per cent of the total farming area around Kununurra, about 3,500 hectares). Plantings are now extending into the Northern Territory with trials also underway in the Burdekin in Queensland. The irrigation requirement for this crop is in the order of eight to 10 ML per hectare (with most of the irrigation need associated with establishment of the host tree).

The Ord Irrigation Area has continued to expand with Stage 2 of the development. However on-farm development has been slower than initially proposed, with the proponent Kimberley Agricultural Investments looking towards further development to bring the necessary scale to support further value adding industry. Whilst relatively small scale, the Ord also has a wide range of crops such as melons, pumpkins, legumes, chick peas and bananas, with recent promising developments around crops such as chia, which has an irrigation requirement in the range of six to eight ML per hectare.

10.6.2.2 Industrial and mining users

Information on industrial and mining water use and the planning lead time required is typically not publicly available. Historically, mining projects have sourced water either from existing bulk water service providers or have secured water through constructing water storage, or tapping into groundwater supply. There are a number of proposed mining projects in the region which are currently exploring their water supply options as part of their feasibility and planning studies. Table 33 provides an indicator of water use for a range of mining enterprises for comparative purposes. Clearly, the level of water use links to the scale of the mining operation; however for comparative purposes a significant mining operation may use between 10,000 to 20,000 ML of water per annum. Usage is also influenced by above or below ground operations.

Table 33: Water consumption per tonne of ore by different mineral industries

Mineral Industry	Water consumption (litres per tonne)
Coal	180-220
Bauxite	30
Gold	633

Source: GHD (2006)

10.7 Water infrastructure gaps

This section provides an initial infrastructure gap assessment for urban and rural water services, outlines some demand management strategies for managing gaps in urban water service, sets out supply optimisation strategies for managing gaps in rural water service, and explores the availability of unallocated water remaining in the water supply system.

10.7.1 Urban water and wastewater gap assessment

Based on the demand projections (see Section 10.6.1), supplemented by information obtained through stakeholder consultation and desktop review of water supply security strategy documents, a gap assessment has been undertaken for key urban centres serviced by the following local government water service providers, as shown in Table 34.

104. Petheram, C., Tickell, S., O'Gara, F., Bristow, K. L., Smith, A. and Jolly, P. (2008)

Table 34: Urban water and wastewater infrastructure summary gap assessment

Location	Current water restrictions	Main source of water supply	Storage capacity (GL)	% full (April 2014)	Gap assessment
Townsville	Level 1	Ross River Dam Paluma Dam Burdekin Falls Dam[3]	231.7 11.4 1,852.1	101% 100% 103%	Additional water supply options should be explored to identify least cost alternatives to supplement growing demand and drought proofing water requirement during low-inflow periods. Potential pipeline duplication to the Burdekin Falls Dam may be needed
Cairns	Permanent	Copperlode Dam Barron River	37.1	102%	Depending on the risk that residents are willing to accept, additional water supply options will need to be explored to reduce the occurrences of water restrictions. Surface water storage (e.g. Nullinga Dam) or other water supply infrastructure assets (e.g. recycling facilities) as well as water efficiency management measures, would be needed sooner with the Aquis tourism resort development
Mackay	Levels 1 and 2	Teemburra Creek Dam	139.2	101%	The region may need to upgrade its water entitlement profile to address future demand. New water treatment plant for Mirani and new wastewater treatment plant for Sarina are identified
Rockhampton	No	Fitzroy Barrage	59.3	99%	Consecutive failed inflows have indicated a need for a new water source – water storage size is small and heavily reliant on continual inflows
Gladstone	No	Awoonga Dam	661.9	96%	No known issue: from full to empty Awoonga dam has 6 years, with a construction lead time of 2 years
Tablelands	Level 1	Tinaroo Dam Barron River groundwater	437.6	91%	New water source is required, or the permission to take more water from existing water source for further industry development and strategies for response to severe drought
Whitsunday	Level 2	Eungella Dam Peter Faust Dam	111.2 490.4	100% 97%	Water treatment plants for Bowen and Proserpine and water pipeline from Burdekin through to Bowen
Central Highlands	Yes	Fairbairn Dam	1,288.8	52%	No known issue
Cassowary Coast	Level 1	Johnstone River	n/a		No known issue
Isaac	Yes	Eungella Dam	111.2	100%	No known issue
Mount Isa	Level 3	Lake Moondarra Dam Julius Dam	108.0 99.3	31% 79%	Options are being explored to increase water supply in view of insufficient inflow into Lake Moondarra dam. Xstrata has started pumping water from Julius Dam and reserving it in Moondarra Dam for town use.
Darwin	No	Darwin River Dam	285.5	101%	New longer term water source is required[1], with a site identified. For wastewater, approximately $43m is required in order to upgrade the existing treatment plant at Leanyer/Sanderson. Approximately $7m is required in order to upgrade East Arm treatment plant. Additional treatment plant facilities will be required to facilitate peri-urban growth in the Darwin region. Further significant investment will be required should a treatment facility be required for industrial/trade or ships waste.
Alice Springs	No	Roe Creek borefield	n/a	n/a	Borefield augmentation works are required to maintain existing borefield capacity at Roe Creek borefield. Investigation of additional borefield area (Rocky Hill), in terms of drilling and testing, is also needed to secure water supply for post 2030
Katherine	No	Groundwater borefield	n/a	n/a	No known issue other than Mataranka aquifer is close to its allocation
Tennant Creek	No	Groundwater borefield	n/a	n/a	Ageing infrastructure outside of the main corridor, some bores are in excess of 30 years old (Council currently maintains by patching because they are too expensive to replace)
Remote Northern Territory	No	Mostly groundwater	n/a	n/a	A large component of assets have reached the end of their economic and technical life. Significant investment is required to replace the aging infrastructure.[2]
Kimberley region	No	Groundwater borefield	n/a	n/a	Efficiency improvement to open channel system of the Ord Scheme. Potential of raising spillway for Ord River Dam is needed to satisfy high water demand crop development (e.g. sugarcane). Additional groundwater borefields will be required to replace exhausted borefields and to meet growing demand
Pilbara region	No	Groundwater borefield	n/a	n/a	New pipelines needed to transport water from the source of mine dewatering surplus to irrigated agriculture precincts. Infrastructure is required for investigation of new borefields feasibility prior to development into public water supply borefields

Notes:

1. Darwin is planning for an additional water source to be connected by 2019 (currently expected to be returning the Manton Dam to service at an approximate cost of $150m). This may be able to be deferred to 2025 through the current programme of enhanced demand management measures.

2. The total expenditure required on water and wastewater infrastructure has been estimated at around $365 million (Indigenous Essential Services 2013).

3. Townsville has a high priority water allocation of 10 GL from this dam.

Source: Local government councils, Australian National Committee on Large Dams Incorporated Dams, Bureau of Meteorology, SunWater, Power and Water Corporation, Queensland Department of Energy and Water Supply, Western Australia Department of Water, Regional Development Australia organisations and GHD analysis

10.7.2 Bulk water gap assessment

This section assesses infrastructure gaps for a range of key resource and agricultural regions in Northern Australia.

Galilee Basin

Early discussions regarding potential water sources for Galilee Basin mining projects indicate the possibility of constructing Urannah Dam in the Burdekin Basin. Additional options include augmenting Burdekin Falls Dam through raising the dam wall or additional new storages in the Upper Burdekin or constructing a Moranbah-Alpha pipeline. Other mining and agricultural precincts that are situated on the Great Artesian Basin, or have access to other groundwater resources, may be able to access groundwater as a source of water supply. However, this will need further hydrological assessment to determine the feasibility of this option.

North West Queensland Mineral Province

Lack of water supply in the North West Queensland Mineral Province has already been identified by the mining and livestock processing industries as a potential limiting factor in relation to further development in this region. This region is not situated within the Great Artesian Basin and will need to explore other alternatives, such as a re-commissioning of previously mothballed mining dams, or construction of a new dam with long distance trunk pipelines. The North and North West Queensland Sustainable Resource Feasibility Study has outlined the proposed Dalrymple scheme, involving a possible major dam on the Upper Burdekin River (at Hell's Gate or Mount Foxton).[105] The proposed dam could have a capacity in excess of 625,000 ML to underpin an irrigated agriculture project capable of supporting between four and 10 million tonnes per annum of sugarcane production. The study indicates that social cost benefit analysis does not provide a positive outcome for the four million tonne case and emphasises the importance of larger operations to achieve economies of scale.[106]

Flinders and Gilbert Basins

Previously identified unallocated water in the Flinders and Gilbert catchments has been auctioned. Additional water to support significant new irrigation prospects within the Flinders and Gilbert Basins will require amendment of the Gulf water resource plan and resource operations plan to identify the amount of water available for consumptive use. A CSIRO study[107] identified that the Flinders catchment hydrology supports smaller off-stream on-farm storages where irrigators can pump water out of the stream during the wet season and when the stream flow is above the required environmental flow. In the Flinders catchment, the combined offstream storage would be capable of delivering 175 gigalitres (GL) of irrigation water in 70 to 80 per cent of years. This is approximately half of the full storage potential (350 GL) of off-stream storages. In the Gilbert catchment, two prospective in-stream water storages (dams) of significant scale have been identified (Green Hills and Dagworth dams). The combined dams are capable of delivering to crops approximately 250 GL of water in 85 per cent of years.

Burdekin and Fitzroy Basins

The Burdekin and Fitzroy basins are prime agricultural regions in Queensland with a large amount of water allocation already taken up by irrigators, mining companies and industries. However, there are still some strategic reserves and general reserves remaining in these catchment systems and additional infrastructure reserves set aside for future infrastructure upgrades / augmentations. There are some projects currently ear-marked for the Central Queensland region to further supplement future bulk water demand. An environmental impact statement (EIS) has been completed for Connors River Dam and Pipelines, which consists of a 373,662 ML dam and a 133 kilometre pipeline to Moranbah to service coal mines (and associated communities) in Central Queensland's coal basins. The EIS is currently being prepared for Nathan Dam, a 888,312 ML dam with an annual yield of 66,000 ML and a 149.3 kilometre trunk pipeline.

Kimberley region

The Ord River catchment has 865 gigalitre (GL) per annum secured from existing infrastructure at a very high reliability for current and future irrigation demand. The Western Australian, Northern Territory and Australian Governments are working together on the potential for further expansion of irrigated agriculture into the Northern Territory.

105. GHD (2014)

106. Sherrington, M (2014) 'Big plans for the North', Farm Weekly, 11 June 2014

107. CSIRO (2013)

Pilbara region

New water supplies are being developed by industry and by the Water Corporation of Western Australia. These are:

- A 10 GL per annum borefield in the Lower Bungaroo Valley being developed by Rio Tinto Iron Ore to supply its port operations in the West Pilbara area. This will allow supply from the Millstream borefield to be wholly available for town water supply
- Cane River borefield expansion by the Water Corporation to provide an additional 0.2 GL per annum, and a new desalination plant (seawater or brackish groundwater) being developed by Chevron to provide a further 0.6 GL per annum to Onslow.[108]

There are also significant amounts of surplus water from mine dewatering processes in the region. Further treatment of excess water to a standard suitable for irrigation or fit-for-purpose town use would be a good alternative to discharging into the environment. However, this will require additional pipelines from mine sites to the destination of demand.

There is considerable interest in the Wallal aquifer in the West Canning Basin given the significant volumes of water that may be available. Studies undertaken to date by the Department of Water indicate that the resource could support:

- Expansion of the Port Hedland Water Supply Scheme to support both industry and population growth
- Agriculture, in particular pastoral diversification
- Both local and remote mining operations.

The current De Grey and Yule bore fields supply 13 GL per annum and are expected to be fully used by Port Hedland and the mining sector. In the long term, there is potential for development of unconventional gas reserves in the West Canning Basin. This kind of development may entail significant water demand for which Wallal aquifer has been identified as an option.[109]

Darwin region

The *Darwin Regional Water Supply Strategy* identifies options for augmenting the Darwin region's water supply in the medium term, to meet urban, commercial, industrial and irrigation demands. This includes potential on-stream and off-stream storages.

Northern Territory groundwater related opportunities

The Northern Territory Government is also advancing the potential development of five groundwater systems (including considerations associated with potential conjunctive use). These systems are as follows:

- Katherine/Daly Basin (including Tindall Limestone/ Oolloo/Jinduckin/Manbulloo/Scott Creek)
- Mataranka (Roper/Tindall Limestone)
- Ngukurr (Roper River and surrounding aquifers)
- Darwin Rural Area (including McMinns, Howard, Berry Springs, Acacia Hills)
- Wildman River.[110]

10.7.3 Managing growing demand

There has been a significant amount of new investment in the water industry in recent years. Between FY06 and FY12, a combined estimate of approximately $30 billion was invested in water supply augmentation by the 30 members of the Water Services Australia Association.[111] It is important to recognise that this level of investment was partly an emergency response to the severe drought experienced across many regions of Australia. Capacity in the water sector is unique in the sense that the size of the water storage does not guarantee the availability of water resource, especially in the variable rainfall environment in Northern Australia. Invariably, managing growing demand becomes a challenging decision by water service providers and water resource policy officials in balancing growing demand and supply pressure in a variable water resource environment. A number of policy and infrastructure responses have been used in the past to manage demand and supply gaps in different jurisdictions – each with advantages and disadvantages to water users, water service providers, society and the environment.

10.7.3.1 Water restrictions

About 90 per cent of Queensland is currently experiencing drought. Nine out of 11 main local government areas in Queensland have water restrictions in place to manage current water demand. While it is debatable whether using water restriction as an indicator of an infrastructure gap is an accurate measure of the actual demand gap, water restrictions have typically allowed an

108. Department of Water (2013)

109. Department of Water (2012)

110. Department of Water (2012)

111. WSAA (2009) Water Services Association of Australia: 2008-09 Report Card, p. 7

immediate reduction in water use during periods of severe water shortage. In the absence of appropriate cost-reflective pricing, policy reliance on water restrictions alone has been criticised as involving higher costs to society than other forms of demand management.[112] The question may also arise regarding what the appropriate amount of water usage should be in Northern Australia, given that key factors in higher water usage in this region are likely to be higher average annual temperatures compared with southern Australia and 'quality of life' expectations of residents.

10.7.3.2 Cost-reflective pricing

In a general sense, economic efficiency is achieved where the cost of providing a water service equates to the benefit consumers derive from using the service. Therefore, appropriately structured water prices perform the following two important functions:

- For users, water prices send a signal on the cost of its provision, allowing them to make informed decisions about whether use will generate benefits in excess of costs. This means prices are a key factor in encouraging a level of water use that is economically efficient
- For water service providers, prices recover the costs of producing and delivering their products and/or services and provide an appropriate return on capital invested in the business.

However, water prices may also be designed to achieve other objectives, such as equity, transparency and administrative simplicity. Price structures may also be set in such a way as to manage price impacts on customers or customer groups. These objectives may often compete and it is then necessary for price structures to balance these objectives. Alternatively, trade-offs may be required.

National Water Initiative pricing approach

Under the National Water Initiative, governments agreed that metropolitan water businesses should 'continue movement towards upper bound pricing', while regional (urban) water businesses are required to demonstrate they have pricing arrangements in place to achieve lower bound pricing. Lower bound pricing involves prices that are set to recover the minimum revenue (lower bound) required for maintaining a financially sustainable water storage and delivery business. It is set to recover the following costs:

- Recurrent expenditure requirements (operations, maintenance and administration)
- The costs of any externalities
- The interest costs on any debt, dividends and tax or tax equivalent payments (if any)
- Capital expenditure for replacement of existing assets and expanding the stock of assets to meet increases in demand, meet required service standards, and any increases in regulatory obligations.

Upper bound pricing involves setting water charges that are above lower bound charges but avoid monopoly rents. Specifically, a water business should not recover more than the costs associated with:

- Recurrent expenditure requirements (operations, maintenance and administration), including the costs of any externalities
- A return of capital (provision for the cost of asset consumption – via depreciation)
- A return on capital, via dividends which are paid out of profits (or accumulated profits).

These definitions were developed by the Council of Australian Governments (COAG) as they relate to water businesses.

Water tariff structures

In setting the pricing arrangements, the structure of tariffs (i.e. characteristics of any fixed and variable charge components) and the level of tariffs can have an impact on consumption behaviour. Tariffs may be structured in the following ways:

- Two part tariff
- Multi part tariff (inclining or declining block tariff)
- Differential tariff (e.g. peak and/or seasonal pricing, postage stamp versus location-based pricing, customer group differentiation).

Two part tariffs adopt fixed charge and variable charge components in the tariff. The fixed charge component generally corresponds to fixed costs incurred by the water service provider, while the variable charge component corresponds to operating and/or capital costs that are dependent on water usage or production volume. The variable charge (or volumetric charge) component is based on the volume of water used.

In Queensland, rural water charging uses two part and differential tariffs, while urban water charging uses two part and inclining block tariffs (see Table 35). In Western Australia and the Northern Territory, urban water charging uses a two part or inclining block tariff, but has also adopted postage stamp pricing to achieve an affordability objective for customers residing in regional locations.[113]

112. Productivity Commission (2011)

113. Under inclining block tariffs, the volumetric charge increases in a stepped manner as consumption increases, so encouraging water conservation. Postage stamp pricing applies uniform charges to all customers receiving a particular service, regardless of their level of use.

Water pricing and cost recovery

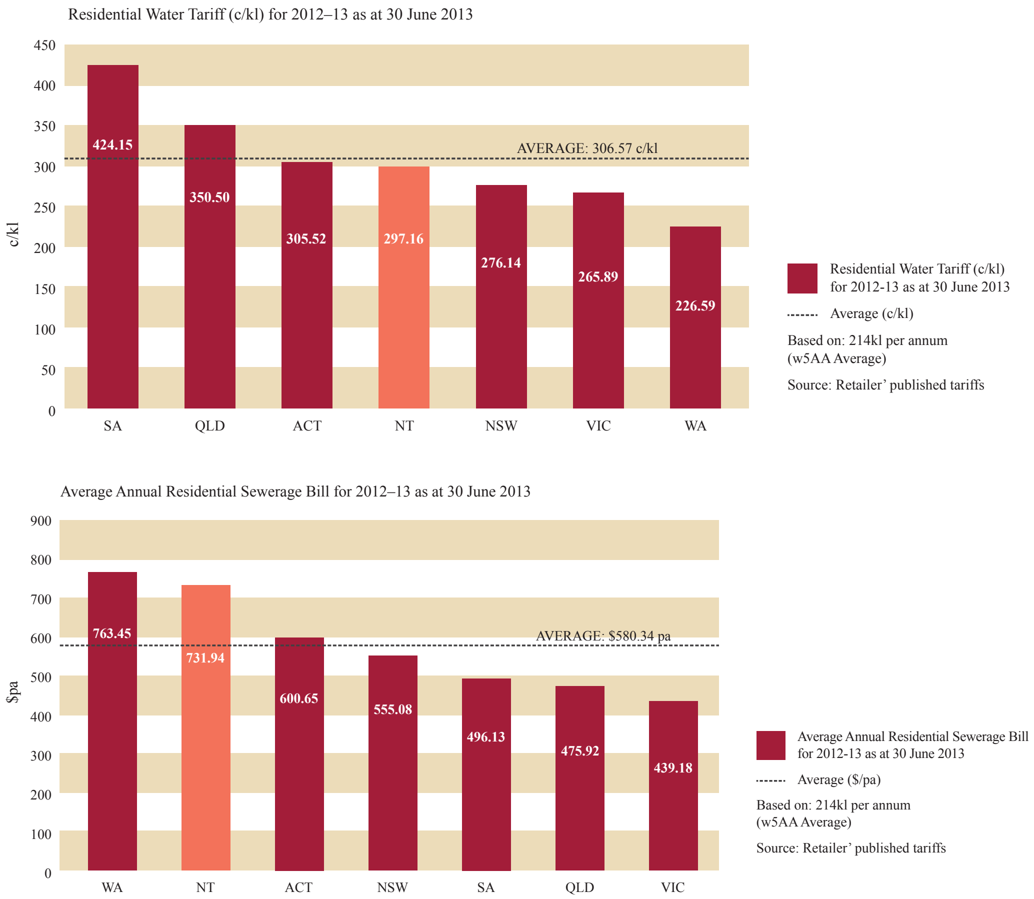
Rural (bulk) water businesses need to demonstrate they have appropriate pricing in place to achieve at least lower bound pricing, with a movement towards upper bound pricing for all rural systems, where feasible. However, currently all gravity irrigation schemes in Queensland require a Community Service Obligation to achieve lower bound costs.

Cost recovery performance in regional urban water businesses across Australia has been variable. Many non-metropolitan water systems do not achieve full cost recovery in Western Australia and the Northern Territory. The Western Australian Government is currently phasing in more cost-reflective charges for country commercial and high-use residential customers. In Queensland, compliance with cost recovery is assessed by way of reporting against guidelines and benchmark returns issued by the Government. Figure 40 shows that the average residential water tariffs for two of the three Northern Australia jurisdictions fall within the mainland Australia average.[114]

Queensland Treasury Corporation reported in 2008, prior to any impact from amalgamation of local councils, which occurred in the same year, that, where water and sewerage services are provided by councils in regional areas, 70 of 109 local councils *"routinely reported operating deficits"*.[115] While information on the water utility business element of council operations is not generally available, it would appear that ongoing financial sustainability of some local councils may pose a risk for future asset maintenance (and limit any scope to support future investment funding) in the water and sewerage sector.

Cost-reflective water pricing can also be challenged by the local area's limited capacity to pay, and by the small size of the population base, preventing capture of economies of scale. However, of the major LGAs and UCLs in the study region, a majority have implemented two-part tariff water charges, as shown in Table 35.

Figure 40: Average residential water tariff and sewerage bill (mainland jurisdictions)



Source: Power and Water Corporation (2014)

114. National Water Commission (2011)

115. Queensland Treasury Corporation (2008)

Water recycling

There is an increasing focus on the use of non-traditional water supply solutions such as stormwater and greywater recycling solutions in new urban built environment designs. In many parts of the major capital cities around Australia, new housing and home improvement planning and development approvals require the installation of rainwater tanks. Under increasingly variable climate conditions, there is heightened awareness of water-sensitive urban designs and a push to incorporate technological innovation in planning and management of water resources and water infrastructure design and operation. An integrated water and wastewater management would enable more efficient use of existing non-traditional water supply sources and allow customers to purchase the category of water products which are fit-for-purpose.

Table 35: Tariff structure for water service provision

Water service provider	Two-part tariff	Service area	Access charge[a] ($/annum)	Volumetric charge a ($/kL)			
				Tier 1	Tier 2	Tier 3	Tier 4
Cairns Water and Waste[b]	Yes		$240.00	$1.09			
Gladstone Regional Council	Yes	Lake Awoonga	$349.00	$1.59			
		Miriam Vale / Bororen	$451.00	$3.65			
		Agnes Water / 1770	$461.00	$3.60			
Isaac Regional Council	Yes		Tbc	tbc			
Water and Waste Services (Mackay)[b]	Yes		$313.05	$1.49	$2.25		
Mount Isa[c]	Yes			>950kL $2.25			
Rockhampton[d]	Yes		$332.70	<= 75kL $0.67	75-150kL $1.04	>150kL $2.09	
Townsville	Yes	Standard plan	$714.00	>772kL $2.74			
		Water watchers plan	$325.00	$1.30			
		Oak Valley water supply area	Connected to the Mt Jack pipeline must pay a capital contribution of $7,155 per property by way of 20 instalments made over a ten year period. The charge for FY14 is $ 357.75 per property.				
Whitsunday[d]	Yes		$496.00	<= 91.5kL $0.84	>91.5kL $1.44		
Power and Water Corporation	Yes	Darwin, Alice Springs, Katherine	$276.89	$1.8231			
Water Corporation of Western Australia[c]	Yes	Broome, Newman, Port Hedland	Dependent on property value	< 350kL $1.464	351-500kL $1.951	501-750kL $2.165	>750kL $2.763
		Derby, Karratha, Kununurra	Dependent on property value	< 350kL $1.464	351-500kL $1.951	501-750kL $2.885	>750kL $3.678

Notes:
a. Prices are current as at April 2014, unless otherwise stated.
b. Access charge is estimated based on National Water Commission (2014) National Performance Report 2012-13 – Urban water utilities.
c. Volumetric limits are based on a kL per annum basis.
d. Volumetric limits are based on a kL per quarter basis.
Source: Local government councils, National Water Commission, Power and Water Corporation, Water Corporation of Western Australia

Water trading

One way to manage supply-demand shortfall in bulk water supply is through the use of water trading. One of the objectives of the National Water Initiative was to introduce registers of water rights and standards for water accounting, as well as to expand the availability of water trading to enable economically efficient water use and drive water resources to their highest value use. There have been instances in the past, particularly around the Bowen Basin and within the Fitzroy catchment, where water allocations were traded out of the irrigation sector and sold to mining and industrial users. Currently there are three water markets operating in Queensland:

- *Water allocation market* – trading of registered water allocation titles. Only surface water allocations can be permanently transferred. Trading in this market requires a tradable water allocation established under the resource operations plan
- *Seasonal water assignment market* – temporary trading of water allocations and other entitlements. Trading rules are set out in water resource plans, resource operations plans and the *Water Regulation 2002*
- *Relocatable water licence market* – relocation of water licences[116] from one parcel of land to another.

In the Northern Territory, water trading can only occur within declared water allocation plan areas, and trading needs to comply with the rules set out in the relevant water allocation plan. By contrast, in Western Australia, water entitlements transactions can occur at any time, subject to approval granted by the Department of Water under the *Rights in Water and Irrigation Act* 1914 (WA).

10.8 Water critical infrastructure requirements

Water infrastructure requirements are based on analysis of infrastructure gaps and take account of existing jurisdiction water strategies and plans. Table 36 (urban) and Table 37 (bulk) provide summaries.

116. A water licence is an entitlement to take water which is attached to land, as opposed to a water allocation. Water licences are only converted to water allocations in areas where the ROP has been completed, therefore water licences is not an asset in its own right. Water licences cannot normally be sold independent of land unless there are management rules in place which allow permanent transfers (relocations) to occur.

Table 36: Critical urban water infrastructure requirements

Location	Primary infrastructure gap(s)	Key requirement(s)
Alice Springs	Demand, service standard	Borefield augmentation works are required to maintain existing borefield capacity Investigation of additional borefield
Cairns	Demand, opportunity	Additional water supply options will need to be explored – surface water storage or other water supply infrastructure assets (e.g. recycling facilities) as well as water efficiency management measures, would be needed sooner if Aquis development eventuates
Darwin	Demand	Additional water source Conjunctive groundwater use and managed aquifer recharge supporting irrigation development
Kimberley region	Demand, opportunity	Water bores system renewal
Mackay	Demand, service standard	Upgrade water entitlement profile before consideration of possible surface water storage capacity increase New drinking water treatment facility upgrade
Mount Isa	Demand, service standard	Increase water supply e.g. through pumping water from Julius Dam and reserving it in Moondarra Dam for town use, to address emerging shortages
Pilbara region	Demand	Connecting and trunk infrastructure Additional borefields
Remote Northern Territory	Service standard	Significant investment is required to replace the end of life infrastructure.
Rockhampton	Demand	Surface water storage capacity increase
Tennant Creek	Demand, service standard	Water bores system renewal
Townsville	Demand	Pipeline and pump augmentation/upgrades and/or other water supply infrastructure assets, e.g. water recycling or desalination facilities, as well as water efficiency management measures

Table 37: Critical bulk water infrastructure requirements

Location	Primary infrastructure gap(s)	Key requirement(s)
Adelaide River	Demand, opportunity	Offstream storage
Galilee Basin	Demand, opportunity, cost	New surface water storages and connecting and trunk infrastructure
Gilbert Basin	Opportunity	Surface water storage and water distribution network
Flinders Basin	Opportunity	Multiple water harvesting developments (offstream storages etc.)
Kimberley region	Opportunity	Ord River Scheme/Dam – raising of spillway, pumps and possibly additional pipelines/channels or efficiency improvement to open channel system
Upper Burdekin	Opportunity	New surface water storages and connecting trunk pipelines

Communications

11.1 Introduction

Telecommunication services represent a key sector in the Australian economy, both in terms of their direct contribution and in facilitating economic activity. They also play a key role in social activity. The telecommunications industry Australia-wide had revenues of $56 billion in FY13 and spent nearly $9 billion in capital expenditure in the previous year.[117] Telecommunications is essentially a national undertaking. The larger providers are national businesses, in some cases international, although there are also smaller providers and niche operators. The sector is regulated nationally.

Nevertheless the importance of telecommunications is at least as great in Northern Australia as in the south, and arguably more important because of the remoteness of many settlements in the north. Thus, while much of the background discussion in this section pertains to the whole of Australia, the key metrics in this audit focus on Northern Australia.

11.2 Communications infrastructure in scope

Telecommunications and the infrastructure that supports it has changed in recent years, and will continue to change. Its development to support the digital economy has become a priority of government. Improved broadband services are being delivered by a Government business entity (NBN Co Limited) that has the responsibility to roll out, operate and maintain the National Broadband Network (NBN), and by commercial mobile service providers who are progressively introducing 4G networks.

In relation to the NBN, the Australian Government has stated that:

'the Government is committed to completing the construction of the National Broadband Network and in doing so ensure that all Australians have access to very fast broadband as soon, as cost-effectively and as affordably as possible'.[118] The policy objective is to give all Australian premises access to fast broadband services.

Existing communications access requirements also continue such as the Standard Telephone Service, operating over the Public Switched Telephone Network (PSTN) covered by Telstra's Universal Service Obligation (USO),[119] intended to ensure that all people in Australia, irrespective of location, have reasonable access on an equitable basis to standard telephone services, payphones and prescribed carriage services.

The infrastructure that is in scope for this audit extends from the existing fixed voice network through to that necessary for the NBN, and includes other fixed and mobile networks. While broadcast infrastructure (radio and television) is excluded, it is considered briefly under this heading largely because of its role as a communications means of last resort in an emergency such as a flood.

117. Australian Bureau of Statistics (2014)

118. Turnbull and Cormann (2013)

119. Telecommunications (Consumer Protection and Service Standards) Act 1999

11.2.1 Fixed infrastructure

The traditional fixed network is the PSTN. It has a history that dates back over more than one hundred years. Infrastructure that supports this was once copper wires or cables providing trunk (backbone) lines and the local customer access networks. The latter comprised dedicated copper cable pairs from local telephone exchanges (or street cabinets) to each residential or business customer. While the basic copper pair customer access network links have seen little change, the manner of their use has changed substantially. Electronic exchanges replaced electro-mechanical switching from the late 1970s. In the past decade and a half Asymmetric Digital Subscriber Line (ADSL) technology has been added to provide data capability over the copper network.

Fibre to the premise (FTTP), building/basement (FTTB), distribution point (FTTdp) and node (FTTN) are all now options for the 'last mile' sub-networks, as is fixed wireless and hybrid fibre coaxial (HFC). Similarly, backhaul and backbone[120] capacity is now provided by new technologies, principally optic fibre, but also including microwave radio relay or microwave multipoint, HFC, and satellite systems.

With deregulation of the telecommunications sector and the opening of the industry to competition, operators other than Telstra have entered the industry to offer a variety of services. Telstra has retained ownership of its vertically integrated PSTN; however, it is required to provide access by other providers to both lines and exchanges. In addition, other providers such as Optus can, and do, provide their own PSTN and other infrastructure to supplement that from Telstra. This infrastructure is used in conjunction with leased components of Telstra's network, and in competition with Telstra.

Although mobile wireless has exceeded fixed broadband as the way most Australians access the internet since June 2011,[121] fixed infrastructure retains a capacity and speed advantage over mobile broadband and remains the preferred platform for services such as video. In summary, the infrastructure comprises:

- **Dial-up:** Dial-up uses telephone lines to establish a low bit-rate connection to an internet service provider. The typical dial-up modems have a maximum theoretical transfer speed of 56 kilobits per second. As such it can be used to access the internet, but is not regarded as suitable for broadband application.
- **Digital Subscriber Line (xDSL, ADSL, SHDSL):** These are technologies designed to give basic broadband performance over copper telephone lines. Speeds for ADSL are up to 8 megabits per second (Mbps) downstream and up to 1.3 Mbps upstream,[122] although enhanced technology ADSL2+ uses a wider frequency range to offer speeds of up to 24 Mbps downstream and up to 3.3 Mbps upstream over relatively short distances. Symmetrical High-Speed Digital Subscriber Line (SHDSL)

120. These terms describe the primary networks that connect distribution points or exchanges, as explained in Section 11.4.3.

121. Australian Bureau of Statistics (2013a)

122. Downstream refers to information loaded from the web to a local device. Upstream refers to data that are loaded from a device to the web.

services offer symmetrical data rates in both the upstream and downstream directions, and is considered business grade with data rates of up to 10 Mbps possible. The length of copper telephone cable and the noise induced onto the cable can have a dramatic effect on the real data rates for ADSL. Maximum data rates mentioned above can only be achieved close to the exchange.

- **Hybrid Fibre Coaxial cable (HFC):** A technology utilising both optical fibre and coaxial cable, typically used for delivery of subscriber television (pay TV), internet and voice services. Speeds of up to 110 Mbps downstream and 2.4 Mbps upstream are available on present Australian HFC networks, although speeds can vary with network usage. Greater speeds are technically possible.
- **Fibre to the node or distribution point (FTTN, FTTdp):** This architecture entails use of optical fibre from the network to a distribution point (a node or street cabinet) that serves a few hundred premises within a radius of about one kilometre. The connections from the node to the customer premises use existing phone lines. Speeds may range from 60 Mbps to 100 Mbps downstream and upstream speeds of 5 Mbps to 50 Mbps.
- **Fibre to the premises (FTTP):** Fibre to the premises entails use of optical fibre from the network to residential or business premises. Typically retail products over FTTP networks offer speeds up to 100 Mbps downstream and 40 Mbps upstream, although services with higher speeds such as 1 gigabit per second downstream and 400 Mbps upstream services are available.
- **Fixed satellite:** All Australian premises are covered by satellite broadband networks, although there is a limit to the capacity of the satellites currently in orbit, and they are not the most cost-effective approach to the delivery of services where other options are available. Fixed satellite is affected by prevailing local weather conditions and suffers from considerable latency (signal delay), making the service not suitable for voice calls and live data base software solutions.
- **Fixed wireless:** Fixed wireless delivers services from towers to equipment that is ‘fixed’ to the customer’s premises. Where fixed wireless is being used by NBN Co, long term evolution (LTE) technology is being used by NBN Co for its fixed wireless installations. LTE is a fourth generation (4G) wireless technology. Speeds of up to 25 Mbps downstream and 5 Mbps upstream can be delivered to a fixed number of premises.

Fixed infrastructure such as ADSL, FTTP and FTTN require connections to each premise and would typically be used in urban and regional centres. Premises in remote areas are likely to rely on fixed wireless and satellite for broadband. As mentioned above, the NBN fixed wireless utilises LTE technology to connect on average 200 premises per radio communications tower or site. NBN wireless users will experience fast download speeds when there are few simultaneous users. Average busy-hour throughput of 500 kilobits per second (Kbps) for each premise within 25 kilometres of the radio tower has been used in the design.[123]

Fixed satellite is likely to be an important medium in the delivery of broadband services to Northern Australia for cost reasons. NBN Co previously offered an Interim Satellite Service (ISS) to regional and remote consumers, which reached capacity in December 2013. Government funding through NBN Co’s Satellite Support Scheme (NSS) has been made available to expand the ISS from mid-2014 to up to an additional 9,000 premises, both residential and business, by subsidising the cost of in-premises equipment and its installation. Regional and remote satellite broadband products over existing Ku-band satellite networks for home users and small businesses offer speeds up to 6 Mbps downstream and up to 1 Mbps upstream.

By definition, the ISS and NSS were temporary arrangements ahead of NBN Co’s Long Term Satellite Service (LTSS) becoming operational. The first of two Ka-Band satellites that NBN Co will use for this upgraded service is expected to be in operation by early 2016, lifting broadband quality for users in remote locations. The LTSS is designed to bring a major change in the experience of broadband users in regional and remote Australia, with download speeds of up to 25 Mbps and upload speeds of five Mbps,[124] similar to fixed wireless. To achieve this, NBN Co has provisioned premises with the satellite reception and transmission equipment providing an estimated 300 Kbps per second per simultaneous user on the download link and 100 Kbps per second per simultaneous user on the upload.[125]

While the LTSS should improve services in the north, satellite communications have a number of distinguishing limitations. These include the need

123. Mason (2012)
124. Advice from Department of Communications 13 June 2014
125. Mason (2012)

for clear line of sight between the satellite and the customer premise equipment – line of sight can be affected by rain, foliage movement, commercial construction and the customer premise equipment antenna moving in high wind. As the available satellite capacity/bandwidth is a shared resource, download and upload speeds are affected by the number of simultaneous users, congestion and interference. Latency between the ground station and satellite affects end user experience, especially for real time applications such as business data base access and telephone calls. An example of latency is live outdoor broadcast interviews where live conversations between a correspondent and the studio are delayed.

11.2.2 Mobile infrastructure

Mobile voice and data services are delivered to mobile devices over cellular networks of towers. Approximately 99 per cent of Australia's population have mobile voice (cell phone) coverage at their normal place of residence. Both Optus (98.5 per cent) and Telstra (99.3 per cent) claim this order of coverage; however Telstra covers a much greater geographical area (2.3 million square kilometres) than Optus (one million square kilometres). In practice there is mobile coverage for only about one-third of Australia's landmass. For the purposes of the audit, the coverage is examined in terms of 3G and 4G technologies that are suitable for broadband data services as well as voice. Due to their lower capacity, older technologies such as Global System for Mobile communications (GSM) and Global Packet Radio System (GPRS) are not considered explicitly. The next generation, 5G, is being piloted elsewhere but is out of scope for this audit.

Third generation (3G) mobile networks typically offer speeds between one and 20 Mbps downstream and 550 Kbps per second to three Mbps upstream. 4G mobile networks typically offer speeds between two and 50 Mbps downstream and one to 10 Mbps upstream. Mobile networks are shared networks, such that speed will reduce when multiple users are accessing the network at the same time.

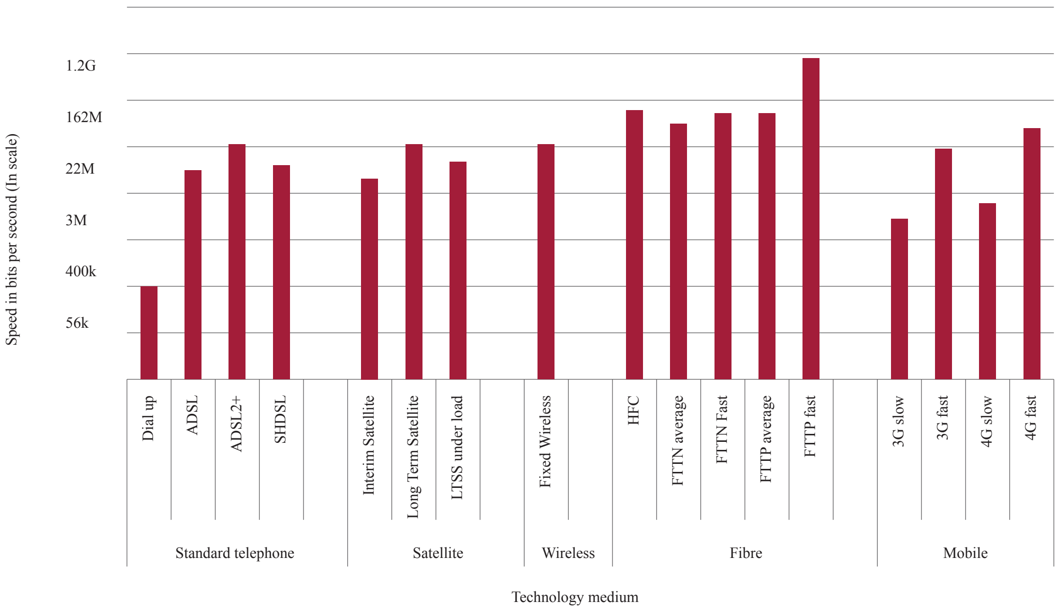
There are also four satellite networks offering mobile voice solutions at present, specifically Iridium, Thuraya, Inmarsat and Globalstar. Importantly, as for fixed satellite installations, mobile handsets require a clear line of sight with the satellite. If the line of sight is interrupted, for example by buildings, mountains, heavy foliage or even weather conditions, then the receiving device will need to be repositioned. Mobile satellite networks are shared networks, as are fixed, such that the user experience is affected by the number of simultaneous users, congestion and interference.

Similar to GSM and GPRS, low capacity satellite data services are also offered. Orbecom, Iridium, Thuraya, and Inmarsat offer satellite machine to machine (M2M) services for remote regional industrial command and control services.

11.2.3 Service quality – broadband speeds

Figure 41 shows the likely download speeds by the various 'broadband' technologies, both fixed and mobile. Speeds are shown to a natural log scale, in order to reduce the disparity between the faster media and the slower ones such as dial-up for clearer presentation.

Figure 41: Download speeds by technology medium (bits per second, ln scale)



Note: For scalability reasons this chart is presented to a natural log scale.
Source: Various and GHD analysis

Speeds shown are typical only and do not represent fastest available speed in ideal conditions. For example, satellite users may experience greater than 25 Mbps when atmospheric conditions are optimal and few other local users are on line; each LTE base station has 36.6 Mbps per cell to be shared with an average of 60 other users.

Figure 41 shows the advantages of the broadband fibre rollout. While FTTN is likely to be slower than FTTP, it is still significantly faster than other media. HFC is also in this range. The ADSL group of technologies over existing telephone lines are next. Dial-up over existing lines is very slow and cannot be regarded as 'broadband'. The next group is the mobile media, 3G and 4G. 4G is a significant improvement on 3G, starting to put mobile broadband in the same speed group as ADSL, at least under favourable conditions (such as light network loads). Fixed wireless – which in the case of the NBN Co rollout is the next generation long term evolution standard – is as good as ADSL and 4G mobile at its best.

The last group is satellite. The first two of the satellite speeds shown reflect the total capacity for a group of receivers. This is a shared product, and while the overall speeds are quite good, under load (i.e. many simultaneous users) the speed may slow, as is experienced with the ISS solution. It is expected that under normal loads NBN Co's LTSS solution will deliver higher busy hour throughput rates than current solutions.

From the perspective of Northern Australia and remote communities in particular, the technologies on the left of the chart will be more common than fibre, and to some extent mobile. This has important implications for the relative quality of service that can be expected.

11.2.4 Key communications issues

Telecommunications infrastructure is among the more ubiquitous of the infrastructure groups. Virtually all Australians and most premises have access to some form of telecommunications, as universal access to a voice service is a regulated outcome. However the delivery platform, service quality and the range of services available does vary, as shown in the previous section. This has been a concern for stakeholders in Northern Australia.

The communications sector is undergoing a period of fundamental change with increasing importance of mobile technology, a step change in the provision of fixed infrastructure through the roll-out of the National Broadband Network (NBN) and fundamental changes in the pattern of demand for services.

Prior to the emergence of the internet, public network telecommunications services were almost entirely for voice, although there were proprietary data applications such as electricity network management and railway signalling, typically on dedicated networks. The internet and a range of digital applications for business and personal use have created a demand for greater bandwidth. This has changed the telecommunications paradigm quite fundamentally. The infrastructure underpinning the traditional public switched telephone networks (PSTNs) are typically carrying quantities of data for which they were not originally built. New networks – fixed, mobile and satellite – are being developed. Moreover, there is an observable convergence of the technologies, such that the boundaries of the different media are increasingly indistinct.

The issues considered in this section reflect this rapidly changing environment and the need to address both it and a potentially widening digital divide between the populated centres of the east coast of Australia and the rural and remote north. Some of these issues include:

- Dramatic increases in expectations for connection to broadband digital services and particularly for mobile connectivity
- Major increases in digital traffic and the number and range of devices compounded by growth in population and the economy
- Increasing demand for various kinds of mobile technology, capable of accessing the cellular network, Wi-Fi and fixed radio
- The lack of competitive infrastructure for both fixed and mobile telecommunications in the north, and therefore lack of wholesale and retail competition and choice
- The poor service quality both for mobile and fixed data service relative not only to other parts of Australia, but to other parts of the world
- A regulatory environment that does little to encourage shared access to the available infrastructure
- The need for a relevant USO for data to address the digital divide for the north, over and above the current minimum functionality.

11.3 Broadband availability and quality

Telecommunications capacity metrics are conceptually different to those in other sectors. While the quality of power and transport services may be measured in terms of reliability, a fundamental metric for telecommunications is *availability* – whether a service is accessible to the consumer. In addition, with the emergence of the digital economy, *quality*, which has become synonymous with bandwidth or speed and hence is closely related to the technology used, has become much more significant.

Telecommunications is also differentiated by rapid technology change and convergence of voice and Internet Protocol (IP) data that has made the delivery platform less relevant. The sector is dominated by the emergence of demand for mobile and fixed broadband service, and this has subsumed the demand for older technologies, notably the traditional PSTN network. For this reason the focus of this section is broadband availability and quality. The methodology and data for this are consistent with the Australian Government *Broadband Availability and Quality Report* of December 2013,[126] as updated in 2014.[127] Mobile telephone coverage and broadcast are also considered.

This analysis is based on Telstra Distribution Areas (DAs). DAs are one level below the Exchange Service Area and nationally comprise 100-200 premises each; however more than half of the Distribution Areas in Northern Australia, while defined geographically, have no premises. Of those that do, they average less than 100 premises each. The locations of Telstra's DAs are shown in Map 20.

11.3.1 Fixed broadband availability

The *Broadband Availability and Quality Report*[128] (the 'Report'), and the updated data cube,[129] describe availability in terms of both the media involved and as ratings that represent the proportion of premises in each DA with access to a given broadband platform. Given the degree to which access to different broadband platforms can vary, this approach avoids the potential privacy issues associated with identifying individual services that may be available at individual premises, and simplifies the underlying data so as to associate regional ratings.

There is very little public fixed infrastructure in Northern Australia other than that owned by Telstra and the links operated by Nextgen. Theoretically, under Telstra's USO all premises in Australia should have access to a Standard Telephone Service, and there are obligations for payphone services. Telstra may consider satellite, radio-communications and wire line where necessary for the provision of voice grade standard telephone services and payphone services. For most premises a fixed line should allow ADSL, and hence some level of data service. However the length of the line and whether the exchange is ADSL equipped will mean that a small proportion (nine per cent nationally according to the Report), have no data service at all.

Areas receiving highest rated availability of broadband access vary significantly within Northern Australia. 88 per cent, or 74,000 premises, in the Northern Territory; 75 per cent, or 27,000 premises, in northern Western Australia and 69 per cent, or 306,000 premises, in northern Queensland are located in distribution areas that receive an 'A' rating for broadband availability. Figure 42 shows the availability rating by the percentage of premises for each of the Northern Australian jurisdictions.

72 per cent of premises in Northern Australia, or 407,000 premises, are located in DA with the highest availability of access (rated 'A') to broadband technology. Between 80 and 100 per cent of premises in these areas receive at least one form of fixed broadband technology. In most cases this is via ADSL technology, although there are small pockets of other technologies. In comparison 87 per cent, or 9,039,000 premises, receive the 'A' rating for availability in southern Australia. This contrast is shown in Figure 43.

11.3.2 Fixed broadband quality

Even though 72 per cent of premises in Northern Australia are located in areas where over 80 per cent of premises receive fixed broadband access, this, for the most part, it is limited to an ADSL service. The number of premises with access to ADSL services is lower in more remote areas. However there is generally little difference in the distribution of modelled median speeds across the remoteness categories, as a significant number of premises in regional and remote areas are just as likely to be located close to the exchange as their metropolitan counterparts. Where the copper line is long, speeds will drop.

As with availability, the Department of Communications employs a five point scale in the *Report* to rate the quality of broadband service.

Quality level A (where at least 80% of the premises have access to high quality FTTP services), applies to only 34,000 premises in Northern Australia currently. This represents five per cent of premises in North Queensland, nine per cent of Northern Territory premises and seven per cent of those in North Western Australia.

126. Department of Communications (2013b)

127. Department of Communications (2014)

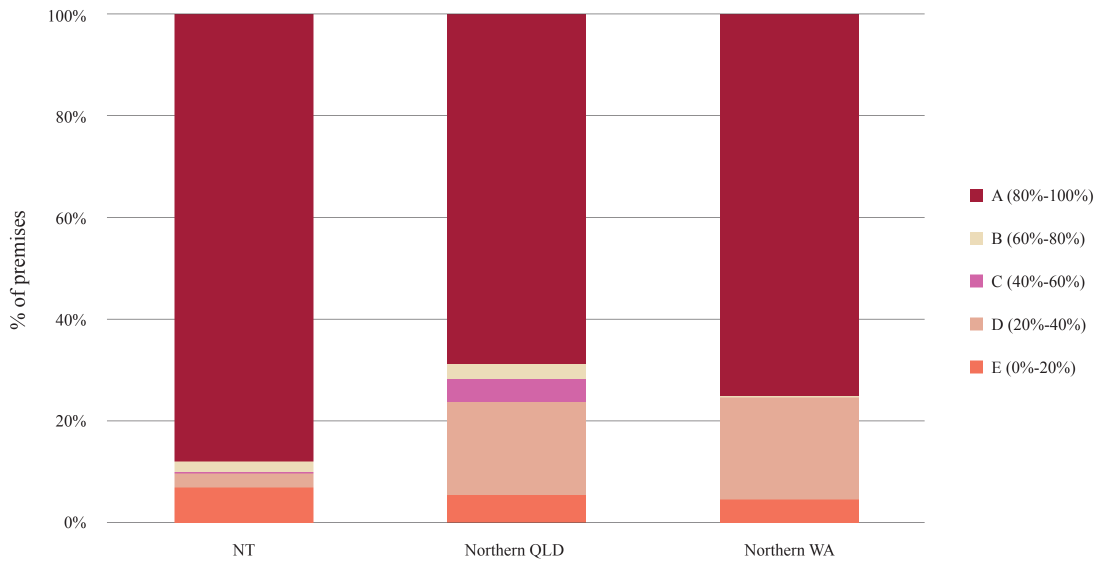
128. Department of Communications (2013b)

129. Department of Communications (2014)

The geographical distribution of broadband availability by rating is mapped in Map 21.

Quality levels B and C have decreasing FTTN or HFC coverage. In quality level B, a small proportion may only have access to broadband through ADSL services while in level C a small proportion may have access to fixed wireless networks. The combined premises in these categories total 25,500; five per cent of north Queensland premises, four per cent of the Northern Territory and one per cent of north Western Australian premises.

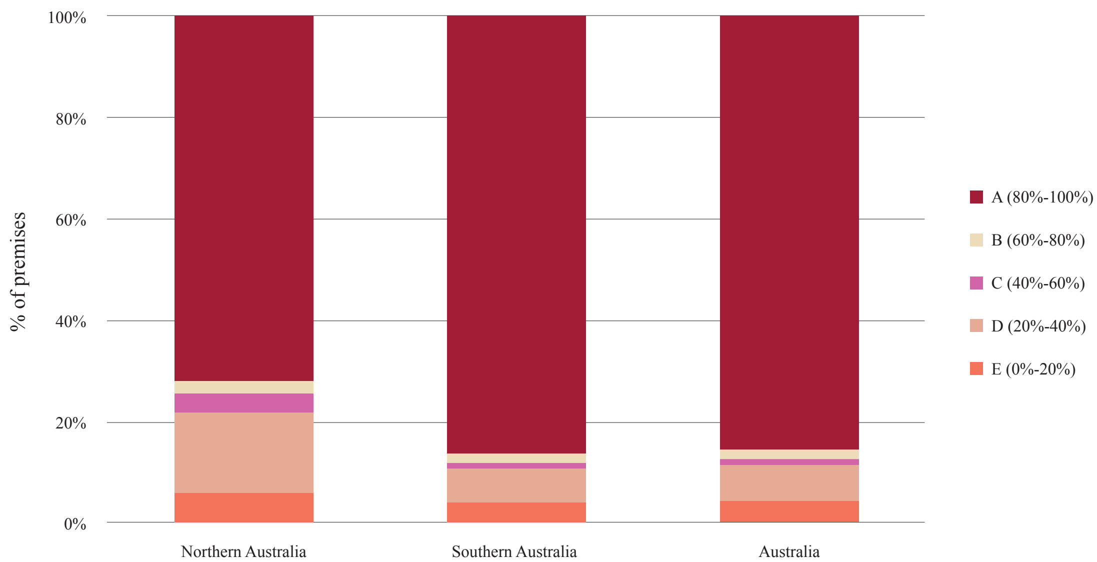
Figure 42: Fixed broadband availability – Northern Australia



Note: An 'A' rating means that more than 80 per cent of premises in the Telstra Distribution Areas in this group have access to at least one fixed broadband technology. Percentage ranges for all ratings are as shown.

Source: MyBroadband Data Cube v3 and GHD analysis

Figure 43: Availability ratings by proportion of premises – comparison with other parts of Australia



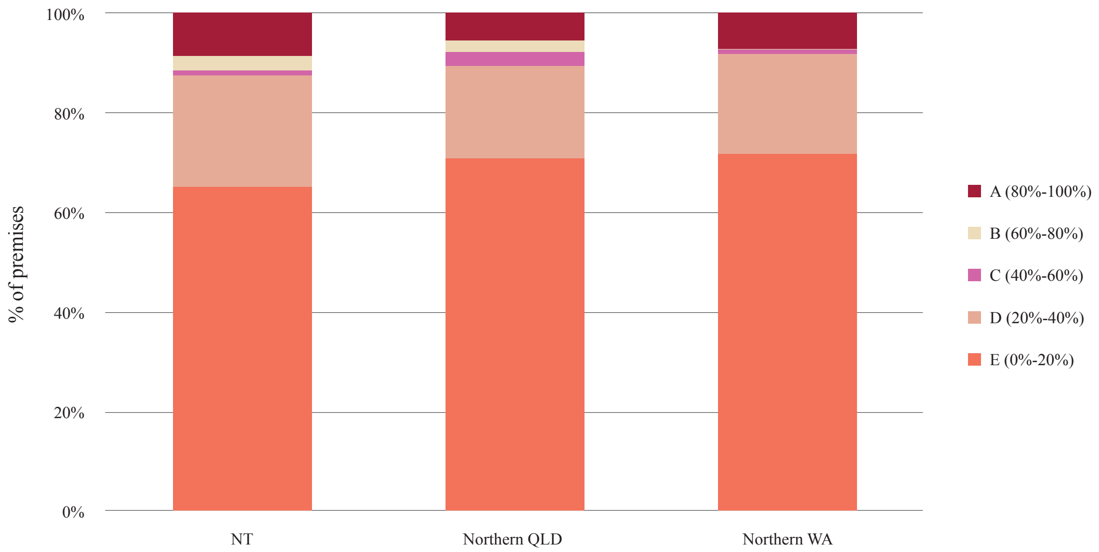
Source: MyBroadband Data Cube v3 and GHD analysis

Most of the premises in Northern Australia fall into the bottom two levels, D and E. In both categories, a majority are likely to have access through ADSL services. In level D a small proportion may only have access through fixed wireless networks; level E includes premises without access to any form of fixed broadband service. Combined, these two lowest quality categories include 90 per cent of premises in North Queensland, 87 per cent in the Northern Territory and 92 per cent of those in North Western Australia, totalling 505,900 premises.

Only 58 per cent of premises in southern Australia would experience the two lowest quality levels of broadband access.

The quality of broadband service available in Northern Australia by state is shown in Figure 44 and a quality comparison with other parts of Australia and with Queensland is shown in Figure 45 and Figure 46.

Figure 44: Quality ratings – Northern Australia



Source: MyBroadband Data Cube v3 and GHD analysis

Figure 45: Quality ratings – comparison with other parts of Australia

Source: MyBroadband Data Cube v3 and GHD analysis

11.3.3 Mobile coverage

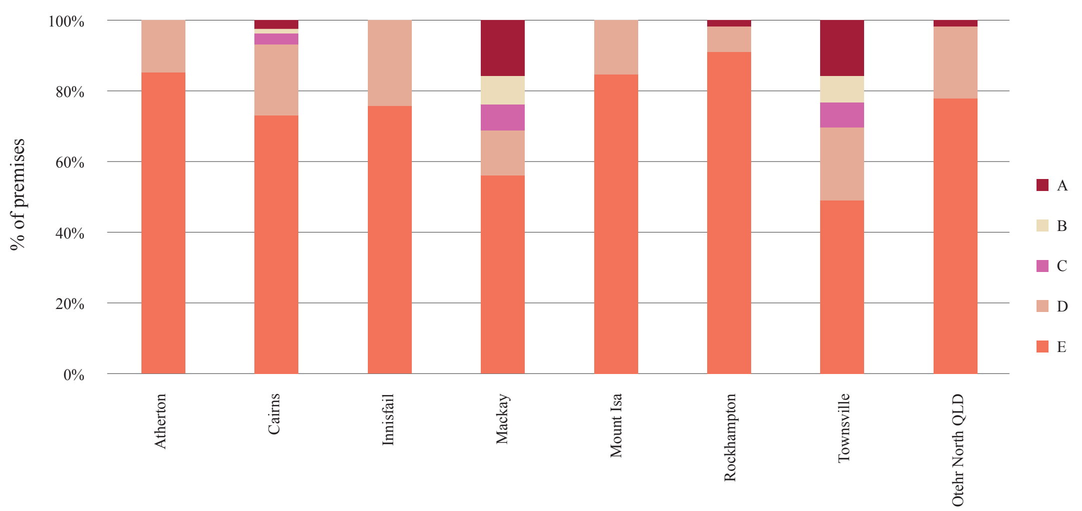
Mobile telephone population coverage is now approaching that of fixed landline, with population coverage in excess of 99 per cent. As with fixed services, mobile communications in Northern Australia is dominated by Telstra. There is mobile coverage of higher density residential areas but it is absent for much of the extended geographic area (Map 23).

Mobile data capability is increasing with each generational upgrade (i.e. 2G, 3G, and 4G). Even for voice coverage however, the quality of a mobile service will depend on factors such as the distance between the user and the transmission tower, the device and external antenna in use, obstructions and whether the phone is being used indoors or out. Similarly, without strong competition, price is likely to be an issue.

The rollout of 4G is proceeding at a considerable rate and has now overtaken 3G in Northern Australia. Figure 48 shows the number of premises in Northern Australia that have access to 3G and 4G mobile services. The introduction of the new 4G 700 MHz LTE networks by Telstra and Optus will increase capacity further. Notably only 21 per cent of premises in Northern Australia were rated as having 'good availability' of access to these mobile broadband services. By contrast, in southern Australia, 91 per cent of premises have either 'good availability' or 'very good availability' access to mobile broadband (Figure 49).

The geographical distribution of broadband quality is shown in Map 22 and map 23.

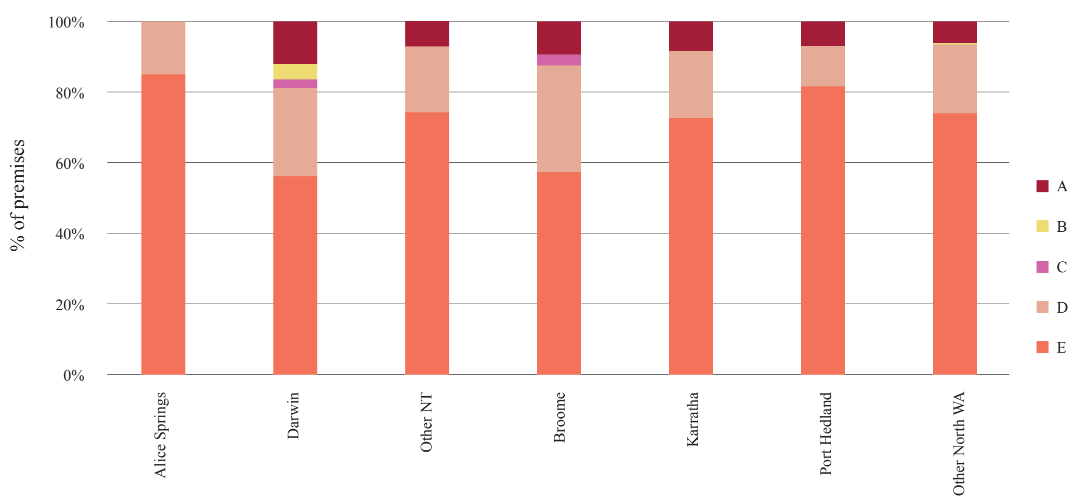
Figure 46: Quality of broadband access – Queensland



Source: MyBroadband Data Cube v3 and GHD analysis

Figure 47 shows the quality of broadband service at selected centres[130] across each of the Northern Australia jurisdictions.

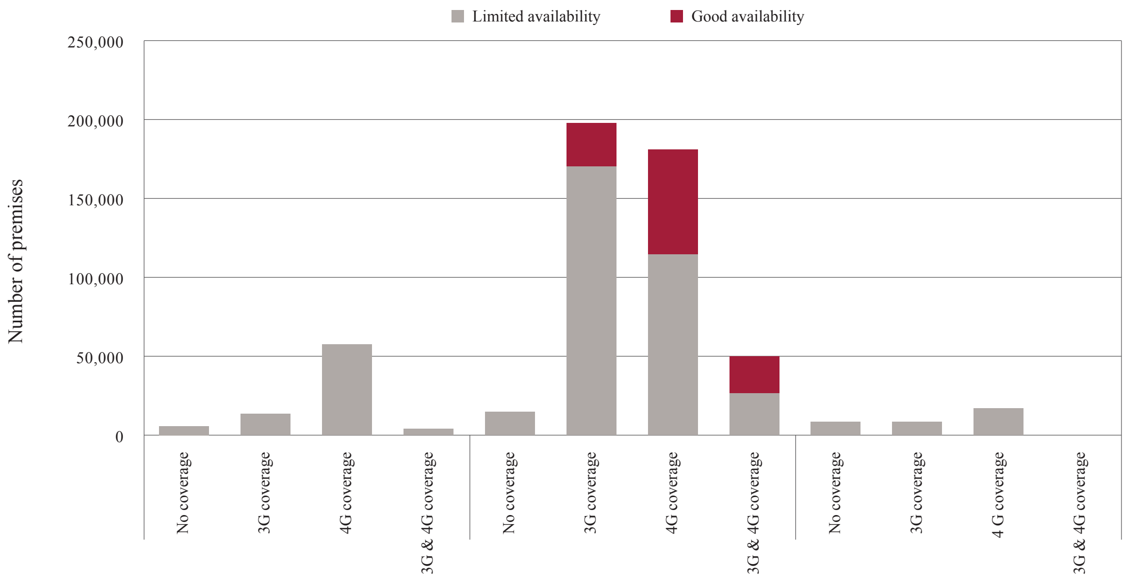
Figure 47: Quality of broadband access – Northern Territory and North Western Australia



Source: MyBroadband Data Cube v3 and GHD analysis

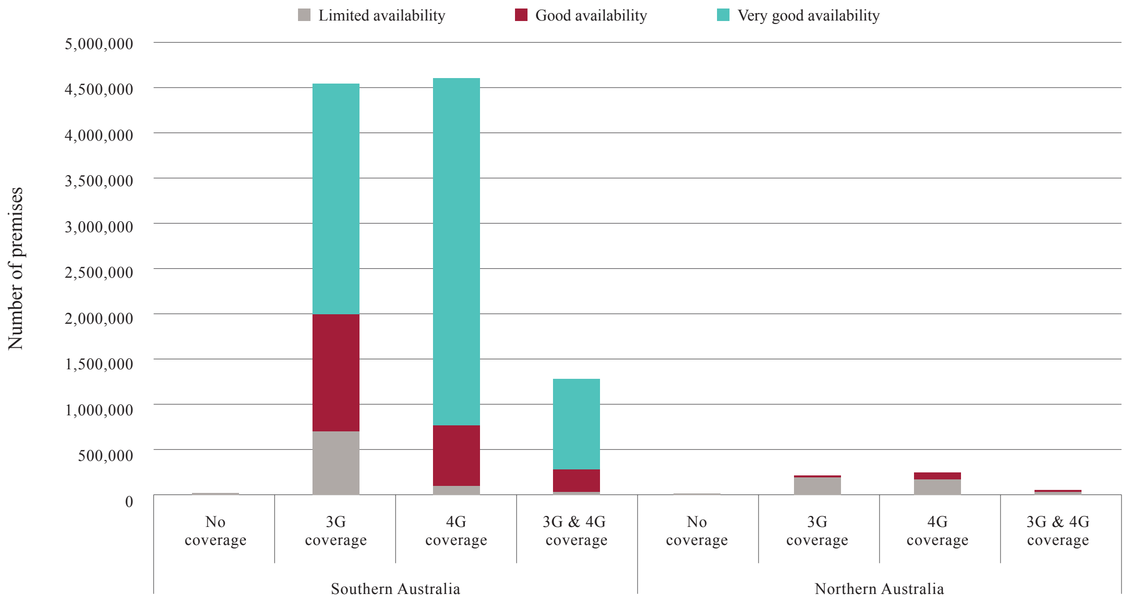
130. Location approximates UCLs but is based on SA2 data

Figure 48: Availability and quality of mobile broadband access in Northern Australia



Source: MyBroadband Data Cube v3 and GHD analysis

Figure 49: Comparison of availability and quality of mobile broadband access across Australia



Source: MyBroadband Data Cube v3 and GHD analysis

11.3.4 Broadcast

In addition to the telecommunications services for personal and business purposes discussed above, the audit has also considered the subject of broadcasting, both of radio and television. Broadcast infrastructure is important, particularly during disaster times. Emergency managers rely on broadcasters to disseminate information in preparation and mitigation strategies, in educating the community on understanding, planning and implementing action when an emergency occurs.

The Australian Communications and Media Authority (ACMA) is responsible for planning and management of the broadcasting services including AM/FM radio and Australian Free-to-Air terrestrial television. Viewers in remote Australia, or viewers who live in regional/metropolitan areas who are unable to receive adequate terrestrial television reception, are able to receive their digital television services through the government-funded Viewer Access Satellite Television service.

The infrastructure requirements for broadcast are similar to fixed wireless in terms of location, with typically high terrain being favoured over low lands/plains. Transmission links are also needed from studios and/or relay sites. However, the very large coverage areas for broadcast require heavier duty and taller towers, and very high transmission output power.

As broadband usage in the north increases, it can be expected that increased use of Internet Protocol (IP) radio and television services may see the requirement for broadcast coverage decrease. Until IP radio and television services are generally accepted as a valid means of communication in times of national disaster and calamity, broadcast remains an essential (and critical) infrastructure.

11.4 Drivers of change in the communications sector

In addition to the massive changes in the level and nature of demand in the communications sector (discussed in the next section) there are three primary drivers of change:

- The rollout of the National Broadband Network
- Progressive upgrade of the mobile network for both voice and data
- Provision of competitive backhaul capacity.

11.4.1 The National Broadband Network

The National Broadband Network rollout is being delivered by NBN Co Limited (NBN Co), which states its aims as to ensure that all Australians have access to very fast broadband as soon, as cost-effectively and as affordably as possible.

In December 2013, NBN Co undertook a strategic review of the project with a view to optimising the rollout.[131] The scenarios that NBN Co considered included:

1. Revised outlook, existing plan
2. Radically redesigned FTTP with improved productivity, architecture, materials and construction techniques to increase rollout speed and decrease costs
3. FTTN short loop (within 400 metres of the pillar) and fibre to the distribution point, basement or building (FTTdp/FTTB) to large developments
4. HFC in HFC footprint, otherwise FTTP and FTTN
5. FTTN and HFC
6. Optimised Multi-Technology Mix.

NBN Co recommended the optimised multi-technology approach, but with the rolling out of the exact priorities to be determined after consultation. The December 2013 review suggested that optimal mix of technologies in the fixed line footprint might be:

- FTTP to about 20-26 per cent of premises
- FTTN/FTTdp/FTTB to about 44-50 per cent
- HFC to about 30 per cent of premises
- Fixed wireless and satellite to serve about seven per cent of premises.

How this mix will impact Northern Australia has not been made clear. However, the economics of service provision are such that the proportion of fixed wireless and satellite for service delivery is likely to be higher than in the south of the country.

Table 38 shows the distribution of services by mode as at 14 August 2014 (no specific Northern Australia data are available).

Table 38: Rollout of NBN service by mode, week ending 14 August 2014 (000s)

	Fixed Terrestrial		Satellite	Wireless		Totals	
Jurisdiction	Lots/ Premises Passed (A)	Premises Activated 3 (B)	Premises Activated (C)	Premises Covered (D)	Premises Activated (E)	Lots/ Premises Passed/ Covered 4 (A+D)	Premises Activated (B+C+E)
Northern Territory	12	2	1	4	0	16	3
Queensland	111	34	11	26	4	136	49
Western Australia	52	12	6	4	0	56	18
Total NT, WA and Qld	175	48	17	34	5	209	70
Total Australia	520	177	42	116	20	636	238

Source: NBN Co (2014b)

131. NBN Co (2013b)

11.4.2 Mobile network upgrades

The third major driver of increased capacity is the need for higher quality mobile coverage, to enable more effective data communications than currently available. Mobile data capacity performs a different function than the rollout of the NBN. The NBN is to serve premises, while mobile extends this reach to activities away from premises. In remote regional Australia, mobile coverage is at least as important as fixed coverage, if not more so, due to the distances involved and the associated need for mobility.

It is important to recognise that wireless or mobile is becoming a lower cost alternative to fixed line. Wireless broadband can provide better coverage and potentially capacity than ADSL in some instances in regional and rural Australia. However this does require that the necessary infrastructure is in place.

The three major mobile service providers, Telstra, Optus and Vodaphone Hutchison Australia (VHA), each continue to expand their 4G mobile phone networks. Telstra reported in October 2014 that its 4G network would cover 90 per cent of the Australian population by January 2015,[132] including 300 regional towns, and expects its network coverage to exceed 90 per cent in 2015.[133] Telstra had previously advised that it would invest $500 million over 2013 and 2014, including on its mobile network. Optus has also indicated an investment strategy for its 4G mobile network to increase its quality and performance. It now has more than 2.15 million 4G-capable devices on its network.[134] VHA has also been investing in its mobile network.[135]

In addition to the commercial offerings, the Australian Government is continuing the Mobile Black Spot Programme to extend mobile phone coverage and competition in regional Australia. The program will provide network infrastructure to improve coverage of high quality mobile voice and wireless broadband services, with the objective of improving coverage:

- Along major transport routes
- In small communities
- In locations prone to experiencing natural disasters
- To address unique mobile coverage problems.[136]

Table 39 shows the mobile transmission sites in Northern Australia compared with the country as a whole.

Table 39: Mobile sites, Northern Australia

	Total sites		Sites with bandwidth greater than 5 MHz	
Carrier	Australia	Northern Australia	Australia	Northern Australia
Telstra	5,057	725	2,510	374
Vodafone	5,078	43	911	0
OPTUS	4,633	209	1,675	13
Total mobile sites	14,768	977	5,096	387
Number of sites per 100 inhabitants	0.07	0.08	0.02	0.03
Number of sites per 1000 sq. km	1.92	0.28	0.66	0.11

Source: Australian Communications and Media Authority

132. Bauer, D (2014). 'Telstra is best, but even worst Australian mobile networks not bad by European standards: report' Sydney Morning Herald, October 7, 2014
133. http://www.computerworld.com.au/article/433391/updated_4g_australia_state_nation/, accessed 9 July 2014
134. http://www.computerworld.com.au/article/545157/_aggressive_investment_4g_central_optus_strategy/, accessed 9 July 2014
135. http://www.theaustralian.com.au/technology/vodafone-splurges-on-network-to-win-back-customers-and-restore-brand/story-fn4iyzsr-1226580662375#, accessed 9 July 2014
136. http://www.communications.gov.au/mobile_services/mobile_black_spot_programme, accessed 9 July 2014

In terms of competition for mobile telephony, nationally the three carriers have a similar numbers of sites. However, this is not the case in Northern Australia. Optus and Vodafone utilise 209 and 43 sites respectively compared to Telstra's 725 sites. Mechanisms to increase competition, such as site declaration and permitting site access to other carriers to lower the cost of site establishment, have not proved effective in Northern Australia. While Optus and Vodafone have several joint ventures to share site infrastructure and transmission nationally, there appears to be little sharing involving all three carriers to date in Northern Australia.

Table 39 shows that there are about the same number of sites per inhabitant in the north as for Australia as a whole; indeed slightly more. However on a per area basis, northern coverage is significantly lower. Also shown in the table are sites of greater than 5 megahertz (MHz) as it is only above this frequency that mobile broadband service is feasible. In Australia as a whole, about one third of sites have this capability. In the north, the ratio is about the same. Similar to the situation with total sites, these sites are mostly Telstra's, with other carriers poorly represented.

11.4.3 Transmission infrastructure

Little public information exists on actual transmission networks in Australia. Communications transmission comprises high capacity, highly available communication paths (sometimes called backbone, long-haul or 'Super Highway' links) and lower capacity 'backhaul' links that connect last mile communications systems to the backbone. The terms 'backbone' and 'backhaul' are often used interchangeably. These links provide high capacity wholesale services that carry large volumes of voice, data and video traffic, often over long distances. The Australian Competition and Consumer Commission (ACCC) describes the domestic transmission network as the Domestic Transmission Capacity Service (DTCS). They are typically used by telecommunications companies to carry the combined traffic of many separate customers, as well as by large corporate customers with high volumes of traffic.

Equally important is transmission of data in and out of Australia at international points of interconnect. Cisco data shows that the traffic through Australia's international gateways was 81 per cent of all IP data in 2013 and is expected to remain at the same rate for five years. However internet data is expected to increase 2.6 fold to 34 gigabytes per capita in 2018. While some internet data will remain inbound, a larger portion can be expected to be outbound. This increase in international traffic will be carried by Australia's current international submarine cables at Sydney and Perth.

Building telecommunications transmission networks is resource-intensive. Backhaul transmission networks are not usually visible to end customers. However, when backhaul networks fail or become congested, the end user experience is severely affected. This was the case with the introduction of smartphones, as these markedly increased the traffic levels.

Transmission links are fixed point-to-point links that typically utilise optic fibre or microwave radio as the transmission medium. System redundancy is required to ensure the communication paths are not affected by singular faults. Whilst hardware redundancy is used to ensure links have high availability, path redundancy further increases the overall system availability. For example, communications between Brisbane and Townsville are normally via a direct connection between the two points. Should this path fail, communications will restore via Longreach. However Northern Australia has a number of long backbone links with either no, or at best, one redundant path. Tennant Creek to Darwin is a prime example. Ensuring transmission resilience and robustness is increasingly important as reliance on electronic communications grows.

Under the Regional Backbone Blackspots Program (Map 24), the Australian Government addressed some of the transmission network issues in parts of the north, including Darwin, and Emerald and Longreach in Queensland. The aim of the program was to enhance competition and encourage service providers to improve the range, quality and prices of broadband services to homes and businesses in regional areas.

The Regional Blackspots Program infrastructure was completed in 2011 and is operated by the Nextgen Group as part of the implementation contract. In addition to the Telstra and Nextgen networks, other transmission networks exist, including those of Ergon Energy, Queensland Rail and Powerlink in Queensland. All telecommunications are governed by the Telecommunications Act[137] which, under Section 42, prohibits the supply of a carriage service to the public without a carrier licence. However the Minister is able to exempt parties from this under subsection 51(1). This has enabled several organisations to share communications links or bandwidth, and to market services more broadly. For example, Nexium Telecommunications, Ergon Energy's provider, has been able to develop

137. Telecommunications Act 1997

its fibre network in Queensland as a wholesale provider. Similarly Australia Pacific LNG Pty Ltd has sought to make its network available to mobile communications providers.

Further opportunities exist with the opening up of additional areas for mining such as the Galilee Basin in Queensland. Infrastructure corridors providing rail and telecommunications have the potential to offer further transmission capability. This concept could be taken further, with the installation of backhaul links as part of road upgrades, and pipeline and rail development. As a general principle, major resources companies, railway operators and energy providers need high quality communications. To the extent that spare capacity exists, these networks present an opportunity to increase connectivity throughout Northern Australia. Access to domestic backhaul services is regulated by the ACCC under the DTCS regulatory framework. It does this to ensure that where there is only one provider of transmission services, or where competition is limited, prices are kept to acceptable levels. This allows carriers to access others' domestic backhaul and backbone links where it is uneconomic to build parallel links. It also opens opportunities, as described above for existing links to be used by third parties.

In addition to the terrestrial backbone links, there are a substantial number of radio communications links such as microwave. ACMA maintains a comprehensive register of radio communications services.[138] The register includes details of the location and output characteristics of licensed transmitters. Using the register and combining the spectrum band plans set out in the microwave fixed services frequency coordination documentation,[139] microwave wireless transmission metrics are described in Table 40. Of all transmission sites nationally, 16 per cent are in Northern Australia.

Table 40: Microwave transmission sites

Wireless transmission sites	Northern Australia		Australia	
	No.	Per cent	No.	Per cent
Licences	3,825	9.0%	42,347	
High-capacity licences	2,437	16.0%	15,256	
Transmission sites	753		4,656	
Sites with less than 5 licences per site	638	84.7%	3,818	82.0%
Sites with 5 licences per site or more	115	15.3%	838	18.0%

Note: Bandwidth of 28MHz or greater is used to define a high-capacity licence.
Source: ACMA and GHD analysis

82 per cent nationally have less than five high capacity licences compared to 85 per cent in Northern Australia.

Several transmission networks are deployed in Australia, with Telstra owning the only ubiquitous network, followed by other large networks owned by Optus and Nextgen. This is a similar pattern to the mobile sites shown in Table 39. Smaller network operators have localised backhaul networks for their own network usage, for example the business and government ICT service provider Amcom and the internet service provider TPG. This presents an issue for NBN Co as a government-funded provider. For the more densely populated areas (urban and regional centres) NBN Co is able to use competitive backhaul networks. For the less populated areas where competitive backhaul is not available supplementary provision of backhaul may be implemented for a limited period of time pending the emergence of competitive backhaul on these routes. These arrangements are regulated by the ACCC under its DTCS framework.

In addition to the domestic backbone links, it is important to recognise the importance of the international links. Australia's international points of interconnect are located at Sydney and Perth with a connection also at Onslow. Shell and INPEX have contracted the Nextgen Group to build a new undersea optical fibre cable between Darwin and Port Hedland to support their LNG development. This new link will connect with existing domestic fibre from Perth. The existing and proposed undersea links are shown in Map 25, together with the main backbone links. There exist further opportunities to enhance both domestic backbone and international links through additional cables from Northern Australia to Asia with an overland connection into Australia's backbone network. Such links would also facilitate improved local communications along their routes.

138. Australian Communications and Media Authority (2008)

139. Australian Communications and Media Authority (2014) RALI FX3 Microwave fixed services frequency coordination Melbourne: ACMA

11.5 Future communications demand

Future communications demand in Northern Australia is largely a product of the demand of the resources sector, population growth and major changes in community expectations. Expectations are developing as people become aware of potential use of the internet to access a growing range of applications in education, healthcare, commerce and industry, as well as social interaction.

The internet and digital systems have become almost mandatory in today's competitive business environment. Businesses without digital capability face increasingly competitive hurdles. This is arguably even more important in isolated areas of Northern Australia. It is now hard to imagine an organisation that has no digital capability and the means to communicate using it. Remote tourism, agriculture and mining rely on quality communications for access to markets and for big data analysis. Demand is also being driven by many new personal applications, such as mapping and social networking.

In addition to the person to person and data applications, there is a M2M use of communications. M2M allows remote monitoring, control and interaction between functioning machines in process and other applications. M2M has a growing number of agricultural and mining applications where non-human monitoring can significantly boost productivity. Cisco Systems forecasts that M2M modules will account for 45 per cent (79.3 million) of all networked devices in Australia in 2018, compared to 26 per cent in 2013.[140] This is a 25 per cent annual average growth rate.

ACMAs *Communications Report 2012-13* identifies consumer behaviour trends and technological changes that are leading to major changes in the way that individuals and businesses access and utilise communications services. These include:

- *A reduced dependency on fixed-voice communications*
- *Growth in use of multiple online and Internet Protocol (IP) communications services with mobile phone services pre-eminent*
- *Significant increases in the number of users of over-the-top (OTT) communications such as VoIP via mobile phones and tablets, providing a growing challenge to fixed and mobile voice revenue streams*
- *Continued growth in use of smart devices such as smartphones and tablets and related applications and services*
- *Internet services delivered over mobile networks*
- *Growth in the delivery and use of content services across multiple networks and consumer devices*
- *Surge in the volume of data being downloaded in Australia, driven by fixed-line broadband subscribers and the increase in viewing of higher quality online video content*
- *Increased use of professionally produced online content services such as catch-up TV, complementing viewing of traditional broadcast services*
- *The expansion of key digital economy infrastructure such as 4G mobile networks and the NBN.*[141]

Some of the key trends are outlined below.

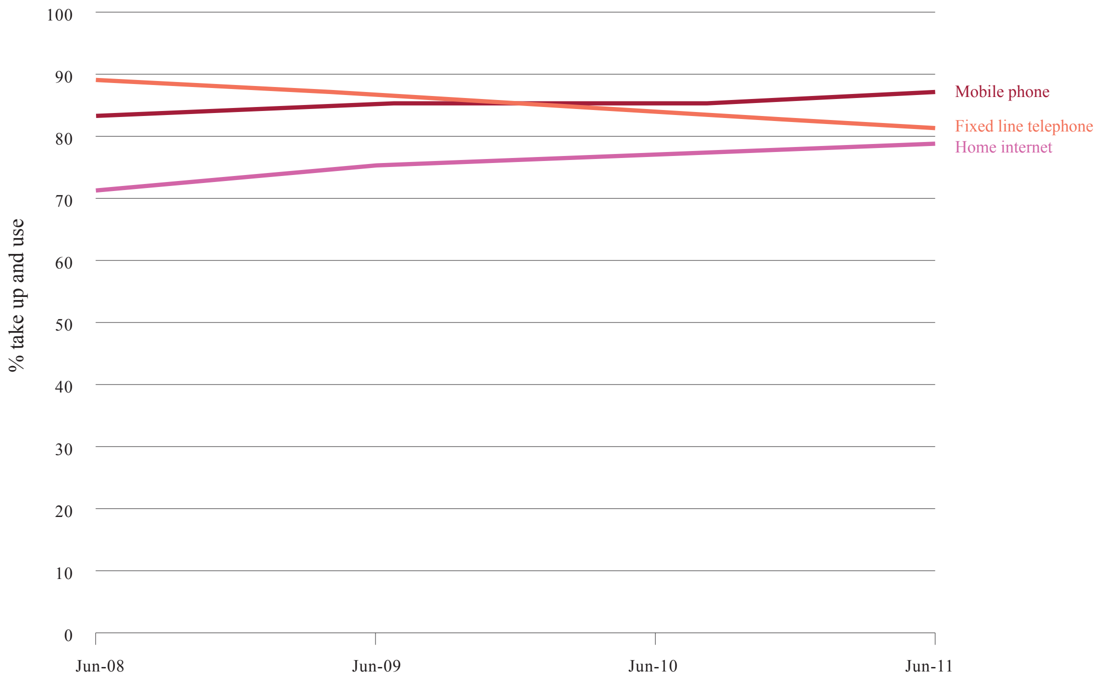
Reduced dependency on fixed-voice communications

One important shift in telecommunications services has been the decline in use of fixed voice services and their replacement with mobile voice communications. ACMA data show that at June 2013, 3.68 million Australians aged 18 years and over were estimated to be without a fixed-line telephone service in the home. This is reflected in the reduced take-up of fixed line service relative to mobile, shown in Figure 50.

140. Cisco Visual Networking Index http://www.cisco.com/c/en/us/solutions/service-provider/visual-networking-index-vni/index.html, accessed 9 July 2014

141. Australian Communications and Media Authority (2013

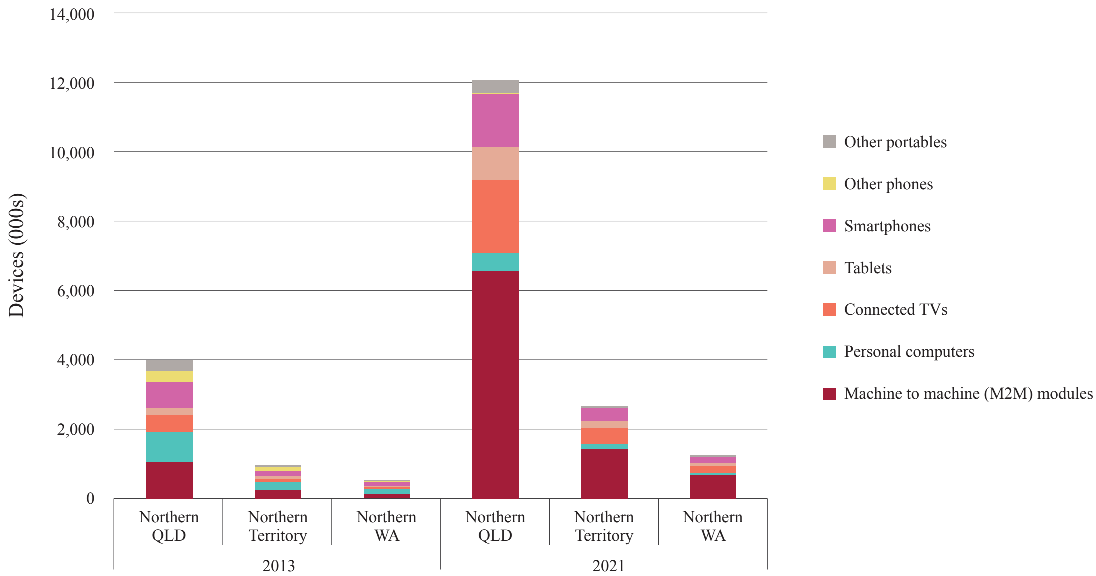
Figure 50: Take-up and use of selected services by persons 18 years and over (per cent)



Source: Department of Broadband, Communications and the Digital Economy (2013) Chart 7

According to Cisco's forecast[142] of the growth in mobile communications, 36 per cent of all Australian networked devices will be mobile-connected by 2018 and mobile traffic will increase nearly six-fold from 2013 to 2018, an annual growth rate of 41 per cent. These forecasts are shown in Figure 51.

Figure 51: Estimated growth in communications devices 2013-2021



Cisco forecast devices per person and GHD analysis. The forecasts are extrapolated to 2021.

142. Cisco, Visual Networking Index

Increases in the number of users of 'over-the-top' communications

The dramatic growth in use of 'over-the-top' services (for example third party content such as Netflix) and Voice over Internet Protocol (VoIP) services (such as Skype), via both mobile and fixed phones, has paralleled the rapid uptake of smartphones and the increased availability of applications providing internet-based services using mobiles. These applications include VoIP services that are beginning to assume the role of the public switched telephone network's voice. Cisco has forecast that IP traffic in Australia will grow three-fold from 2013 to 2018, an annual growth rate of 22 per cent.

Diversification in communications services used

ACMA's consumer research also reveals that there is growing diversity in the communications services used by Australians. In the six months to May 2013:

- 29 per cent of adults identified mobile voice calls as their most used communications service
- 24 per cent identified texting
- 20 per cent identified email
- Only 16 per cent identified fixed-line telephone calls, which was a reduction from 22 per cent in the previous year
- Nine per cent identified social networking.

However, particularly with the advent of smartphones, mobile communications continue to be at the forefront of consumer communication activity. Again the forecasts by Cisco for Australia are striking:

- 174.7 million networked devices in 2018, representing 7.0 devices per capita, up from 98.7 million and 4.2 per capita in 2013
- Personal computers (PCs) will account for 11 per cent (19.8 million) of all networked devices in 2018, falling from 22 per cent in 2013
- Tablets will account for seven per cent (11.7 million) of all networked devices in 2018, compared to five per cent in 2013.

Internet services

In 2013, around 80 per cent of Australian adults lived in homes with internet access and 62 per cent used the internet via a mobile handset.[143] Australians access the internet through fixed line services – delivered through the variety of technologies now available – and through mobile services to mobile phone handsets, tablets, dongles, Universal Serial Bus (USB) modems and data cards. The highest proportion of connections to the internet were via mobile handsets, although the number of fixed line and mobile broadband subscriptions connections were roughly equal. Nevertheless, the average data downloaded on a fixed line was 23 times greater than that to a wireless device and over 32 times greater than that downloaded to a mobile phone.

With the increase in Wi-Fi available, this technology is bridging the gap between mobile and fixed connections. Despite its limited range, Wi-Fi allows a mobile-like wireless connection that both enhances the internet connection experience and allows a range of devices.

The Cisco forecast for internet traffic is for 2.7-fold growth from 2013 to 2018, an annual growth rate of 22 per cent.

11.6 Infrastructure gaps

The levels of service available in the north of Australia and those enjoyed in the major metropolitan areas differ significantly. The economics of communications provision in remote areas militates against extensive provision of terrestrial backbone links, whether by microwave radio or optical fibre, and mobile phone coverage. This may result in the only option being satellite, with its inherent limitations. Satellite internet can deliver acceptable service, although it will deteriorate under a range of conditions and with simultaneous users. Voice calls over satellite are poor due to the latency of the service. However, the need for high quality communications is exacerbated by remoteness – in delivery of e-health and e-education for example. In addition, mobile broadband is in certain situations more useful than fixed in remote areas.

To a substantial degree, the NBN Co rollout of broadband access will determine the extent to which the disparity between Northern Australia and the east coast is closed. As at this stage NBN Co does not publish detailed rollout plans,[144] it is not possible to realistically determine the extent of remaining gaps. However, the present restriction of NBN Co to fixed service (rather than mobile) will limit the options available for remote Northern Australia. It effectively leaves mobile broadband to the commercial sector, with, on present indications, smaller carriers (such as Optus or Vodafone) focusing on urban areas only.

143. ACMA (2013)

144. The NBN Co web site shows locations completed or where build has commenced, and is open to submissions as part of its Network Extension Program; however this remains under review as at the date of writing.

11.6.1 Service quality gap

Quality is in part a consequence of capacity, where the number of connections to an exchange, mobile tower or satellite is either finite or the bandwidth is shared. Mobile networks have the important characteristic of switching between towers to provide coverage and capacity. Adjacent towers can use different frequencies, coding or orthogonal frequency division to create different channels. Where the number of towers is sparse, these advantages diminish. As the distance from the tower (or the exchange) increases, the power that the mobile phone receives is reduced, as is the quality of the signal. Inevitably, with the sparse population of remote Northern Australia, this problem is noticeable. Similarly the quality of satellite service will diminish with the number of simultaneous users.

Mobile towers and higher capacity landlines are not without costs and the economics of providing this infrastructure in sparsely-populated areas is challenging. For this reason, providers (including NBN Co) turn to satellite as the means for delivery. Satellite is both expensive to the consumer and of poorer quality (in terms of reliable download speed dependant on the number of concurrent users) than is often achievable with terrestrial technologies. In the absence of some form of policy intervention, remote customers are likely to continue to experience a poorer quality of service for a higher cost than those in highly urbanised areas.

This poorer quality of service experienced by remote customers is a challenge for Australian economic competitiveness. Moreover, this limits the attractiveness of investment in Australia both in the sectors that rely on good telecommunications and in telecommunications itself.

Fibre is only economical in the more densely settled parts of the country. This is also true of mobile, where population density also governs the commercial returns. The technologies to the left in Figure 41, ADSL, Satellite and Fixed Wireless, are those more likely to be adopted in Northern Australia, away from the major settlements. It follows that the ‘digital divide’ between remote and rural Australia and the populated coastal areas may continue.

Carrier quality communications infrastructure and broadband serving major centres and smaller locations are essential economic facilitators for the north. They are needed to enhance quality of life, education, health, tourism and industry. The huge growth in the digital economy that is forecast internationally must be reflected in Northern Australian if it is to reach its full potential.

11.6.2 Transmission infrastructure gap

A key consequence of the broadband rollout and substantial increases in demand is the need for supporting infrastructure – the backbone or trunk links – that connect the major communications points of presence to the nation and internationally. There are two related issues for Northern Australia. The first is the need for reliability, or the ability to maintain a service should a backbone link go down. Network reliability is a measure of how a network reacts and recovers from failures. A reliable network must have multiple paths connecting key locations. The second is the cost of communications service, which is in part related to competitive backbone and backhaul infrastructure. Without competitive backbone links – in the sense of equitable access to a shared resource – high prices may flow on to the consumer. Furthermore, the network may lack the redundancy needed to maintain service in case of failure or overload. In Northern Australia and in Queensland and Western Australia particularly, there is a need for greater coverage inland, which in turn would require backhaul links away from the coastal developed areas or the major (coastal) road links.

In July 2012, the ACCC commenced a review of the domestic transmission capacity service and fixed line services. The ACCC’s Final Access Determination Discussion Paper – Primary Prices (July 2014) included submissions from several Regional Development Australia committees, which noted the high cost of regional transmission. The commission commented that this remains prohibitive to the extension of mobile and broadband coverage in regional areas.

There exists an opportunity to enhance both domestic backbone and international links by a cable from Northern Australia to Asia with an overland connection into Australia’s backbone network. Such a link would facilitate improved local communications along the route and further strengthen the resilience of Australia’s transmission services in the north. A simultaneous failure on the Darwin to Tennant Creek link has the potential to severely impact data and voice services at Darwin and Port Hedland. However, the Regional Backbone Blackspots Program has delivered a third link to Darwin, and the Darwin-Port Hedland connection noted above will add further redundancy.

11.6.3 Addressing communications infrastructure gaps

Shortcomings in communications services in Northern Australia will not be solved by expecting market forces alone to establish the necessary infrastructure. Even with the NBN Co broadband rollout, the north, particularly the more remote parts, will lag behind. More creative solutions are needed. These will need cooperation between all levels of government. While the Commonwealth has the major role in telecommunications, state and territory governments have roles in facilitating planning approvals, identifying local opportunities and facilitating implementation, and encouraging communications infrastructure provision from both private and government sectors. One such opportunity is the use of state and local programs for road construction to include laying of communications cable when major works are undertaken, and where there is a coherent plan to ultimately connect into a network.

The role of NBN Co remains critical. NBN Co is at present limited to providing fixed infrastructure, albeit including satellite and wireless. Importantly, NBN Co is expected to operate commercially, and provide an economic return. In view of growing technological convergence, NBN Co's remit might be better executed were its direction to be less focussed on the technologies that it uses and more on the service it can underpin as the primary communications wholesaler. While this has partly been accomplished with the multi-technology model for the last mile it remains focussed on fixed modes of delivery.

With regard to funding, there are several possible ways that this could occur:

- **Financial support for provision of the necessary infrastructure:** A model for this might be the previous Regional Backbone Black Spots Program. It could address the need for further backhaul links or mobile towers.
- **Funding to telecommunications providers in the form of 'universal service obligation' payments:** There are well-established models for a community service obligation or universal service obligation approach in a number of services sectors, where the payments are calculated on the costs of provision of the non-commercial services.
- **Incentivise or obligate owners or developers of new infrastructure:** This approach could involve both public and private projects, including roads, railways and mines to include carrier quality communications links in their development. Several developers have incorporated such links in their proposals, in order to make them more acceptable to governments or to local communities. In turn, improved communications can benefit the infrastructure owner – for example, in assisting the monitoring of road conditions on a real time basis.

11.7 Communications critical infrastructure requirements

Critical infrastructure requirements for the communications sector are summarised in Table 41.

Table 41: Communications critical infrastructure

Infrastructure gap	Region	Primary gap(s)	Key infrastructure requirement(s)
Broadband service	Throughout Northern Australia	Demand, service standard	Progressive rollout of NBN, both to catch up on existing deficiency and to accommodate growth, with the program to be determined by NBN Co. Note specific needs below
		Demand, service standard	Incentivise, require or subsidise provision of higher quality communications to remote regions through universal service obligation, or other arrangements, e.g. infrastructure programs
Mobile service	Inland Western Australia	Demand, service standard	Expand mobile coverage away from Highway 1 to the interior of the state, with associated loop backhaul
Transmission infrastructure	Central and Western Queensland	Demand, service standard, cost	Leverage investment in resources infrastructure to create new backhaul and mobile coverage
	Across Northern Australia	Demand, service standard, cost	Seek opportunities to incentivise existing private communications infrastructure owners to allow third party access
International connections	North Western Australia, Northern Territory	Demand, service standard	Encourage international cable link via Northern Western Australia or Northern Territory with associated domestic backbone connections

"The role of NBN Co remains critical. NBN Co is at present limited to providing fixed infrastructure, albeit including satellite and wireless."

Growth scenarios

12.1 Introduction

The report so far has explored Northern Australia's critical infrastructure gaps and requirements under baseline population growth and economic growth. The baseline population projections reflect a continuation of past demographic trends such as fertility, mortality and migration while baseline economic projections reflect trends in incomes, technology, industry performance and productivity, external demand and more. These are described in detail in Section 3.

This section focusses on certain specific economic and population growth scenarios for Northern Australia development as an additional basis for measuring future infrastructure gaps.

The targets and the regional distribution of growth modelled in this section are approximations which will help to understand the critical infrastructure gaps under a range of possible futures. They should not be considered as a final set of policy options and do not include a comprehensive analysis of distributional impacts.

12.2 Industry economic growth targets

Northern Australia has experienced exceptional rates of population growth in the past decade as the strength of the resources sector attracted workers from interstate and overseas. Continued economic growth in the resources sector as well as Northern Australia's other key industries – tourism and agriculture – could further stimulate population growth in the region.

The greatest opportunities for growth in Northern Australia to 2030 could be driven by the agriculture, tourism and resource sectors with targets for:

- Developing a food bowl, including premium produce, which could help to double Australia's agricultural output
- Growing the tourist economy in the North to two million international tourists annually
- Building an energy export industry worth $150 billion to the economy, with a major focus on clean and efficient energy and providing major increases to resource exports.

The States and Territory have their own respective policy targets and settings for the agriculture, tourism and resource sectors which could help to meet the *2030 Vision* targets which are outlined in the sections below.

12.2.1 Agriculture targets

The real value of world agrifood demand in 2050 (in 2007 US dollars) is projected to be 77 per cent higher than in 2007. This represents an annual average increase of 1.3 per cent over the projection period. Most of the projected rise occurs in Asia, where agrifood demand is expected to double over the projection period (in 2007 US dollars). Demand in the rest of the world is projected to increase by 48 per cent over this period. China accounts for 43 per cent of the projected increase in global demand, while India contributes 13 per cent of this growth.

The projected increase in the real value of global agrifood demand (in 2007 US dollars) is greatest for vegetables and fruit, meats, dairy products, cereals and fish. Dairy products, meat and fish increase their share of global agrifood demand

Photo courtesy of Pilbara Ports Authority

over the projection period. This is consistent with the expected change in diets towards high value products as consumer incomes rise.

Australia is in a good position to meet some of this higher demand. Australia has a comparative advantage in the production of several agricultural products and its geographical location means lower transport costs in exporting to Asia. The projected increase in global agrifood demand is expected to lead to increased production and exports of key Australian agricultural commodities. In particular, the real value (in 2007 US dollars) of Australian production of agrifood products covered in this analysis is estimated to be 77 per cent higher in 2050 than in 2007 (an annual average increase of 1.3 per cent). The largest increases in the real value of Australian production (in 2007 US dollars) are projected for beef, wheat, milk and sheep meat.

The real value (in 2007 US dollars) of Australia's agrifood exports in 2050 is projected to be 140 per cent higher than in 2007 – an annual average increase of 2.1 per cent. This is driven by substantial increases in the real value of exports of beef, wheat, dairy products, sheep meat and sugar. China is driving the projected higher global import demand for beef, wheat, sheep meat and sugar, while India accounts for over 60 per cent of the projected increase in global import demand for dairy products.[145]

12.2.1.1 Current state and policy settings

Growing populations are placing increasing pressure on global food production. The United Nations projects that world population will increase from 7 billion in 2011 to 8.4 billion by 2030.[146] Ongoing research by ABARES projects that world consumption will increase 1.3 per cent year-on-year and that food production in Asia in particular will not be sufficient to meet the growth in Asian food consumption for many commodities.[147] Rising incomes have also lead to increasing demand for more varied diets, higher quality produce such as premium fruit and vegetables, and more protein rich diets such as meat and dairy.[148] There are diverse opportunities for Northern Australia to be a significant producer of high quality food.

The *2030 Vision* proposes that growth in Northern Australia could be driven by "developing a food bowl, including premium produce, which could help to **double Australia's agricultural output**" by 2030.

At a jurisdictional level:

- The Queensland Government has identified agriculture as one of the four key pillars of the Queensland economy. *Queensland's Agriculture Strategy* outlines a target to **double Queensland's agricultural production** by 2040.[149]

145. ABARES, (2012), p.1
146. United Nations (2011), p.147
147. ABARES (2013), p5
148. ABARES (2013), pxiii
149. Department of Agriculture, Fisheries and Forestry (2013)

- The Western Australia Government launched *Agrifood 2025+: the future WAy* in 2012 to examine future opportunities for a globally competitive agriculture and food industry in WA. *Agrifood 2025+: the future WAy* outlines a target to **double the value of the sector by 2025.**[150]
- The Northern Territory's *Framing the Future* blueprint for the Northern Territory includes an objective of 'an economy that unlocks the potential of our regions, encourages new investments and growth of existing businesses in the pastoral, fisheries and agriculture sectors (among others).[151] The Northern Territory's Industry Development Plan 2013-2017 is a commitment to achieving the objectives of profitable and productive primary industries.[152]

In the 2014-2015 Northern Territory Budget, an additional $2.4m funding was provided for expanding the land and water assessment program to find new agricultural precincts throughout the Territory. This is in addition to the $1.8m for land and water suitability assessments for agricultural developments currently taking place in the Tiwi Islands. This accelerated land and water assessment program is planned for the next 4 years.[153]

In addition the Commonwealth Government has suggested that the White Paper on Developing Northern Australia *will consider a Water Project Development Fund for northern Australia. The 'Supporting More Efficient Irrigation in Tasmania Programme' is a possible model……Capital infrastructure costs are then met by the Australian and state governments and industry, with ongoing costs met by irrigators. There may be scope for similar approaches in Northern Australia.*[154]

12.2.1.2 Agriculture in the scenarios

For the purposes of developing the agriculture scenarios for the Northern Australia infrastructure audit, the following simplifying assumptions were made:

- "Double Australia's agricultural output" is interpreted as doubling the value of Australia's agricultural output in FY11 by FY31 in real terms (gross value add)
- "Could help to double Australia's agricultural output" is interpreted as Northern Australia contributing more than its current share of Australia's agricultural output
- The policy target is reached in FY31, with straight line growth between FY11 and FY31
- "Agriculture" includes agriculture, fisheries and forestry as defined by the ABS.

The economic output of Australia's Agriculture, Fisheries and Forestry Industry (the Agriculture Industry) in FY11 was $33,143 million.[155] The agriculture target for Australia as a whole would be $66,286 million.

The economic output of Northern Australia's Agriculture Industry in FY11 was $3,726 million.[156] Under the baseline rate of growth, the Agriculture Industry is projected to grow 88 per cent in real terms to $7.0 billion by FY31, or 3.2 per cent year-on-year.

A minimum target of $7,452 million in agricultural output from Northern Australia by FY31 in real terms would be required to maintain the region's current contribution to Australia's agricultural output of 12.2 per cent, representing 3.5 per cent year on year growth between FY11 and FY31. This is the agricultural element of **Scenario 2**.

Northern Australia could double its contribution to Australian agricultural output by FY31 to 24.4 per cent or $14,906 million, representing 7.2 per cent year on year growth between FY11 and FY31. This is the agricultural element of **Scenario 1**.

12.2.1.3 Challenges to achieving the agriculture growth targets

Across Northern Australia the opportunities for the economic development through irrigated agriculture are highly dependent on availability of good soils and water, and access to economic infrastructure such as transport networks.

Achieving the growth opportunities in Northern Australia's agriculture industry (as outlined in the scenarios) will rely on the efficient and effective movement of food to key markets. Economic infrastructure assets are essential components of Australia's domestic and international food supply chains.

150. Personal advice, West Australian Department Agriculture and Food (2014)
151. NT Government (2013), *Framing the Future*, p5
152. NT Department of Primary Industry and Fisheries (2013), p3
153. Personal advice, NT Department of Land Resources Management (18 July 2014)
154. Australian Government (2014), p52
155. PwC's GEM. Gross Value Added, Chain Volume Measure in real FY11 dollars, consistent with the base year in the ABS State Accounts and ABS National Accounts.
156. PwC's GEM. Gross Value Added, Chain Volume Measure in real FY11 dollars, consistent with the base year in the ABS State Accounts and ABS National Accounts.

Climate

Climate is a real exogenous risk to the projections as changes in temperature, rainfall and the occurrence of extreme weather events (such as cyclonic winds and floods) will affect the scenarios over time in a range of areas, including water availability and reliability of supply. In addition, seasonal variation of the wet season across Northern Australia significantly affects irrigation water use. By way of illustration, Figure 52 demonstrates the high degree of climatic variability impacting irrigation water needs for both the Mareeba-Dimbulah and Burdekin-Haughton Irrigation Schemes in north Queensland.

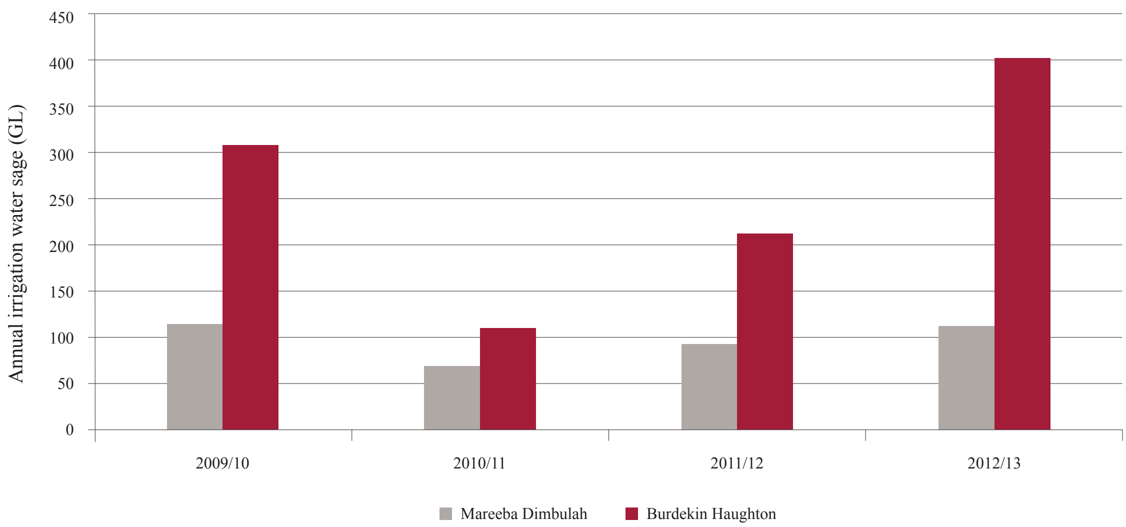
The challenges in accessing water for agriculture include the impact of a high evaporation rate on surface water resources, including water in open storages, and the relatively flat topography in many regions including the Northern Territory for the transportation of water by gravity. As a result of these factors, water for agriculture in many areas is sourced from groundwater resources, extracted close to the point of use.

Irrigated agriculture potential and challenges

Irrigated agriculture will need to be at the forefront of any significant increase in agricultural production from Northern Australia, as it currently comprises less than 1 per cent of all Australian agricultural land, yet produces around 30 per cent of the total agricultural output and over 50 per cent of all farm profits.[157] In this regard it is noted that:

- The Western Australian Department of Water has previously identified that there were more than 1,000 gigalitres of sustainable fresh water in the Pilbara and Kimberly alone[158]
- The state's 2008 water study estimated that there were 10 million hectares of land suitable for irrigation agriculture in Western Australia, half of which is in the west Kimberley[159]

Figure 52: Irrigation scheme water usage



Source: SunWater annual reports and GHD analysis

- The Ord River Irrigation further expansion project is investigating the potential suitability of 60,000 hectares for irrigation development, with approximately 14,500 hectares identified in the Northern Territory. The latter component would equate to an increase in irrigated area of Northern Australia of approximately 11 per cent
- The Northern Australia Land and Water Taskforce's 2009 report, *Sustainable Development of Northern Australia*, suggested in the order of an additional 600 gigalitres per annum (approximately) of groundwater could be accessed to support a mosaic irrigation development. CSIRO suggests this could irrigate between 50,000 and 120,000 hectares in Northern Australia, depending on the type of crop (which dictates water requirements) and irrigation efficiency[160]
- The *Darwin Regional Water Supply Strategy* also identified the Adelaide River Offstream Water Storage (AROWS) scheme which has the potential to provide in excess of 30 GL/year of additional water to support the economic and urban development within the greater Darwin

157. See http://www.csiro.au/Outcomes/Water/Water-Book/Chapter-8-Irrigation.aspx, accessed 10 August 2014.

158. http://www.ceda.com.au/news-articles/2014/06/24/waagribusiness, accessed 30 June 2014

159. Pers Comm. WA Minister for Water and Forestry, the Hon. Mia Davies at CEDA Agricultural Forum 25 June 2014 as reported http://www.ceda.com.au/news-articles/2014/06/24/waagribusiness

160. CSIRO (2013)

region. The AROWS scheme would involve: the development of an already identified 300GL off stream storage, in proximity to Darwin[161]

- The following five systems have been identified for conjunctive water use planning through a 3 phase process of master planning and concept development, feasibility studies and the development of business cases:
  - Katherine/ Daly Basin (including Tindall Limestone/ Oolloo/Jinduckin/Manbulloo/ Scott Creek)
  - Mataranka (Roper/Tindall Limestone)
  - Ngukurr (Roper River and surrounding aquifers)
  - Darwin Rural Area (including McMinns, Howard, Berry Springs, Acacia Hills)
  - Wildman River.[162]
- In the Flinders catchment, farm dams could support 10,000 to 20,000 hectares of irrigation in 70 to 80 per cent of years; irrigation may not be possible in very dry years.[163] The addition of 20,000 hectares of irrigated agriculture in the Flinders catchment would increase the irrigated area of Northern Australia by approximately 15 per cent
- In the Gilbert catchment, large instream dams could support 20,000 to 30,000 hectares of irrigation in 85 per cent of years.[164] The addition of 30,000 hectares of irrigated agriculture in the Gilbert catchment would increase the irrigated area of northern Australia by approximately 22.5 per cent. In addition, the *i-fed* proposal within the Gilbert River catchment envisages the irrigation development of approximately 50,000 hectares[165]
- Townsville Enterprise Ltd also recently released the *North and Northwest Queensland Sustainable Resource Feasibility Studies* which identified the potential for up to 125,000 hectares of irrigation development in the Upper Burdekin catchment (subject to more detailed soil investigations). This level of development could potentially equate to a 93 per cent increase in the area of irrigated agricultural production of Northern Australia[166]
- Within Queensland the General Water Reserve under existing Water Resource Plan areas sets aside approximately 500,000 megalitres (refer to Table 26) of water allocation (i.e. approximately 50,000 hectares of irrigation development at an application rate of 10 megalitres per hectare). This level of development could potentially increase the area of irrigated agricultural production of northern Australia by 36 per cent.

While there is some overlap with the information presented above, it is apparent that suitable land and water exist in Northern Australia to support large-scale irrigated agriculture development. However, dams and water delivery/distribution infrastructure are likely to be required to achieve the significant growth envisaged in the scenarios. Moreover, most existing irrigation schemes across Queensland are only approaching recovery of 'lower bound prices'[167] which would not incentivise private sector investment. The Queensland Government's irrigation water pricing policy is based on cost-reflective price targeting lower bound costs only, i.e. irrigation water prices do not to include consideration of return on capital. The Queensland Competition Authority, as the economic regulator, reviews irrigation pricing to recommend what is prudent and efficient costs that are then considered by the shareholding Ministers, who determine irrigation prices.

In essence, the lower bound costs comprise the 'cash' costs of the scheme which must be recovered in order to operate the scheme, such as labour, maintenance and asset replacement and do not include a return on capital from this sector of SunWater's business.[168] However, many irrigation channel schemes in Queensland are not yet achieving lower bound prices and a 'price path' has been established with a view to achieving this target over time. Where costs are not recovered from water users they are supplemented by Community Service Obligations (CSO) from the Queensland Government to meet the financial viability requirement of SunWater. The current levels of CSO provided for the irrigation channel schemes in northern Queensland are shown in Table 42.

161. Personal advice, NT Department of Land Resources Management, 18 July 2014

162. Personal advice, NT Department of Land Resources Management, 18 July 2014

163. CSIRO (2014)

164. CSIRO (2014)

165. http://i-fed.com.au/project/, accessed 1 July 2014

166. GHD (2014)

167. Schedule B(i) of the NWI sets out COAG's definition of lower bound pricing as – the level at which to be viable, a water business should recover, at least, the operational, maintenance and administrative costs, externalities, taxes or TER (not including tax), the interest cost on debt, dividends (if any) and make provision for future asset refurbishment/replacement. Dividends should be set at a level that reflects commercial realities and stimulates a competitive market outcome.

168. SunWater is a state owned corporation responsible for an extensive network of water storages, irrigation schemes and pipelines that deliver bulk water to over 5,000 customers across Queensland.

Table 42: Community service obligation provision by Queensland Government to SunWater (dollars)

Scheme	FY13	FY14	FY15	FY16	FY17
Nogoa bulk (high priority)	7,759	2,206			
Burdekin distribution – Channel	3,335,916	2,845,146	2,327,084	1,779,082	1,204,112
Burdekin distribution – Giru	231,058	154,518	74,024		
Burdekin distribution – Glady's	18,193	15,788	13,262	10,601	7,793
Emerald distribution (medium priority)	232,592	61,981			
Eton distribution	1,504,909	1,433,426	1,357,457	1,277,063	1,191,242
Mareeba distribution – up to 100ML	89,123	57,065	23,319		
Mareeba distribution – 100-500ML	167,017	95,666	20,467		
Mareeba distribution – above 500ML	174,271	67,021			
Mareeba (Re-Lift)	126,495	112,538	97,772	82,203	65,835
Total for northern Queensland	**5,887,333**	**4,845,355**	**3,913,385**	**3,148,949**	**2,468,982**
Total for southern Queensland*	***3,085,602***	***2,571,969***	***2,075,305***	***1,589,454***	***1,247,141***
TOTAL CSO	**8,972,935**	**7,417,324**	**5,988,690**	**4,738,403**	**3,716,123**

*Note: * Southern Queensland schemes include Barker Barambah regate (Re-Lift), Bundaberg distribution, Callide Valley bulk, Lower Mary distribution, Lower Mary (Tinana and Teddington Weir), Macintyre Brook bulk, St George distribution, Theodore distribution, Three Moon Creek bulk (groundwater) and Upper Condamine bulk (NB risk A*
Source: SunWater

The Queensland Government has embarked on a process of exploring the transition of gravity irrigation schemes from government to local ownership to achieve a range of outcomes including more efficient water pricing and investment in asset maintenance and renewals.

Major green-field irrigation projects involve considerable risk and significant capital investment. As identified by GHD for the Dalrymple Scheme in the Upper Burdekin:

- *The economics of .... the irrigated agriculture project assessed in these studies is very challenging, even assuming that the project does not have to pay for water rights (water allocation), and particularly where the agriculture project bears the full cost of a dam and water transport infrastructure* [and ancillary infrastructure such as power and rail spur connections]
- *...government will need to incentivise private sector investment before meaningful development expenditure will occur. Incentives, if the government wished to provide them, could be in the form of financial contribution and/or policy encouragement… including stimulating early-stage development expenditure. Government may also consider if it wishes to relieve some burden of infrastructure costs for long-life intergenerational assets such as water infrastructure*
  - *For the irrigated agriculture project to have a reasonable likelihood of success the government would need to make a material contribution during both development and construction (capital expenditure) phases. This contribution could be through policy (i.e. non-financial) or through financial support (including financial instruments such as guarantees), and both mechanisms are likely to be required. Policy support could include options such as:*
  - *Minimising the development risk associated with land acquisition and approvals through policy and/or use of available legislative mechanisms such as Infrastructure Facility of Significance (IFS) or State Development Area (SDA) under the State Development and Public Works Organisation Act*
  - *In the absence of a government capital contribution to the cost of a dam and related infrastructure, establishing a mechanism to provide some benefit back to the dam provider in respect of the change of land values (dry land vs. irrigable land value)*
- *Economies of scale clearly benefit the irrigated agriculture project and while this will appeal to some investors, increased capital cost increases risk and relies on more land and water resources. The outcomes of analysis conducted for these studies implies that private sector firms are likely to require some incentive from government to invest in the proposed development activity*

- *The contribution of private sector entrepreneurship and intellectual property from a committed proponent may identify additional value that would improve the financial and economic outcomes*
- *The long life of water infrastructure such as dams and channels, make these multi-generational assets. Assessing the net economic benefits of these assets is challenging as many of the future users and sources of economic benefit are uncertain on day one, leading to potential benefits not being quantified in economic assessments.*[169]

The degree of alignment that exists between stated government policy objectives (and reflected in scenarios), project requirements, market conditions and community expectations provides an important basis from which major irrigation developments could be pursued by a proponent. A proponent strategy that uses this alignment to support practical execution of a project development process will enhance the probability of the successful delivery of the projects (or similar alternatives) assuming market conditions and other externalities remain within accepted bounds.

The roadblocks to major project developments tend to be most confronting at conception and at the point of final investment decision (FID). Private sector firms are more likely to be willing investors for the development and construction of projects which meet their return expectations where relevant government policy and community expectations are likely to be stable. Feedback from industry stakeholders consulted during the North and Northwest Queensland Sustainable Resource Feasibility Studies noted that the Government can play a role through establishing and maintaining transparent and efficient policy settings.

Based on outcomes of these studies, it would appear that major irrigation developments will be challenging investments without financial or strong policy support from government. Government's willingness to invest (based on economic benefit) in agriculture developments of the scale considered in the scenarios below has not been tested in Queensland since the investment in the Burdekin Falls Dam and associated regional development in the 1980s.

In contrast, the ongoing Ord Irrigation Scheme development in Western Australia has achieved a commitment from a major international investor based on mutual commitments by the private sector and governments. However, even in the case of the Ord, governments (WA and Commonwealth) have been major investors in the water infrastructure (dam, channel system), roads, drains and ancillary infrastructure and community programs.

Governments have historically played a key role in major irrigation led developments around Australia. The conventional approach has been that construction costs of critical water infrastructure are met by governments, with water users meeting ongoing operational and maintenance costs. The Australian Government has flagged its intention to consider establishing a Water Development Fund.[170] This fund may also be a source of a co-contribution for project feasibility to assist remove/mitigate early project related risks. The two most recent large scale irrigation development cases (other than Cubbie Station and the current smaller scale irrigation schemes supported by government in Tasmania and referenced in the Australian Government's *Green Paper on Developing Northern Australia*)[171] i.e. the Ord and Burdekin Schemes, are discussed further in Appendix D.

169. GHD (2014)

170. Australian Government (2014) p. 52

171. Australian Government (2014) p. 52

Figure 53: Corella Dam (70 kilometres east of Mount Isa)

Finally, the Queensland Government is currently considering options associated with 'orphaned' major water storages. For example, Corella Dam (Figure 53) was originally constructed to provide water supply to the Mary Kathleen uranium mine. It is now maintained by the State Government. The storage and its environs are currently utilised for recreational activities. No commercial activities are associated with the water allocation available from the storage or its environs.

Development of a major dam and associated irrigation development would in turn increase attractions and provide a catalyst for additional tourism related opportunities e.g. accommodation, guided tours, boat hire, fishing etc. Land tenure issues may need to be addressed to facilitate such outcomes.

12.2.2 Tourism growth targets

12.2.2.1 Current state and policy settings

Tourism is an iconic sector in Northern Australia, with great economic importance in terms of employment and opportunity for regions which have traditionally relied on mining and agriculture in order to diversify to services such as accommodation, restaurants, retail trade, transport, arts and recreation.

The United Nations World Tourism Organisation defines a tourist as a traveller taking a trip to a destination outside their usual environment, for less than a year, for purposes of leisure, business, education or other personal purpose. This definition may be broader than what is ordinarily considered to be tourism but it acknowledges the variety of sources and types of tourism activity.

Visitation to Northern Australia has been steadily declining over the past decade. International tourism has been affected by weaker global conditions in some of Northern Australia's key source markets such as United States, United Kingdom and Japan. The relative strength of the Australian dollar and resource and labour shortages have also played a role in declining international competitiveness in the tourism sector – few sectors are more exposed to historically high exchange rates and labour shortages than tourism, where wages are the largest portion of business expenses.[172]

The number of unique international visitors has fallen slightly from a high of 1,072,000 in FY01 to around 909,000 in FY11, but the number of stopovers per visitor has fallen from around 2.5 to 1.8 stopovers per visitor in the same period.[173] Details are shown in Figure 54.

172. PwC (2011), p. 5

173. Stopovers are measured as the number of visitors which stay in a single SA2 region for one or more nights. A visitor who stops in more than one SA2 is counted multiple times. However totals may be understated because data is not published for some SA2s due to the small sample size. Source: Customised data from Tourism Research Australia (2014)

The recent FY13 data shows that the trend is starting to reverse, with both unique visitors to Northern Australia and the number of stopovers in Northern Australia SA2s increasing since the prior financial year.

Rapid population and income growth in neighbouring Asian economies, combined with the emergence of low cost carriers will be a source of major growth in international visitation to Northern Australia. As the global population expands and becomes more urbanised, Northern Australia's wild and natural experiences will be an important draw card for international visitors.[174]

The *2030 Vision* proposes that growth in Northern Australia could be driven by "growing the tourist economy in the North to two million international tourists annually".

At a jurisdictional level:

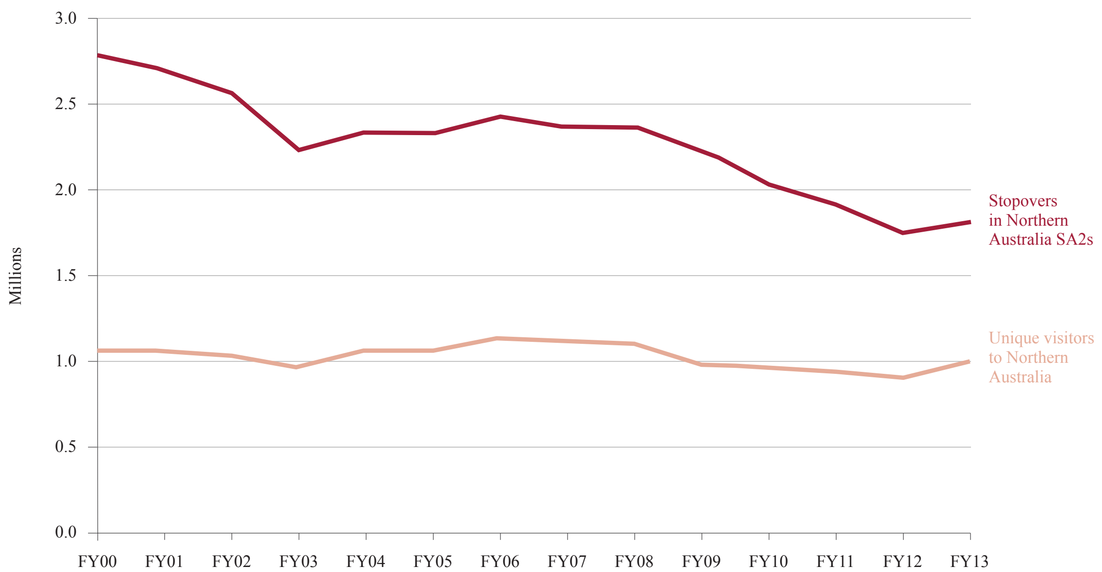
- *Tourism NT's Tourism Vision 2020* set out a target to grow the visitor economy in the NT to \$2.2 billion **by 2020** (as measured by **overnight visitor expenditure**), of which **\$559 million is from 416,000 international visitors.**[175]
- *Tourism WA's State Government Strategy for Tourism in Western Australia 2020* set out a target to **double the value of tourism** in Western Australia from \$5 billion in 2010 to \$12 billion **by 2020** (direct spend), of which **\$4.5 billion will be from international visitors.**[176]
- The Queensland Government's *Destination success: The 20-year plan for Queensland tourism* set out a target to **increase visitor expenditure to \$30 billion by 2020.**

12.2.2.2 Tourism in the scenarios

For the purposes of developing the tourism growth scenarios for the Northern Australia infrastructure audit, the following simplifying assumptions were made:

- 'Two million international tourists' is interpreted as international tourist *stopovers* in Northern Australia SA2s. That is, an international tourist who visits both Cairns and Darwin is considered to be one *unique* visitor but two tourist *stopovers*
- The policy target is reached in FY31, with straight line growth between FY11 and FY31
- International tourists comprise visitors coming to Australia for holiday, visiting friends and relatives, business, education and employment.

Figure 54: International visitors to Northern Australia (FY00 to FY13)



Source: Customised data from Tourism Research Australia (2014)

174. Collected from multiple sources including Queensland Government (2014)
175. Visitors include segments outside the traditional leisure market, such as business events, education and military segments. See Tourism NT (2013)
176. Tourism WA (2012), p6

Unique international visitors to Northern Australia and stopovers in Northern Australia SA2s have been declining at a rate of 0.6 per cent and 3.3 per cent respectively on average each year since FY01. To reach the target of two million stopovers would require a reversal in this trend through either increased international visitors (who stopover at the same number of places each) or an increase in the number of stopovers per international visitor. This is the tourism element of **Scenario 1**.

There are significant opportunities for the tourism sector in Northern Australia. An ambitious but achievable target would be to return the number of stopovers to the same levels as in FY00 – approximately 2.8 million stopovers in Northern Australia. This is the tourism element of **Scenario 2**.

Economic infrastructure is only one part of the infrastructure puzzle. The development of the tourism sector in Northern Australia relies on the provision of adequate cultural, recreational and accommodation infrastructure from quantity, quality and range perspectives. These are variously developed by the private sector or through government but the provision of economic infrastructure will also contribute to the viability of these developments.

12.2.2.3 Challenges to achieving the tourism growth targets

The total number of international visitors to Northern Australia has trended downwards since FY01 to reach a low in FY12. While the trend reversed in FY13, there is much to be done to achieve the tourism targets outlined in Scenario 1. Asia has been the strongest growing source market for Australia, with visitation increasing at around four per cent each year over the past 10 years. Yet supply side constraints in air access, tourism products and skilled labour are affecting Northern Australia's ability to serve high yield Asian markets.

Despite being located close to Asia, lack of direct overseas air access to Northern Australia is a time and cost barrier for potential visitors. There are only two major international airports, Darwin and Cairns. Darwin has direct routes to only four countries in Asia: Indonesia, Singapore, Malaysia, and the Philippines; while visitors can only fly direct to Cairns from Japan, Hong Kong, PNG or New Zealand.

A further challenge is that key tourism products and offerings in Northern Australia have historically catered to traditional source markets such as United States, United Kingdom and Japan. Differences in global economic, income and population growth rates (and population ageing in markets such as Japan) and exchange rate fluctuations have changed the composition of visitor source markets. Tourism products and offerings in the north may need to be updated to better match the changing mix of international visitation. These include more diverse and high quality short stay accommodation, physical structures, attractions, events and services.

Finally, competition from other industry sectors has reduced the availability of an adequately skilled tourism and hospitality workforce to service international tourists. This is magnified in regional areas of Northern Australia.

12.2.2.4 Communications requirements for tourism

It is now expected that the tourism experience includes quality Wi-Fi access to devices and good mobile phone availability, irrespective of the remoteness of the destination concerned. Given the limitations of major parts of the existing communications networks discussed in Section 11, in many instances major enhancement of telecommunications services will be required to meet the expectations of tourists and tourism ventures.

Broadly, it is anticipated that the NBN rollout will contribute substantially to the future broadband communications and data needs of tourism development; however it should be acknowledged that the very high expectations of international tourists will be reflected in the demands of resort developers and other operators. These demands are likely to include:[177]

- Fixed line service for the operation of the resort and for high bandwidth data services
- High quality mobile phone coverage of hotels, other facilities and attractions
- Broadband capable Wi-Fi service with similar coverage
- Upgrade of the associated back haul capability
- Allowance for new technology and changes in consumer use of voice, text and data services
- Emergency communications, including when the public system may be inoperable.

177. Flanagan Consulting Group (2014)

12.2.3 Energy export targets

12.2.3.1 Current state and policy settings

Northern Australia is known for its abundant energy sources which have provided our residents and businesses with a secure domestic energy supply.[178] Australia has the largest natural gas reserves in the Asia-Pacific region, of which 90 per cent are in the Bonaparte, Browse and Carnarvon basins in the North.[179] There is also potential for Northern Australia to harness renewable energy sources such as solar, wind power, hydro, modern biomass from its large tracts of land and water.

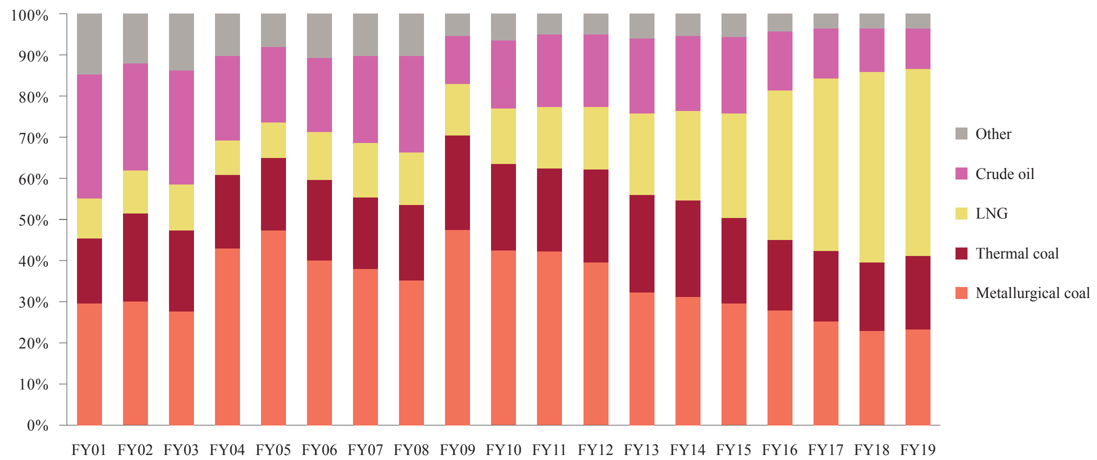
Growth in Northern Australia could be driven by "building an energy export industry worth $150 billion to the economy, with a major focus on clean and efficient energy, providing major increases to resource exports". This aligns with the priorities being explored in the Energy White Paper, with the Green Paper, released in 2014, to "attract the investment required to continue growth in the [energy and resources export] sector."[180]

The Bureau of Resource and Energy Economics' medium term outlook for Australia's energy commodities forecasts that energy exports will grow from $70.8 billion in FY13 to $119.2 billion in real terms by FY19 (an increase of $48.4 billion in 6 years or a CAGR of 9.1 per cent). If growth continued at the same rate, the value of energy exports would reach $216.0 billion by FY31 (linear) or $337.9 billion (compounded). Gas is forecast to make up the biggest portion of energy exports with a 45.2 per cent share, followed by metallurgical coal (23.5 per cent) and thermal coal (21.2 per cent).[181] With Northern Australia's large gas reserves, the export target of $150 billion is potentially achievable. This information is presented in Figure 55.

12.2.3.2 Energy in the scenarios

Governments are investing in precompetitive geoscience information to stimulate exploration (see for example the Northern Territory's initiative *Creating Opportunities for Resource Exploration*);[182] and these are early indications of where future energy growth may occur. However the outlook for growth in energy exports relies on global commodity prices, global supply and demand, and exchange rate movements which affect the viability of energy exports and production. The exact location of future growth cannot be predicted with great accuracy out to FY31 within the scope of this study. For the purposes of developing the energy growth scenarios for the Northern Australia infrastructure audit, BREE's biannual publication, *Resources and Energy Major Projects*, provides a medium term snapshot of the pipeline of energy projects.

Figure 55: Composition of Australian energy exports (FY01 to FY12 actual, FY13 estimate, FY14 to FY19 forecast)



Source: PwC analysis of data from BREE (2014)

178. We adopt the Bureau of Resource and Energy Economics (BREE 2014) definition of energy which includes coal (black and brown), gas (conventional, coal seam gas, shale gas and tight gas), oil (crude oil, LPG, condensate and oil shale), uranium, natural gas and renewable energy sources.

179. Manpower Group (2011), p3

180. Department of Industry (2014), p 1

181. PwC analysis of data from BREE (2014)

182. Read more at http://www.core.nt.gov.au

Scenario 1 assumes that all planned energy projects in the pipeline proceed to operation, while **Scenario 2** adjusts for the probability of energy projects progressing to operations at the FY16, FY21 and FY31 milestones (depending on their current status).

12.2.3.3 Challenges in achieving the energy targets

Commodity prices for Northern Australia's most significant mineral and energy resource exports of iron ore, coal and liquefied natural gas peaked in FY11, although they remain historically high. Combined with the high value of the Australian dollar, this has led to a fall in the number and value of new investment projects. As always, the response to future commodity price rises will be an increase in supply, both in Australia and overseas, which makes it unlikely that the price levels at the peak of a cycle will ever be sustained for more than two or three years. However, in the long term, strong demand from China and south and southeast Asian countries could continue to support prices to ensure growth in the principal markets for the energy and minerals resources of Australia's north. Therefore, while it seems likely that market conditions will be subdued in the short term, relative to the recent past, cyclically strong market conditions should return. In the longer term the trend in commodity prices, although never guaranteed, is likely to be underpinned by historically high levels of international demand.

Approvals for new mining and resource processing projects are lengthy and require, amongst other things, an environmental impact statement process. Community opposition to mining may be derived from the expectation of various economic costs, from despoiling Indigenous lands, impacts on water resources or minimal local economic benefit.

On top of these local environmental issues, objections to coal mining projects might be mounted on climate change grounds. Again it is uncertain how future Commonwealth and state governments might respond. Even in the absence of an Australian carbon tax or permit scheme, finance for greenhouse gas intensive projects — especially coal-fired generators — may be withheld due to the risk of international climate change policies and the mere existence of uncertainty over future domestic climate change policy.

None of the projects under consideration are located close to major power infrastructure. High costs to connect to an electricity network are a significant issue when considering the feasibility of developing new remotely located mineral resources, since such developments generally have high power requirements and need high voltage connections. After connection, the location of a mine can put it at an operational disadvantage in terms of energy charges. The alternative is on-site generation, which for relatively small projects is prohibitively expensive and may be inefficient from the community's perspective. The discussion in Section 8.5.3 deals with these issues in the context of the National Electricity Market.

12.3 Population growth targets

Population and demographic change can profoundly affect Northern Australia's economic landscape, especially where they relate to the working age population. Japan, Greece and Italy are contemporary examples where lower population growth, combined with ageing populations, has contributed to stalling of economic growth. More countries are likely to experience this over the next decade and some have considered policies which specifically target population growth as a driver of economic prosperity.[183]

In Northern Australia, the Queensland Government and the Western Australian Government have developed policies and plans with a regional focus:

- The Queensland Plan working draft has an aspirational target that half of Queensland's population live outside of South East Queensland in 30 years' time. This is based on initial consultation with the public through the plan – the final is yet to be released – and the Queensland Government is developing its response to the Queensland Plan.[184]
- The Pilbara Cities Vision has an aspirational target to grow the number of Pilbara residents to 140,000 by 2035 (from around 62,000 currently), with 50,000 people in each of Karratha and Port Hedland, 15,000 in Newman, and the remaining 25,000 in other Pilbara cities such as Tom Price and Onslow.[185]

183. Reserve Bank of Australia (2010) analysis found that slowing population growth and diminishing expansion in the working age population will directly contribute to a noticeable slowdown in trend economic growth for a number of countries in the decade from 2011 to 2020.

184. Queensland Government (2013). The growth in Queensland's population including Northern Queensland will be supported by solid growth in Queensland regional economies in the future. Based on current population projections by Queensland Government (medium) – strong population growth is projected in regional centres in Northern and Central Queensland including Cairns, Townsville and Fitzroy over the period 2011-2036

185. Department of Regional Development and Lands (2013).

The Northern Territory also made changes to its *Pastoral Land Act* in 2013 to assist and streamline progression with developments associated with non-pastoral purposes and provide greater investor certainty.[186]

12.4 Scenario population results

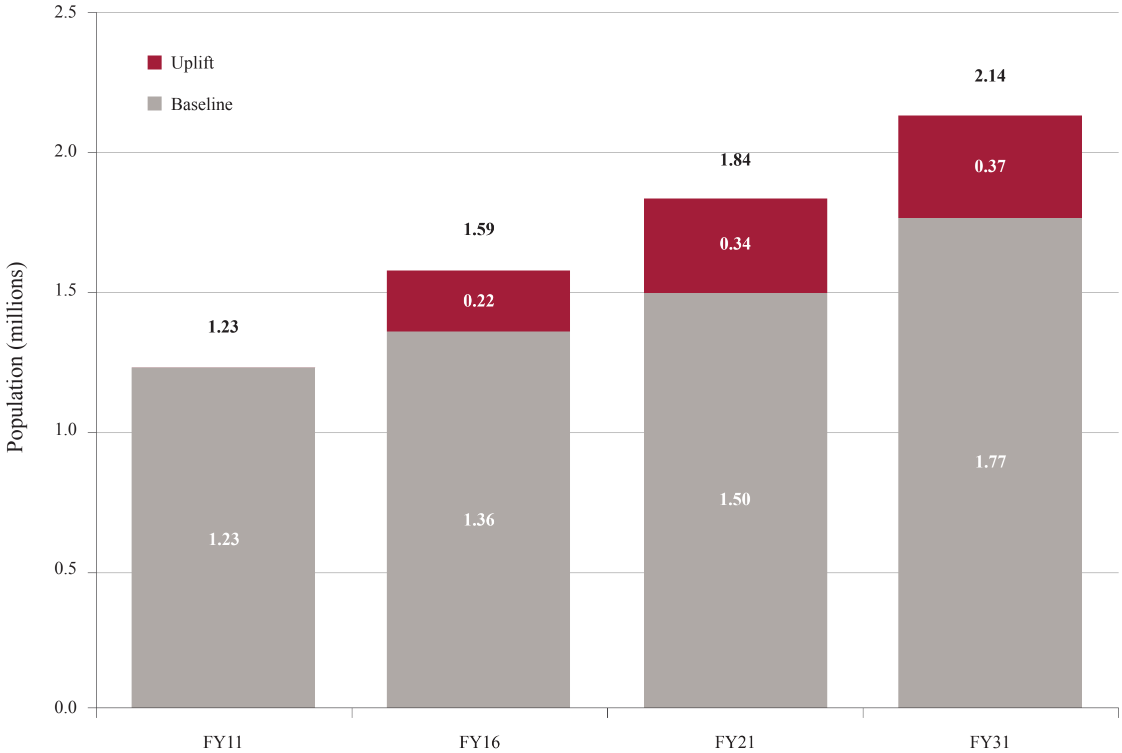
12.4.1 Scenario 1: Aspirational economic growth against industry opportunities outlined in the 2030 Vision

Scenario 1 involves levels of economic growth in line with the three main opportunities outlined in the 2030 Vision:

- Increasing the real value of Northern Australia's real agricultural output to $14,906 million by FY31, which helps double Northern Australia's contribution to Australia's agricultural output to 24.4 per cent
- Increasing international visitor stopovers to 2.8 million per annum by FY31 (same levels as in FY00)[187]
- Increasing energy exports from Northern Australia to $150 billion by FY31 with all publicly announced energy projects, projects in feasibility stage and committed projects proceeding to completion.

Achieving the above would stimulate an increase in resident population in Northern Australia from 1.23 million in FY11 to 2.14 million in FY31, which is 21.2 per cent higher than the baseline population in the final year. This is shown in Figure 56 and Table 43. Map 26 shows the impact by SA2 (see tables in Appendix C for figures).

Figure 56: Scenario 1 (Aggregated high industry growth – population impacts)



Source: PwC analysis

186. Pastoral Land Amendment Bill 2013, Northern Territory, http://www.austlii.edu.au/au/legis/nt/bill/plab2013232/ (accessed 25/8/2014)

187. Stopovers are measured as the number of visitors which stay in a single SA2 region for one or more nights. A visitor who stops in more than one SA2 is counted multiple times. An international tourist who visits both Cairns and Darwin is considered to be one unique visitor but two tourist stopovers.

Table 43: Scenario 1 population impacts in Northern Australia (FY11 – FY31)

	FY11	FY16	FY21	FY31
Baseline population	1,234,059	1,363,762	1,498,059	1,767,846
Additional population	-	224,165	343,811	374,022
Scenario 1 population	**1,234,059**	**1,587,926**	**1,841,870**	**2,141,868**
Increase from baseline (%)	-	*16.4%*	*23.0%*	*21.2%*

Source: PwC analysis

Baseline and Scenario 1 population impacts can be broken down by state as detailed in Table 44.

Table 44: Scenario 1 population impacts by state and territory in Northern Australia (FY31)

	Baseline population	Additional population	Scenario 1 population	Increase from baseline (%)
Northern Queensland	1,311,940	305,694	1,617,634	23.3%
Northern Territory	316,611	41,262	357,873	13.0%
Northern Western Australia	139,294	27,067	166,361	19.4%

Source: PwC analysis

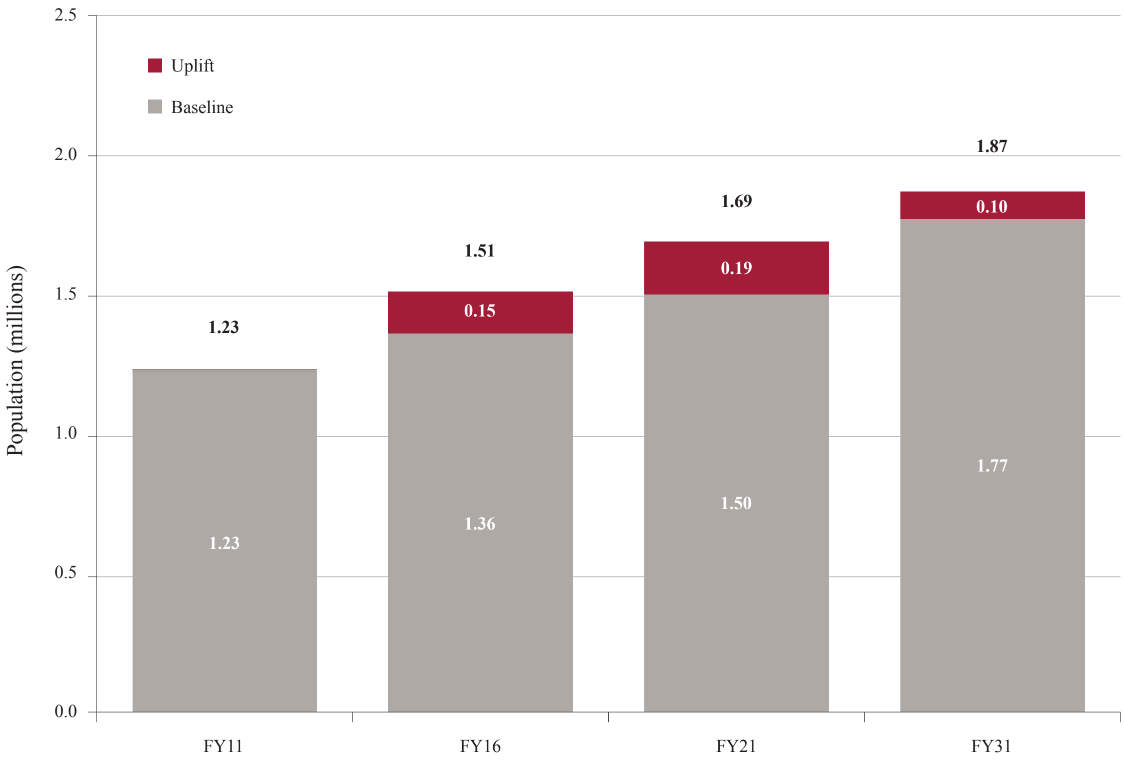
12.4.2 Scenario 2: Medium economic growth against industry opportunities outlined in the 2030 Vision

Scenario 2 involves medium levels of economic growth against the three main opportunities set out in the *2030 Vision*. While these targets are lower than in Scenario 1, they are slightly higher than economic growth projected in the baseline. Scenario 2 involves:

- Increasing the real value of Northern Australia's real agricultural output to $7,452 million in FY31 (around $442 million above baseline economic output in the same year)
- Increasing international visitor stopovers to 2.0 million per annum by FY31
- Increasing energy exports from Northern Australia to $150 billion by FY31 with a weighted probability that publicly announced energy projects, projects in feasibility stage and committed projects proceeding to completion (based on their capital expenditure value and progress to date).

Achieving the above would stimulate an increase in resident population in Northern Australia from 1.23 million in FY11 to 1.87 million in FY31, which is 5.6 per cent higher than the baseline population in the final year. This is shown in Figure 57 and Table 45.

Figure 57: Scenario 2 (Aggregated medium industry growth – population impact)



Source: PwC analysis

Table 45: Scenario 2 population impacts in Northern Australia (FY11 – FY31)

	FY11	FY16	FY21	FY31
Baseline population	1,234,059	1,363,762	1,498,059	1,767,846
Additional population	-	147,190	186,964	98,123
Scenario 2 population	**1,234,059**	**1,510,952**	**1,685,023**	**1,865,969**
Increase from baseline (%)	-	*10.8%*	*12.5%*	*5.6%*

Source: PwC analysis

Northern Western Australia is projected to experience the greatest percentage increase from baseline population in FY31 under Scenario 2, due to its larger share of growth in energy exports (Table 46). Map 27 shows the impact by SA2 (see tables in Appendix C for figures).

Table 46: Scenario 2 population impacts by state and territory in Northern Australia (FY31)

	Baseline population	Additional population	Scenario 2 population	Increase from baseline (%)
Northern QLD	1,311,940	74,950	1,386,890	5.7%
NT	316,611	10,720	327,331	3.4%
Northern WA	139,294	12,453	151,747	8.9%

Source: PwC analysis

12.4.3 Scenario 3: Northern shift in population

Scenario 3 involves a shift in the Australian population from the south to the north, achieved by:

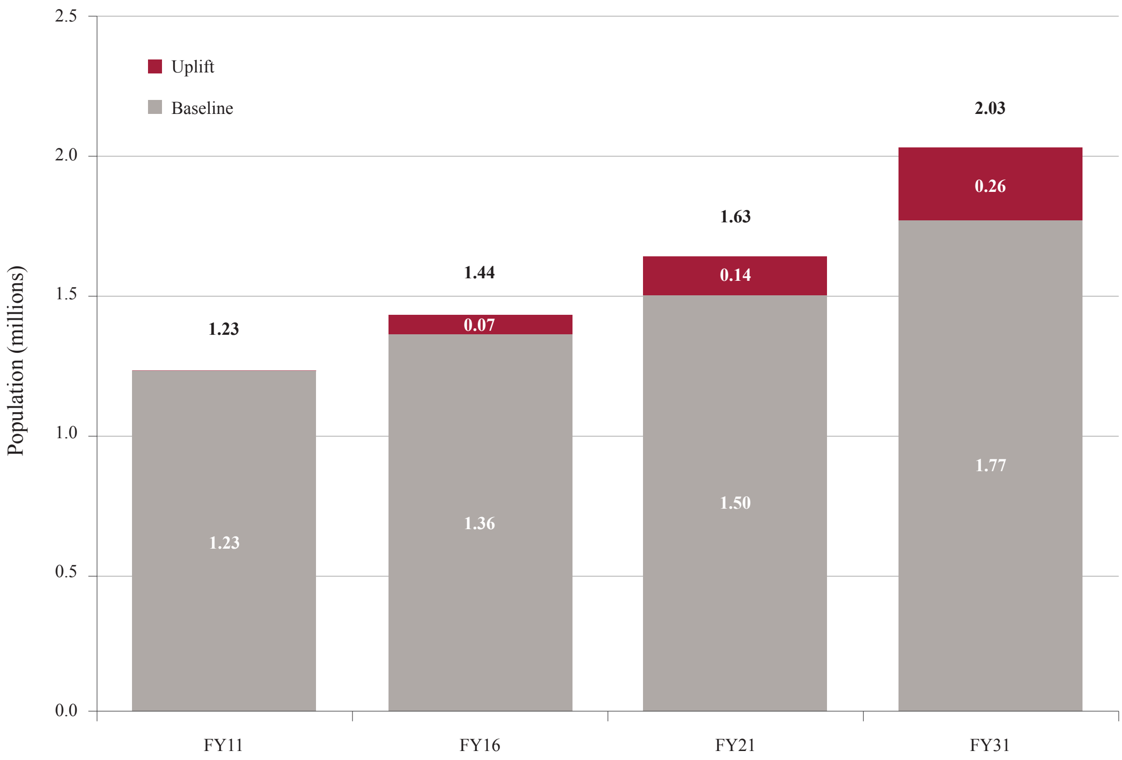
a) Growing the population in Northern Queensland to 1.52 million people by FY31, to help achieve the target in the *Queensland Plan* to double the population outside of South East Queensland by FY44[188]

b) Growing the population in the Pilbara region to 127,000 by FY31, to help reach 140,000 by FY35.

The aim of this scenario is to understand the economic infrastructure required to support the Northern Australia community and help achieve government policies and targets relating to regional population growth.

Achieving the above would stimulate an increase in resident population in Northern Australia from 1.23 million in FY11 to 2.03 million in FY31, which is 14.7 per cent higher than the baseline population in the final year. This is shown in Figure 58 and Table 47.

Figure 58: Scenario 3 (Northern shift in population)



Source: PwC analysis

Table 47: Scenario 3 population impacts in Northern Australia (FY11 – FY31)

	FY11	FY16	FY21	FY31
Baseline population	1,234,059	1,363,762	1,498,059	1,767,846
Additional population	-	71,713	135,045	259,906
Scenario 3 population	**1,234,059**	**1,435,475**	**1,633,104**	**2,027,751**
Increase from baseline (%)	-	*5.3%*	*9.0%*	*14.7%*

Source: PwC analysis

188. This scenario assumes linear growth in the population outside of South East Queensland between 2011 and 2044. The population in Northern Queensland was derived by allocating the population top down by each SA2's share of the baseline population outside of South East Queensland in 2016, 2021 and 2031.

Northern Queensland is projected to experience a 16.1 per cent increase compared with the baseline population in FY31 under Scenario 3 and northern Western Australia is projected to grow 34.7 per cent in the same year (Table 48). The scenario assumes that the shift in population is from the south of Australia. As such, there is no assumed interstate migration from Northern Territory (additional to that in the baseline). Map 28 shows the impact by SA2 (see tables in Appendix C for details).

Table 48: Scenario 3 population impacts by state and territory in Northern Australia (FY31)

	Baseline population	Additional population	Scenario 3 population	Increase from baseline (%)
Northern Queensland	211,583	211,583	1,523,524	16.1%
Northern Territory	316,611	–	316,611	-
Northern Western Australia	139,294	48,323	187,617	34.7%

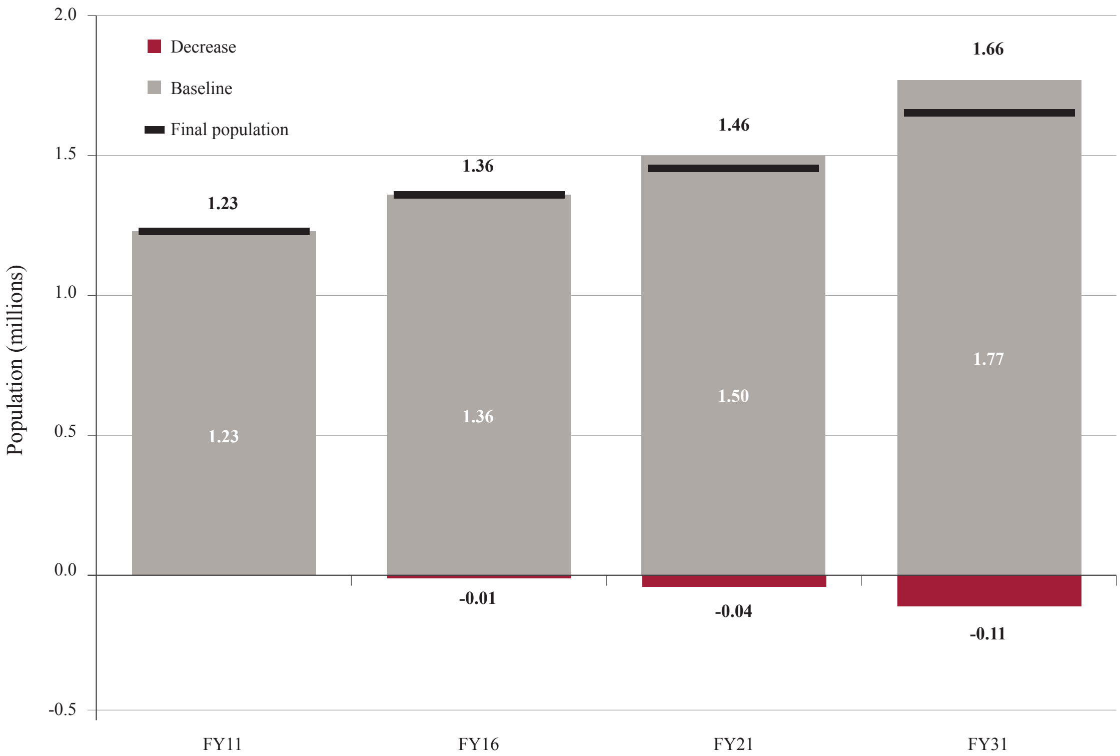
Source: PwC analysis

12.4.4 Scenario 4: Low population growth

While the underlying assumptions regarding fertility and mortality can be modelled to a high degree of accuracy in population projections, there has historically been greater volatility in NOM and NIM. The volatility in migration will likely continue as economic and social drivers of migration change domestically and internationally. These factors can be difficult to anticipate. The aim of this scenario is to test the sensitivity of critical infrastructure requirements to changes in these more volatile components of population growth. Achieving the above would stimulate an increase in resident population in Northern Australia from 1.23 million in FY11 to 1.66 million in FY31.

Scenario 4 involves a slowing of population growth in the north, modelled as lower net overseas migration (Figure 59).

Figure 59: Scenario 4 (Low population growth)



Source: PwC analysis

The population in FY31 is 6.2 per cent lower than the baseline population of 1.77 million. This is shown in Figure 59 and Table 49. Map 29 shows the impact by SA2 (see tables in Appendix C for details).

Table 49: Scenario 4 population impacts in Northern Australia (FY11 – FY31)

	FY11	FY16	FY21	FY31
Baseline population	1,234,059	1,363,762	1,498,059	1,767,846
Change in population	-	- 8,405	- 37,690	- 110,246
Scenario 4 population	**1,234,059**	**1,355,357**	**1,460,368**	**1,657,600**
Increase from baseline (%)	-	*- 0.6%*	*- 2.5%*	*- 6.2%*

Source: PwC analysis

The Northern Territory is projected to experience the greatest percentage decrease from the baseline population in FY31 under Scenario 4, due to its large interstate outflows (around 2,000 people each year, compared to 1,000 in the baseline). While the difference in interstate outflows in one year is small, its effect on population compounds over time. Table 50 shows the impact by state and territory (see tables in Appendix C for details).

Table 50: Scenario 4 population impacts by state and territory in Northern Australia (FY31)

FY31	Baseline population	Change in population	Scenario 2 population	Increase from baseline (%)
Northern Queensland	1,311,940	- 74,684	1,237,257	- 5.7%
Northern Territory	316,611	- 27,503	289,108	- 8.7%
Northern Western Australia	139,294	- 8,059	131,235	- 5.8%

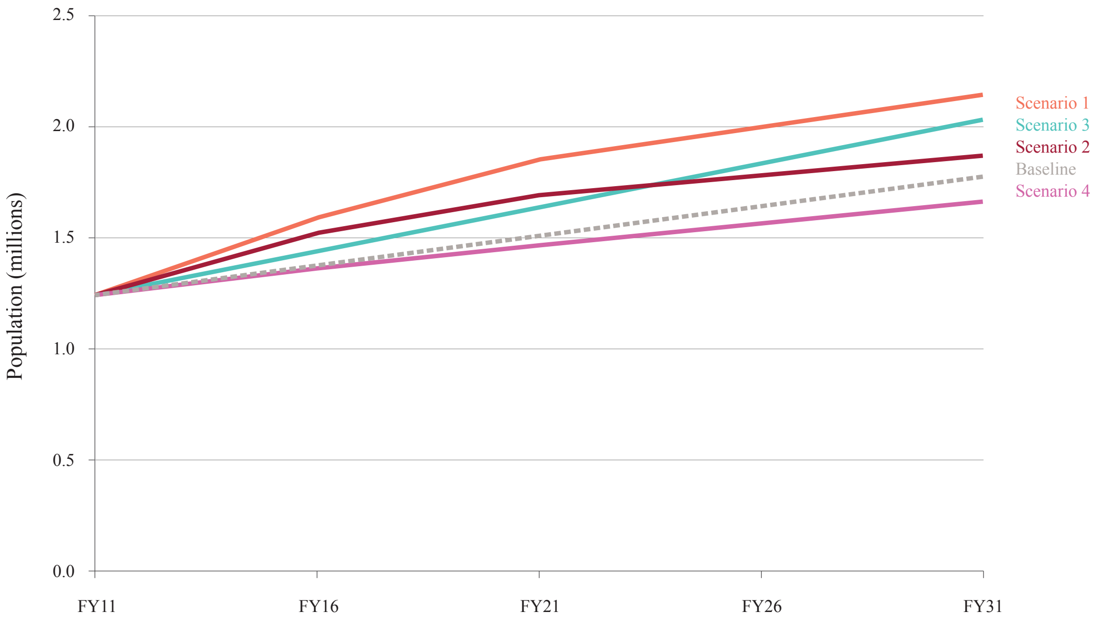
Source: PwC analysis

12.4.5 Comparison of results

Scenario 1 generates the highest projected population growth in Northern Australia over the period FY11 to FY31, while Scenario 4 results in the lowest projected population growth in the same period.

The projected population under Scenario 2 is higher than in Scenario 3 between FY11 and FY21. However the projected population in Scenario 2 grows at a slower pace past FY21, as the known energy projects further in the future receive a lower weighting (i.e. deemed more uncertain) in Scenario 2 (Figure 60).

Figure 60: Comparison of population in all scenarios



Source: PwC analysis

These four scenarios provide a range of population projections and, in respect of scenarios 1 and 2, associated industry impacts, for analysis of economic infrastructure gaps to support the development of Northern Australia's industries and communities.

12.5 Industry scenarios infrastructure gap assessment

12.5.1 Infrastructure gaps – agriculture

12.5.1.1 Agriculture scenario demand profile

Predicting the agricultural demand profile against the range of scenarios involves significant uncertainty. By way of example, aquaculture could play a significant role in achieving policy objectives given growing global demand and domestic production that has increased at over 11 per cent a year since the early 1990s.[189] In FY11 aquaculture products comprised 43 per cent of Australian seafood production (edible and non-edible) by value and 32 per cent by weight, with a small component from Northern Australia. In recent times, the real value of production over a comparable time appears to have plateaued.[190] However, some opportunity exists for both salt and freshwater based systems.

There has been greater interest in recent times in the development of land-based agricultural systems and for this reason this audit has largely focused on these areas.

The beef industry dominates the agricultural landscape (by area) of northern Australia; however the sugar industry is driving recent major irrigation developments (and development proposals). In addition, rain-fed crops from the Wet Tropics Region and elsewhere (including strategically irrigated crops) make a large contribution to the existing value of agricultural production from Northern Australia.

189. http://www.daff.gov.au/fisheries/aquaculture/the_aquaculture_industry_in_australia , accessed 17 July 2014

190. http://www.daff.gov.au/fisheries/aquaculture/the_aquaculture_industry_in_australia , accessed 17 July 2014

As discussed in the following sections, doubling the gross value added from agriculture from a FY11 base (Scenario 2) will be challenging and achieving the higher targets of Scenario 1 would be highly unlikely.

12.5.1.2 Understanding the scale of scenario increase

Beef cattle opportunity

Northern Australian supports approximately 7.7 million cattle.[191] Increasing the beef production and productivity of Northern Australia will be reliant on a range of factors including genetics and increasing carrying capacity through irrigation of forage/feed crops, market access and market conditions.

CSIRO notes that, *"Under favourable circumstances, the estimated 600 GL of groundwater that could be extracted per annum in the project area [Northern Australia] could be used to produce 2.4 million tonnes of forage under irrigation, assuming the use of 5 ML of water per hectare and a forage yield of 20 tonnes per hectare. This could potentially be used to turn off over 200,000 cattle per annum with a market value of around $219 million ($1000 per head). Our most conservative scenario, using estimates of 12 ML of water, producing 15 tonnes of forage per hectare and a sale price of $600 per head, yielded a turn off of 68,000 cattle with a market value of $41 million."*[192]

This would equate to an increase in the current cattle herd of Northern Australia by approximately one per cent.

Irrigated agriculture opportunity

Water run-off across Northern Australia totals 152,000 GL, with only two per cent captured, while CSIRO has identified 17 million hectares of arable soil across the north.[193] In broad terms it would appear that the natural resource base could support even Scenario 1 as outlined in this report. However, the juxtaposition of water supply and land suitable for development can often challenge the economics of major greenfield developments particularly when considering ancillary infrastructure requirements.

The statistics for the annual value of agricultural production for the following irrigation schemes across Northern Australia are:

- Mareeba Dimbulah Irrigation Area – approximately $270 million (off approximately 19,000 hectares)[194]
- Gravity channel section of the Burdekin River Irrigation Area – approximately $230 million (off approximately 45,000 hectares)[195]
- Ord Irrigation Area – approximately $123 million (off approximately 15,000 hectares)[196]

Averaging these three schemes provides a coarse indication of the potential gross value of agriculture production for any new major irrigation development at an upper level of $8,000 per hectare of irrigation development. The cost per hectare may be lower in rivers such as the Gilbert Basin and the Flinders where gravitational extraction methods would reduce capital and operational expenditures. These cost savings may be reduced by the isolated location of such developments.

To achieve an increase of agricultural production from irrigated agriculture alone of $3,726 million per annum (i.e. to double the FY13 gross value added from agriculture – Scenario 2) would require the development of a further 705,000 hectares approximately (based on a current discount factor of 0.66[197] for calculating gross value added). This equates to an area approximately nine times the total area of the three irrigation schemes mentioned above. In addition, assuming an irrigation application rate of 10ML per hectare, a storage efficiency of 75 per cent and an irrigation distribution efficiency of 90 per cent would equate to an annual stored water demand of 10,500 GL per annum. This would equate to an increase in current water consumption for irrigation of approximately eight times the current water usage of these three irrigation schemes.

In terms of scope and scale, a comparison could be made between the establishment of a major water irrigation scheme in Northern Australia and the Murray Darling Basin. It is important however to note that a new irrigation scheme would be considerably more efficient because

191. CSIRO (2013b)

192. CSIRO (2013b)

193. Trade Minister Andrew Robb quoted at https://email.ghd.com/owa/redir aspx?C=4FDU4rKGb0Oy0SlB5Y7sdvfep95zdtEIsCctBKNGftKzzPqiUjP_iAJphpiruhYh9wP5KW0KT-4.&URL=http%3a%2f%2ftrademinister.gov.au%2farticles%2fPages%2f2014%2far_ar_140715.aspx

194. Personal advice, Queensland Department of Agriculture, Fisheries and Forestry (FY11 statistics)

195. Personal advice, Queensland Department of Agriculture, Fisheries and Forestry (FY11 statistics)

196. WA Department of Agriculture and Food 2014

197. National Gross Value Added of Agriculture ($31,859 million)/National Gross Value of Agricultural Production ($48,048 million) = 0.66

of improvements in technology and water management techniques. The Murray Darling Basin:

- Has a total volume of publicly managed water storage capacity of just over 22,200 gigalitres[198]
- Receives about 32,500 GL per year of surface water inflows, including about 950 GL per year of surface water transferred into the Basin from other valleys mainly through the Snowy Mountains Hydro-electric Scheme
- Has baseline diversions for surface water systems in the basin total 13,623 GL per year
- Has a basin-wide long-term average Sustainable Diversion Limit for surface water of 10,873 GL per year[199]
- Had a gross value of irrigated agricultural production of $6,691m in FY12. This accounted for:
  - 49 per cent of Australia's irrigated produce
  - Nearly 100 per cent of Australia's rice
  - 94 per cent of Australia's cotton
  - 74 per cent of Australia's grapes
  - 60 per cent of Australia's hay
  - 59 per cent of Australia's production from sheep and livestock.[200]

The opportunities for irrigation-led developments identified in Section 13.2.1.3 are shown in Table 51 to provide further context in terms of capacity to contribute to meeting scenarios.

Table 51: Broad comparator of identified potential irrigation development opportunities

Initiative/opportunity (1)	Area (ha)	Gross value of production ($m) (2)	Gross value added (GVA) ($m)	Increase in Northern Australia's GVA (%)
Groundwater resources	85,000	41	27	1
Pilbara and Kimberley	100,000	800	528	14
Ord River Scheme (further expansion)	60,000	480	317	9
Adelaide River Offstream Storage (3)	1,500	12	8	0.2
Flinders catchment	20,000	160	106	3
Gilbert catchment	30,000	240	158	4
Upper Burdekin catchment	125,000	1,000	660	18
Existing unallocated water reserves in QLD	50,000	400	264	7
Total	**471,500**	**3,133**	**2,068**	**55.2**

Notes:
(1) The table incorporates the following assumptions:
• Identified groundwater resources are used to produce forage and support additional beef production based on CSIRO assessment
• Other surface water resources usage is based on 10 ML/ha and converted to a coarse potential irrigable area to largely align with other data sources
(2) Gross value of production is based on $8,000/ha and discounted to provide Gross Value Added comparators as noted above.
(3) Assuming an annual water yield of 30,000 ML with 50 per cent of available yield directed to irrigated agriculture and an average water use of 10ML/ha.
Source: Various and GHD Analyxix

198. http://www.canberra.edu.au/murray-darling-crn/quick-facts-imported (accessed 24 July 2014)

199. http://www.mdba.gov.au/what-we-do/water-planning/sdl (accessed 24 July 2014)

200. http://www.mdba.gov.au/about-basin/basin-economy (accessed 24 July 2014)

Productivity growth contribution

It is reasonable to expect that increasing productivity from existing farm enterprises will continue to play a significant role in meeting growth objectives. Productivity varies significantly between agricultural industries. Cotton for example has had high productivity growth while other sectors such as wool have had lower rates. Variations will continue and are driven by factors such as new R&D leading to the introduction of new technologies and techniques and also the development new geographic location leading to additional production opportunities.

While productivity will vary, ABARES has identified that *productivity growth across all broadacre agriculture (that is, non-irrigation cropping and extensive livestock industries) has been around 1 per cent a year for more than three decades. This has been largely due to reduced input use (-0.9 per cent), rather than output growth (0.1 per cent a year)………Productivity growth of cropping specialists averaged 1.5 per cent a year between 1977-78 and 2010-11.*[201] ABARES also flagged policy opportunities for government to assist increased productivity. These included: facilitating structural adjustment and efficient resource use across farms; reducing regulatory burdens; improving the efficiency of the rural research, development and extension system and labour availability and skills.[202]

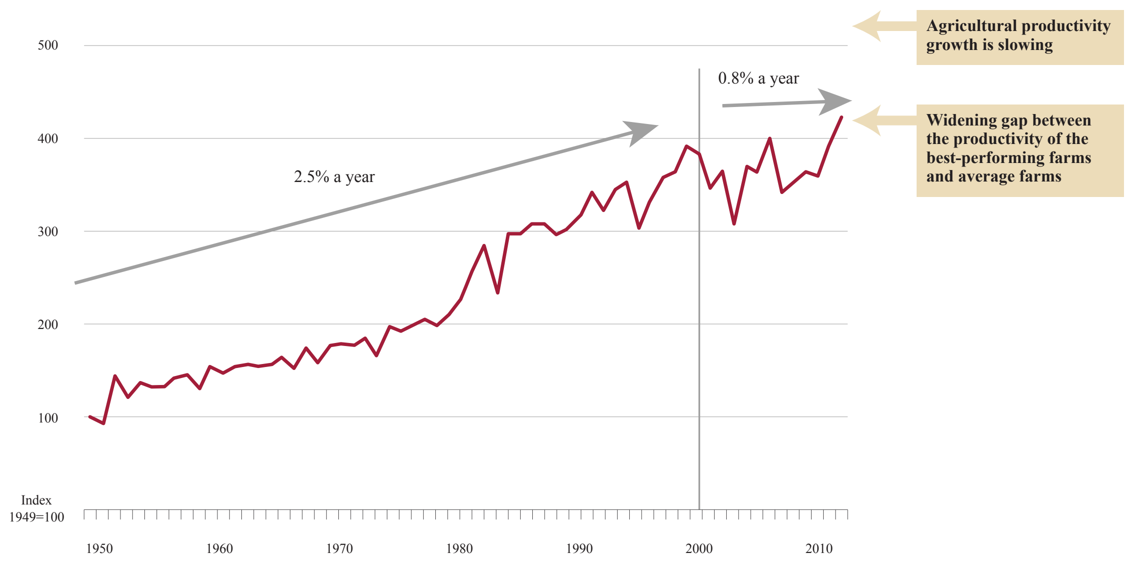
Illustratively, an annual productivity increase from existing operations of 1.5 per cent through to FY31 (and all else remaining equal) would see the gross value added from agriculture across Northern Australia increase by in the order of $1.3 billion over FY11 figures (i.e. a 35 per cent increase). However, as shown in Figure 61, agricultural productivity growth has been slowing for more than a decade. To further illustrate the issue of slowing productivity, the growth in public funding for agricultural research has been slowing since the late 1970s, and this is evidenced in the fall of expenditure as a proportion of industry output, as shown in Figure 62 – the fall in research intensity line.[203]

It is apparent that doubling the gross value add of agriculture will be extremely challenging. However it is also noted that other potential irrigation opportunities may well exist across other catchments of Northern Australia (including opportunities for a mosaic of smaller scale water harvesting developments) which could be largely serviced from existing ancillary infrastructure.

12.5.1.3 Potential water infrastructure requirements

No single initiative is capable of delivering on the growth targets set out in this report. However there is a range of potential initiatives that could contribute to achieving growth objectives. These may include non-structural measures such as

Figure 61: Agricultural productivity growth (1949-2013)



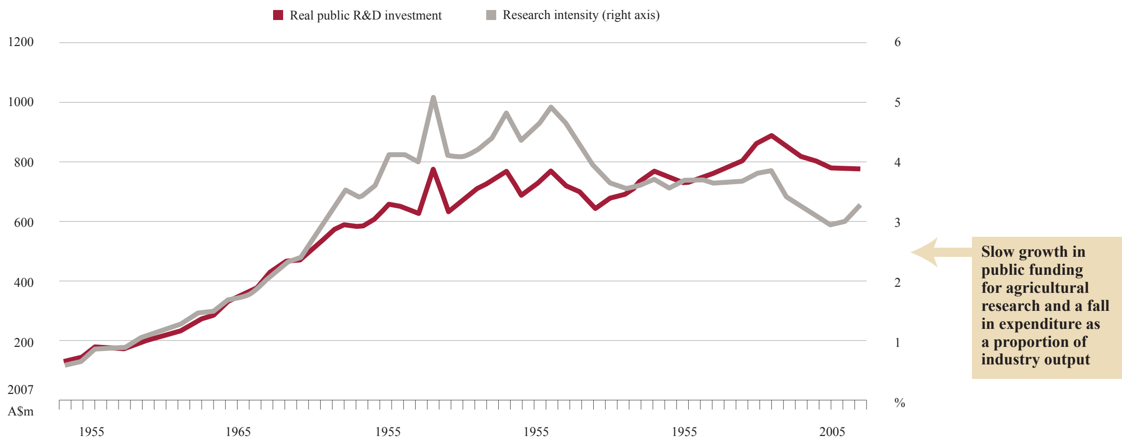
Source: ABARES (2014b)

201. ABARES (2014a), Australian agricultural productivity growth – Past reforms and future opportunities, Feb 2014, pp 9-10

202. Ibid, pp 28-38

203. ABARES (2014b)

Figure 62: Research and development investment (1950-2010)



Source: ABARES (2014b)

freeing up water trade to allow water to move to the highest and best use, water pricing that reflects the true cost of the resource and encourages efficient use and incentive programs that also encourage efficient water use, identification of additional allocable water resources in catchments (and groundwater systems) across Northern Australia. Structural measures could include:

- Facilitating the utilisation of underutilised assets such as orphaned assets in Queensland
- Water reuse schemes (utilising waste water from mining operations or treated urban effluent)
- Increased utilisation of groundwater resources through individual or group bore field schemes, including opportunities around managed aquifer recharge: for example, artificial recharge from surface water (e.g. during high-flow events) is undertaken through infrastructure and/ or management to take advantage of storage capacity in aquifers)
- Conjunctive use, incorporating but not limited to managed aquifer recharge, can increase the consumptive pool for allocation, improve security and reliability of access to the consumptive pool and improve the reliability of environmental flows. The planned conjunctive use of groundwater and surface water has the potential to offer major benefits in terms of economic, social and environmental outcomes through significantly improved efficiencies in water management and use
- Direct pumping from watercourses utilising run-of-river flows
- Water harvesting into off-stream storages at an individual enterprise level or group scheme
- Raising of existing dams to increase allocable water resources
- Major new on-stream dams.

12.5.1.4 Other infrastructure gaps for agricultural growth

With regard to the impact of other infrastructure sectors on achieving significant agricultural growth, it is useful to note that:

- Transport-related issues associated with the beef industry extend beyond national, state and shire roads with access often restricted during the wet season due to internal station roads and tracks
- The commissioning of the AACo meat processing facility in association with AACo's increased property holdings in the Darwin region is expected to assist in alleviating this issue to a degree. Currently cattle in the region are generally transported over nearly 3,000 kilometres to various processing plants across Australia. Once commissioned, the facility will process more than 1000 head of cattle a day at full capacity[204]
- Underutilised capacity in existing rail infrastructure can be beneficial in supporting major agricultural developments e.g. the Townsville – Mount Isa line in relation to potential opportunities in the Upper Burdekin catchment. However this will often require the construction of a spur line to connect to the area (as is the case with the Upper Burdekin)
- Airport infrastructure capacity is generally adequate for air freight to Asia or to southern capitals, but is only likely to be called on if and when there is a sufficient volume of high value,

204. http://www.aaco.com.au/operations/beef-processing-facility/, accessed 17 July 2014

time-sensitive products that could underwrite a dedicated air freighter service (see also Section 4.5.3)

- Major irrigated agricultural developments are also likely to require both significant new power infrastructure (lines and substations) and the development of a substantial road network. The ultimate length of service roads would be determined based on topography, soils and other factors. However, to provide a broad based comparator, a greenfield development involving 100,000 hectares may involve the development of approximately 500 kilometres of roads
- Water requirements to support increased population associated with growth scenarios are an order of magnitude smaller than water requirements to support irrigation development, notwithstanding recognition of the significant water treatment and distribution related costs to support increased population projections associated with respective scenarios.

12.5.2 Infrastructure gaps – tourism

12.5.2.1 Tourism scenario demand profile

The number of unique visitors to Northern Australia has remained largely constant between FY00 and FY13 at one million visitors. Stopovers on the other hand have declined by 3.3 per cent per annum on average since FY01. Scenarios 1 and 2 imply annual average growth of 2.4 per cent and 0.1 per cent respectively between FY 13 and FY31.

Tourism growth in Northern Australia will be influenced by a range of factors including economic growth in source markets, the international security climate, the level of the Australian exchange rate, the competitiveness of tourism product offerings in Australia in general and in the north in particular and air service networks and connections.

12.5.2.2 Airport infrastructure gaps for tourism growth

Ninety nine per cent of international tourists arrive in Australia by air,[205] making airports the first point of call. However, with total Northern Australia air travel having increased by seven per cent a year over the past decade, the scenario targets are modest in the context of likely future overall growth in air travel to and from the region.

Northern Australian airports have historically accommodated the stopover targets under both scenarios. With adequate maintenance and pavement rehabilitation, these airports should retain the capacity and capability to accommodate the targeted stopovers with relative ease. This would include the proposed Aquis Great Barrier Reef resort near Cairns, with the possibility of an additional 100,000 international visitors.

Tourism growth could, however, in some circumstances be ‘crowded out’, if airport capacity does not increase sufficiently or in a timely way to accommodate resource sector growth. Broome is a key international tourism destination with an airport that is also accommodating growing demand to service the off shore oil and gas sector in the Browse Basin, particularly through helicopter operations. Expansion through relocation away from the centre of the town is under Western Australian Government consideration for the longer term.

Many key tourism airports (Alice Springs, Ayers Rock, Hamilton Island and Proserpine) do not currently have direct international flights. However, border control facilities aside, infrastructure is not generally a key constraint on achieving direct international flights to and from Asia. An exception is Kununurra, where extension of its current comparatively short (1,800 metre) runway would improve potential to attract direct tourism flights, from southern Australia and possibly Asia (as well as possible longer term air freight services).

Among small airports, upgrading the Dampier Peninsula and Mitchell Falls airstrips (both Kimberley region) have been identified as potentially benefitting tourism growth.

12.5.2.3 Other infrastructure gaps for tourism growth

The audit has identified, through consultation with tourism agencies, a number of roads that are important as tourism routes or for accessing particular destinations (see Table 52). Upgrades sought range from road formation (Wolfe Creek Crater Road) and sealing (Larapinta Drive, Tom Price Road), together with duplication (Dunne Road) and intersection upgrade (Yorkeys Knob Road – Captain Cook Highway), with a safety improvement objective and elevation (Yorkeys Knob Road) for flood proofing.

205. http://www.tourism.australia.com/statistics/aviation.aspx, accessed 17 July 2014

Table 52: Tourism roads requiring upgrade

Jurisdiction	Road description	Tourism interest	Included in baseline gaps
Northern Territory	Red Centre Way – Larapinta Drive	Regional tourism	Yes
	Arnhem Highway	Regional tourism	Yes
	Litchfield Park Road (Litchfield National Park)	Eco tourism	No
	Jim Jim Falls Road (Garnamarr campground)	Eco tourism	No
	Namatjira – Watarrka National Park (Larapinta Drive)	Eco tourism	Yes
	Cahills Crossing (East Alligator River)	Eco tourism	No
	Oenpelli Road (Kakadu National Park) (1)	Eco tourism	No
Queensland	Gladstone-Agnes Water	Coastal tourism	No
	Proserpine-Whitsunday Coast Airport (Bruce Highway) (2)	Coastal tourism	Yes
	Gregory Development Road to Charles Towers	Regional tourism	Yes
	Yorkeys Knob Road and Captain Cook Highway	Resorts – Aquis, Cairns	Yes
	Dunne Road	Resorts – Aquis, Cairns	No
Western Australia	Fairfield-Leopold Road (Gibb River to Great Northern Highway)	Regional tourism	Yes
	Broome – Cape Leveque Road to Dampier Peninsula	Coastal tourism	No
	Karratha to Tom Price (via Millstream-Chichester National Park)	Regional tourism	Yes
	Geikie Gorge Road	Regional tourism	Yes
	Tanami Road – Hall creek to the Northern Territory border	Regional tourism	Yes
	Carranya Road (Wolf Creek Crater Road)	Regional tourism	No
	Gibb River – Kalumburu Road (Mitchell River National Park)	Regional tourism	No

Notes:
(1) Tourism NT (2012), p.32 (2) http://teq.queensland.com/~/media/Corporate/Plans%20and%20Strategies/Destination%20Tourism%20Strategies/Destination%20Strategy%20Gladstone.ashx
Source: Consultation and GHD analysis

Major resort developments generate broad-ranging infrastructure requirements at the local level. For the planned Aquis Resort near Cairns, infrastructure agreements are proposed with the Department of Transport and Main Roads (roads) and Cairns Regional Council (water and wastewater). In view of the additional demand generated by the resort, the council has indicated a need to upgrade the water distribution network.[206] This could include connections to the existing supply network and water treatment plant, enabling subsequent irrigation and other non-potable uses. Similarly, upgrades to the Ergon Energy distribution network and to fixed and mobile communications networks will be needed once the resort is operational.

12.5.3 Infrastructure gaps – energy exports

12.5.3.1 Energy export scenario demand profile

In FY13 Australia exported 182 million tonnes of thermal coal, 154 million tonnes of metallurgical coal and 24 Mt of liquefied natural gas (LNG), with a total value of $70.8 billion. Half the coal was produced in northern Queensland and all the LNG was either produced in northern Western Australia or exported through Gladstone (in northern Queensland).

Scenario 1 and 2 energy projects are listed in Table C.6, with commodity volumes summarised in Table 53. These amount to a 93 per cent increase in national coal exports and a 250 per cent increase in LNG exports.

206. Flanagan Consulting Group (2014)

Table 53: Scenario energy export volumes

Commodity and scenario allocated port	Scenario 1 (mtpa)	Scenario 2 (mtpa)
Coal Gladstone	11	0
Coal Abbot Point	224	133
Coal Hay Point	78	46
Coal total	**343**	**208**
LNG Gladstone	29	29
LNG Darwin	8	8
LNG Ashburton	19	19
LNG total	**56**	**56**

Source: GHD analysis

Scenario export volumes are based on currently announced projects. Whether or not Scenario 1 achieves $150 billion in export revenue would depend on Australian dollar export prices, possible additional stages of identified projects and on the extent of projects yet to be announced. The scenario can nevertheless be interpreted as a possible maximum energy export scenario.

12.5.3.2 Transport infrastructure gaps for energy exports

LNG

All Queensland LNG projects considered will include gas field development, pipelines, compressors and port development and ship-loading facilities at Gladstone. Some of the power requirements will also be provided by the proponents within the scope of the projects. Some short term difficulties with rail capacity may have been experienced during the construction phase which is now largely complete. These projects are therefore not anticipated to put further demands on port infrastructure.

The Wheatstone and Gorgon LNG projects in Western Australia include development of offshore gas fields, pipelines (including connection to the Dampier-Bunbury gas pipeline), port facilities, gas liquefaction plant and power generation, as well as substantial contributions to local economic and social infrastructure. These projects are not anticipated to put further demands on port infrastructure, with the exception of supply base support activities (Ashburton).

The Ichthys project, including gas field development in the Browse basin, pipelines, onshore processing and storage facilities near Darwin, power generation and export facilities is not anticipated to put further demands on port infrastructure beyond development of a marine supply base adjacent to East Arm.

Road infrastructure requirements are substantially addressed in the baseline infrastructure gaps and include port access roads (Darwin, Gladstone, Onslow) and major highways (Bruce, Capricorn, Great Northern).

Airport development is an essential part of mining and resource development during both construction and operational phases, for fly-in fly-out (FIFO) workforce movement and for general business travel. While in the LNG sector, the operational workforce is quite small, the reduction in size of the workforce following the construction phase is less marked in the coal sector. In addition, the geography of Queensland, in contrast to Darwin and the Pilbara iron ore region favours greater use of drive-in drive-out travel. Development of the Galilee Basin coal mines can be expected to lead to expansion of some or all of the key regional airports of Barcaldine, Blackall and Emerald.

Coal

Significant demand on port infrastructure and capacity will be driven by developments in the Queensland coal regions of the Bowen and Galilee basins. The major northern coal ports of Abbot Point, Hay Point and Gladstone currently handle coal exports for this network.

New coal projects are expected to add 224 million tonnes per annum to the throughput volumes at Abbot Point under by FY31 under Scenario 1. Proposed terminal developments and expansions at Abbot Point (T0, T1, T2, T3, AP-X) were expected to provide sufficient capacity to handle these volumes. However, proponents of the T2 and AP-X coal terminals have withdrawn from the projects, on the back of declining coal prices. The scenario assumes that these projects will proceed before FY31 and that a solution to concerns over dumping of dredge spoil are resolved.[207]

Under Scenario 1 an additional 78 million tonnes per annum of coal would be exported out of Hay Point by FY31 from new projects and there is long term projected export need of around 300 million tonnes per annum.[208] Hay Point was expected to have sufficient capacity to handle this throughput until FY31 given the proposed development and expansion of the Dalrymple Bay Coal Terminal, Hay Point Coal Terminal and Dudgeon Point Coal Terminal. However, the recent cancellation of the Dudgeon Point Coal Terminal[209] project (due to changing market conditions) would cut potential export capacity by around 180 million tonnes per annum. Under Scenario 1, this proposal could be revived and developed before FY31, enabling Hay Point to meet the expected coal export demands in connected regions.

Proposed terminal developments at the Port of Gladstone should ultimately develop its port throughput capacity to 250 to 300 million tonnes per annum.[210] These developments include the closure of the Barney Point Coal Terminal, the expansion of the RG Tana Terminal and the opening of Wiggins Island and Yarwun Coal Terminals. New projects through Gladstone under Scenario 1 are in any case limited (only an estimated 11 million tonnes per annum) and will not constrain the capacities of the Port of Gladstone, with significant available capacity in the existing port configuration.

Rockhampton (Port Alma) was expected to be a new entrant to the coal export market. The proposed Fitzroy Terminal at this port was designed to have the capacity to export 22 million tonnes of coal per annum. However this project has now lapsed due to proponent failing to produce an environmental impact statement.[211] Planned coal exports through this port will likely be diverted to Gladstone which is expected to be able to handle this relatively small quantity of coal.

While not currently configured for coal exports, the Port of Townsville's connection to the Mount Isa to Townsville rail line (and potential new coal mines) may result in the introduction of coal as an export commodity. Further, should any of the proposed terminal expansions at the larger coal ports alter (as has already occurred at Rockhampton and Hay Point), Townsville may be able to position itself as an alternative. To do this Townsville will need to develop its bulk berth and terminal capabilities which may also require redevelopment of its Outer Harbour.

The medium growth Scenario 2 involves far lower demand from new projects (Table 45), on infrastructure than does Scenario 1. Given that there appears to be sufficient proposed capacity to handle the needs of Scenario 1, the port infrastructure needs of Scenario 2 will also be adequately met.

Both rail and road infrastructure requirements are substantially addressed in the baseline infrastructure gaps. Rail requirements centre on expansion of the Blackwater system in the Central Queensland Coal Network (existing constraint on longer trains), together with either expansion of the network in conjunction with new rail connections to the Galilee Basin, or alternatively new direct connections from the Galilee Basin to port, or both. Upgrading of the Mount Isa Line, including the eastern access rail corridor to bypass the city (with productivity and urban amenity benefits), would also be required in conjunction with any reconfiguration of the Port of Townsville to accommodate coal exports.

Road requirements will include upgrade to key regional links (Bruce, Capricorn, Flinders, Peak Downs, Gregory Highways, Gregory Developmental Road, Clermont-Alpha Road), as well as port access roads (Gladstone, Mackay).

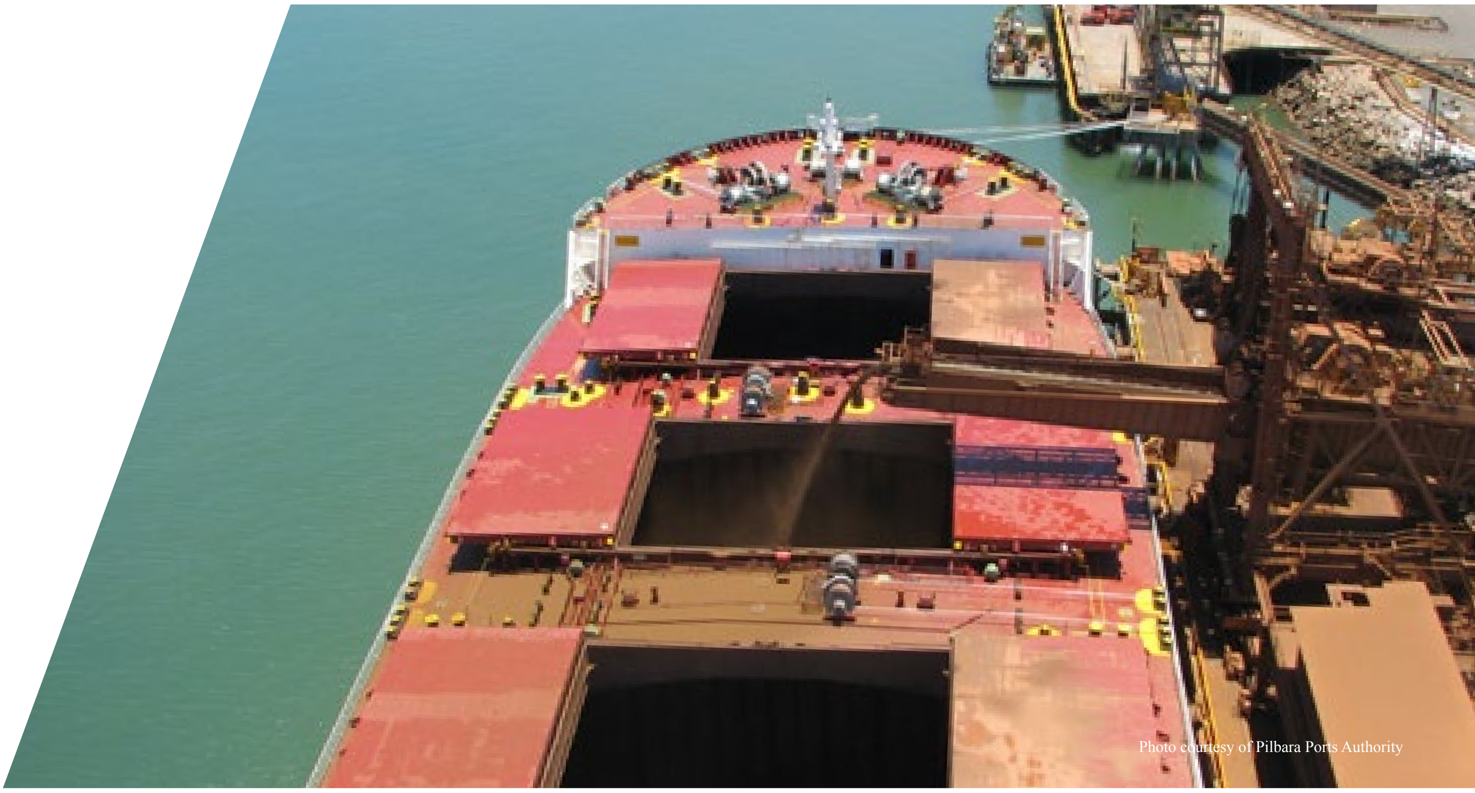
207. See "Abbot Point dredging: spoil to be dumped on land, not in Great Barrier Reef waters", http://www.abc.net.au/news/2014-09-08/abbot-point-dredge-material-to-be-dumped-inland, accessed 17 October 2014.

208. http://www.miningaustralia.com.au/news/hay-point-coal-port-development-moves-forward, accessed 15 October 2014

209. http://www.miningaustralia.com.au/news/dudgeon-point-coal-terminal-cancelled, accessed 15 October 2014

210. Gladstone Port Corporation (2012)

211. http://www.themorningbulletin.com.au/news/Planned-terminal-off-agenda-as-EIS-deadline-missed/2250180/



12.5.3.3 Other infrastructure gaps for energy export growth

Scenario 1 would add an estimated 60 per cent to Northern Australia's peak electricity capacity requirement, while Scenario 2 would add in excess of 20 per cent, relative to the expected baseline demand in FY31 (see Figure 63).

Scenario 1 sees large demand increases in northern locations and would likely require generation investment in Queensland, the Pilbara and the Darwin-Katherine system to meet them. There is also likely to be a need for transmission developments to support increased flows to north and central west Queensland. The nature of these developments partly depends on future new generation location. The large number of projects would see a need for an equal number of new connections. There are established National Electricity Market processes to activate developments in eastern Queensland. However the cost of connection and ongoing electricity charge issues outlined in Section 8.6 would be highly significant and how they are resolved may be a factor in whether the scenario can be achieved.

Scenario 2 does not see demand increases comparable in scale to Scenario 1. However, the demand increases are concentrated in the north of Queensland and in the Pilbara and so similar transmission investment, connection and ongoing cost and coordination issues will still be relevant.

To address the relatively high price of delivered energy/inefficient supply, it would therefore be particularly important to:

- Review the commercial incentives for generator location in north Queensland, including the cost of connection assets and the application of National Electricity Rules
- Review future supply options for the wider Mount Isa area, including National Electricity Market connection, local generation expansion and new gas supply options
- Move towards more coordinated planning and integrated infrastructure development in the Pilbara to respond to future load growth, with a focus on the advantages of multi-user open access networks and interconnecting transmission gas hubs and load centres.

While new generation capacity, network connections or independent sources of supply, both directly to the primary loads and to associated rail and port infrastructure will be important, higher demand growth will not significantly alter the amount of asset replacement that becomes necessary. However, local development plans for additional or replacement generation capacity and/or deferment using renewable generation installation will need to align with augmentation options.

Higher demand growth is essentially unconnected to policies relating to service quality or access in isolated areas. However some augmentations triggered by higher than baseline demand growth may as a by-product provide opportunities to improve service in some locations.

While mine sites typically have a reactive attitude to water supply,[212] the scale of potential coal industry development in the Galilee Basin calls for proactive regional planning of water storage and supply. Options include a pipeline from the Burdekin Falls Dam and development of the proposed Urannah Dam.

12.6 Population scenarios infrastructure gap assessment

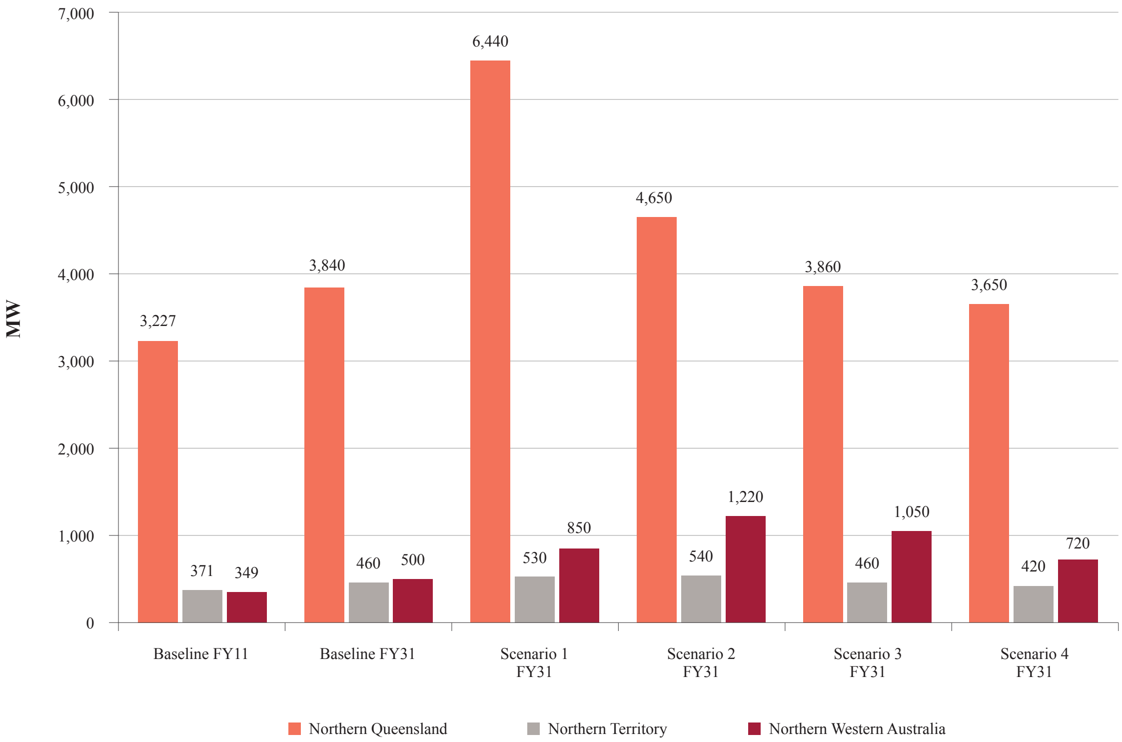
The infrastructure gap assessment for scenarios 3 and 4 focuses solely on population-related infrastructure impacts, abstracting from the industry impacts that population change necessarily implies. The attention is on the infrastructure demand arising from a larger (or smaller) population, not from the combined impacts of both industry change and population change, which were explored in scenarios 1 and 2.

The two scenarios distribute population in proportion to the size of SA2s in the corresponding year in the baseline population projections.[213] As Table 54 shows, for Scenario 3 this generates the largest absolute increases in the major Queensland coastal centres of Townsville, Cairns, Mackay and Rockhampton. Key inland mining centres (e.g. Dysart, Walkerston) and agricultural centres (e.g. Katherine) which grow strongly both absolutely and proportionally in Scenario 1, experience much lower absolute population increases in Scenario 3.

Table 54 also shows that Scenario 1 has a more significant regional effect in the Northern Territory compared to Scenarios 2 to 4 due to the modelled growth in agriculture. In Scenario 1, around 43.8 per cent of the Northern Territory population is expected to live outside the major urban centres and localities defined in this report in Scenario 1.

The infrastructure gap assessment is addressed sequentially for each infrastructure sector.

Figure 63: Projected electricity peak demand FY31



212. Levy et al (2006)

213. To illustrate, if the population of Mount Isa SA2 makes up 2.4 per cent of Northern Queensland's population in FY11, 2.5 per cent in FY16, 2.6 per cent in FY21 and 2.9 per cent in FY31 in the baseline population projections, it will receive the same proportion of the total Northern Queensland population in Scenario 3 and Scenario 4. This is different to Scenario 1 and Scenario 2, where population growth is dependent on the location of growth in tourism, agriculture and energy related activities.

Table 54: FY31 baseline and scenario populations, by urban centre and locality (UCL)

UCL	Actual FY11	Baseline	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Townsville	157,748	238,310	242,737	239,658	276,743	224,744
Cairns	133,893	181,359	201,287	185,619	210,608	171,035
Mackay	74,219	121,044	126,069	123,233	140,566	114,154
Rockhampton	61,724	79,115	81,746	79,937	91,874	74,611
Gladstone	32,073	51,329	59,827	57,692	59,607	48,407
Yeppoon	15,141	28,141	29,258	28,418	32,680	26,539
Mount Isa	20,570	24,571	25,088	24,724	28,534	23,172
Gordonvale	5,482	21,890	22,632	22,000	25,420	20,644
Emerald	12,895	21,302	26,335	23,961	24,738	20,090
Tannum Sands – Boyne Island	9,348	20,615	23,877	23,136	23,940	19,442
Gracemere	8,159	17,443	18,058	17,587	20,256	16,450
Moranbah	8,626	13,443	23,830	19,504	15,611	12,678
Bowen	8,604	12,058	22,761	17,597	14,003	11,372
Airlie Beach – Cannonvale	7,868	11,935	15,640	12,675	13,859	11,255
Mareeba	7,294	9,769	11,851	9,917	11,345	9,213
Ayr	8,392	9,157	11,380	9,317	10,634	8,636
Atherton	6,676	8,129	9,908	8,265	9,441	7,667
Charters Towers	8,234	8,048	8,408	8,114	9,346	7,590
Innisfail	7,176	7,674	8,267	7,753	8,911	7,237
Emu Park	3,736	6,991	7,249	7,050	8,119	6,593
Calliope	3,058	5,773	7,012	6,495	6,704	5,444
Blackwater	4,837	5,462	8,914	6,241	6,343	5,151
Port Douglas – Craiglie	3,939	5,356	6,990	5,669	6,219	5,051
Weipa	3,334	4,844	4,871	4,861	5,625	4,568
Proserpine	3,390	4,720	5,632	4,780	5,481	4,451
Sarina	3,539	4,676	5,331	4,778	5,430	4,410
Ingham	4,706	4,643	6,094	4,729	5,392	4,379
Dysart	3,003	4,257	8,952	6,244	4,943	4,014
Walkerston	3,089	4,117	5,136	4,228	4,781	3,883
Other areas of northern Queensland	681,187	375,770	574,791	411,845	436,372	354,379
Queensland total	**1,311,940**	**1,311,940**	**1,609,930**	**1,386,028**	**1,523,524**	**1,237,257**
Darwin	103,016	135,860	144,864	139,622	135,860	124,058
Alice Springs	24,208	34,628	35,346	35,180	34,628	31,620
Katherine	6,094	8,618	10,291	8,876	8,618	7,870
Nhulunbuy	3,933	5,477	5,572	5,563	5,477	5,001
Tennant Creek	3,062	4,387	4,556	4,461	4,387	4,006
Other areas of Northern Territory	176,298	127,641	156,055	133,497	127,641	116,553
Northern Territory total	**316,611**	**316,611**	**356,685**	**327,199**	**316,611**	**289,108**
Broome	12,766	27,850	28,642	28,009	27,850	26,239
Karratha	16,475	24,159	28,305	27,662	43,109	22,761
Port Hedland	13,772	21,147	24,722	24,207	50,509	19,924
Newman	5,478	7,344	8,484	8,389	12,930	6,919
Kununurra	4,573	6,346	9,985	6,679	6,346	5,978
Derby	3,261	3,863	5,152	3,963	3,863	3,640
Other areas of northern Western Australia	82,969	48,585	69,963	53,833	43,009	45,774
Western Australia total	**139,294**	**139,294**	**175,252**	**152,742**	**187,617**	**131,235**

Note: Only the UCLs with population over the threshold of 3,000 in FY11 are included in this table (that is, the major population centres identified earlier in this report. The balance of the jurisdiction population is shown in 'other areas'. Scenarios have been modelled at an SA2 level and allocated to UCLs based on their 2011 profile. For example, if 96% of the Mount Isa SA2's population lived in the Mount Isa UCL in 2011, this is applied to Mount Isa SA2's population 2031 to derive Mount Isa UCL's population in 2031.

Source: ABS and PwC/GHD analysis

12.6.1 Transport sector impacts

12.6.1.1 Ports

The strong population growth projected under Scenario 3 would increase the quantities of goods and services that need to be moved across Northern Australia to satisfy increased consumer demand. This will require a greater quantity of goods to be imported through the most cost effective international ports and then moved by road, rail and coastal shipping to the final destination. These consumer goods will be largely containerised.

At present, a significant volume of containerised imports to Northern Australia arrive at the major container ports of Brisbane, Adelaide and Fremantle. However, there are a number of ports in Northern Australia that handle containers, including Broome, Cairns, Darwin, Port Hedland, and Rockhampton (Port Alma). These ports handle small container volumes that are project-related, and not regularly served by liner vessels. Townsville, on the other hand, has a more significant container task (50,173 twenty foot equivalent units during FY13) and is regularly serviced by a limited number of liner services operating largely on loops through the Pacific Islands.

The ports of Northern Australia have an inherent geographical advantage when it comes to serving their populations. However, the economies of scale associated with serving a larger, local population base limit the cost viability of these ports for general consumer goods. Under Scenario 3, an increase in the catchment population for the ports of Port Hedland and Cairns, may generate sufficient volume to induce regular international liner service calls, or, for the Port of Townsville, increase vessel size, call frequency or additional liner services. With the increase in direct call international liner services, this would be likely to offset demand for coastal shipping and road and rail freight. In order to facilitate efficient transport, these ports may require landside infrastructure improvements which will include container handling equipment, larger warehousing facilitates and reefer points. Improvements and expansion of infrastructure will likely occur incrementally in step with demand growth. A further consequence of increased demand at these ports may be increased strain on the logistics supply chain (service schedules, port rotations, feeder linkages of liner ship services).

Scenario 4 is unlikely to see a significant change in the routing and scheduling patterns of container ships.

12.6.1.2 Urban road and rail

Scenario 3 population growth will be concentrated around existing population centres. This will result in a proportional increase of vehicles in these areas with respect to population growth. In the Northern Territory, for example, there is an estimated 627 vehicles per 1,000 population.[214] In addition to increased light vehicle traffic, there will also be a proportional increase in the number of heavy vehicles on the road. These heavy vehicles, such as B-doubles, will be used to move containerised goods from port and rail terminals (and from southern points of origin) to destination customers.

Urban roads will experience the brunt of the vehicle demand pressures which may create congestion and delays along key arterial roads. This will include the Mackay Ring Road and urban sections of major highways (e.g. North West Coastal Highway and the Stuart Highway).

These issues can be addressed by increasing the capacity of existing roads and by providing alternatives. Congestion management strategies include:

- Engaging in a program of lane widening and lane duplication
- Building alternative bypass routes
- Route tolling
- Implementing direct road user charges for some classes of vehicle (e.g. heavy vehicles)
- Providing viable public transport alternative options.

The last of these points is key to effectively increasing the accessibility and mobility of a growing population. Bus public transport across major Northern Australia population centres generally has limited connections, low frequency, a lack of reliability and lack of dedicated bus lanes. A combination of infrastructure, logistics and technology investment is needed to provide an efficient solution. An example of this would be:

- Infrastructure: designation and development of bus priority lanes and additional bus stops and interchanges
- Logistics: undertaking an assessment of bus routes and implementing non- infrastructure solutions to move passengers more efficiently. Examples include timetable changes, express bus routes and the utilisation of an integrated hub and spoke model

214. Australian Bureau of Statistics (2014)

- Technology: technology already in use in southern urban centres such as electronic ticketing and the availability of real time passenger information will improve ticketing and boarding times and improve the experience and reliability of using public transport in the north.

It is not anticipated, under Scenario 3, that the population levels in Northern Australian cities will reach a level requiring the building of city passenger rail systems. However, large population increases will grow the potential market for inter-city rail and even tourism rail.

12.6.1.3 Freight rail

Much of the additional rail infrastructure needed under Scenario 3 will be associated with increased demand for containerised goods.

While it is expected that a greater number of containers would arrive through Northern Australia ports, this is likely be in addition to the intensified use of existing rail links which deliver containers to the north from the ports of Adelaide and Brisbane. Consequently, the North Coast Line and the Adelaide to Darwin Railway will see increases in intermodal traffic.

Continued strong north-bound container demand along the Adelaide to Darwin Railway will require additional services under Scenario 3. A major constraint to achieving this is the railway's limited ability to allow increased train movements without sacrificing efficiency (e.g. increased wait times at passing loops). Significant investment will be needed in duplicating sections of track, by way of additional passing loops, to facilitate efficient container movements along this central corridor.

The North Coast Line is the main intermodal freight route connecting Brisbane to northern Queensland. Additional container movements, as a result of Scenario 3, may require longer train lengths to remain cost-effective. Extending the length of passing loops and improving the reliability of the track will be key to an efficient rail service. Reliability improvements will come by way of bridge upgrades, grade levelling and by upgrading the capability of the track to handle severe weather.

12.6.1.4 Airports

The remoteness of some communities in Northern Australia make air travel an essential means of passenger transport, with limited mode alternatives for some routes.

An increased population under Scenario 3 will increase outbound and inbound passenger movements to Northern Australia airports. The increased Northern Australia resident population will travel domestically and internationally for work, leisure and visiting friends and family, while non-residents will travel to and from Northern Australia for the same reasons.

Northern population centres that are expected to see a significant increase in resident populations include (in order of greatest increase in residents by FY31) Townsville (increase of 119,000), Cairns, Mackay, Port Hedland, Darwin, Rockhampton, Gladstone and Karratha (increase of 27,000). Airports whose catchments include these centres are likely to experience the greatest increase in passenger throughput.

The airports at Gladstone, Karratha, Port Hedland and Townsville will likely need expanded terminal facilities and taxiway/apron improvements to handle the additional passengers and associated aircraft movements.

12.6.2 Energy sector impacts

The impact of higher or lower population growth is of much less significance for electricity demand compared to large new mining or even irrigated agriculture developments, which can lead to significant and geographically concentrated load increases. Increased electricity demand as a result of increased population in Scenario 3 is estimated to be of the order of less than 200 MW greater than baseline (compared with Scenario 1 projects which add almost 1,700 MW to baseline demand).

As a consequence, Scenario 3 has a relatively small impact on electricity demand relative to the baseline, although there would still be a need to strengthen supply to some locations including Far North Queensland and the Pilbara.

Scenario 4 implies marginally lower electricity demand, relative to the baseline. It may be difficult to raise awareness of cost of supply issues in an environment where no major new industry investment is taking place.

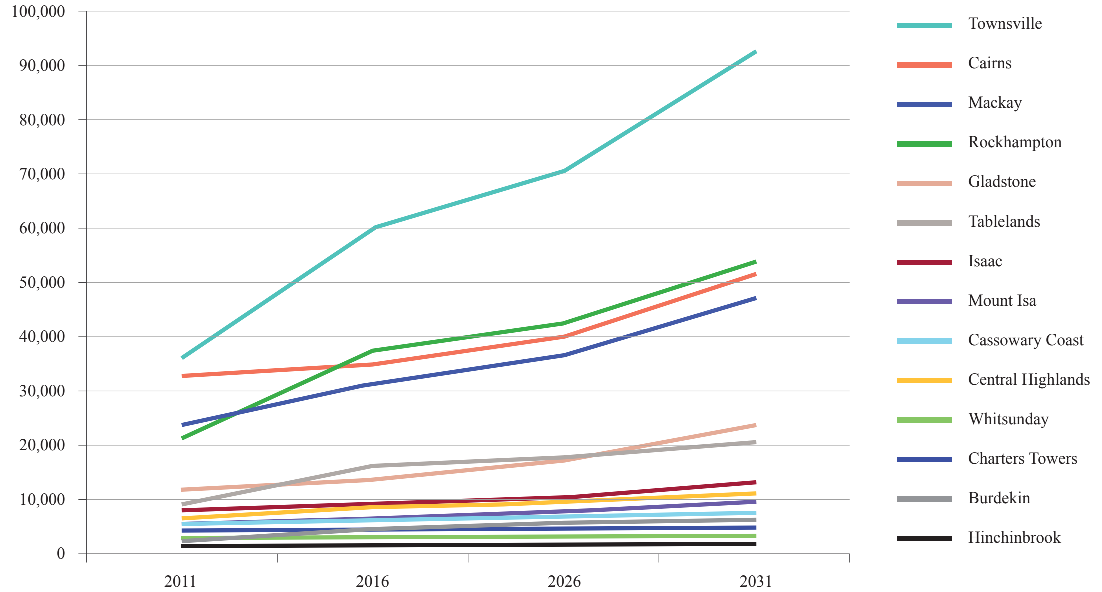
The need for generation investment in Queensland will also depend on demand growth in the rest of the National Electricity Market and on whether there is any change to the incentives to locate generation in northern, rather than southern Queensland. Climate change policies could potentially become a significant investment driver if new coal fired generation is no longer feasible, or if new renewable corridors are opened up by favourable relative prices for renewable versus non-renewable generation and access to network connection. A more rapid change in decarbonisation of electricity supply would be possible in a scenario with strong demand growth.

12.6.3 Water sector impacts

Water supply and wastewater services are essential services for any community. Under the increased population projections for Scenario 3, there will be strong population growth in the major Queensland coastal centres (Townsville, Cairns, Mackay, Rockhampton and Gladstone) and the Pilbara cities (Karratha and Port Hedland) over the next twenty years.

The existing urban water supply and wastewater services in these major regional cities in Northern Australia would find difficulty in delivering the existing level of service in the absence of upgrades and augmentations. Results of the urban water demand projections for the main regional centres are shown in Figure 64 for Queensland and Figure 65 for Northern Territory and Western Australia.[215] A majority of the major centres (with the exception of Central Highlands and Cassowary Coast) would generate an additional 16 per cent increase in water demand under Scenario 3 populations compared with the FY31 baseline.

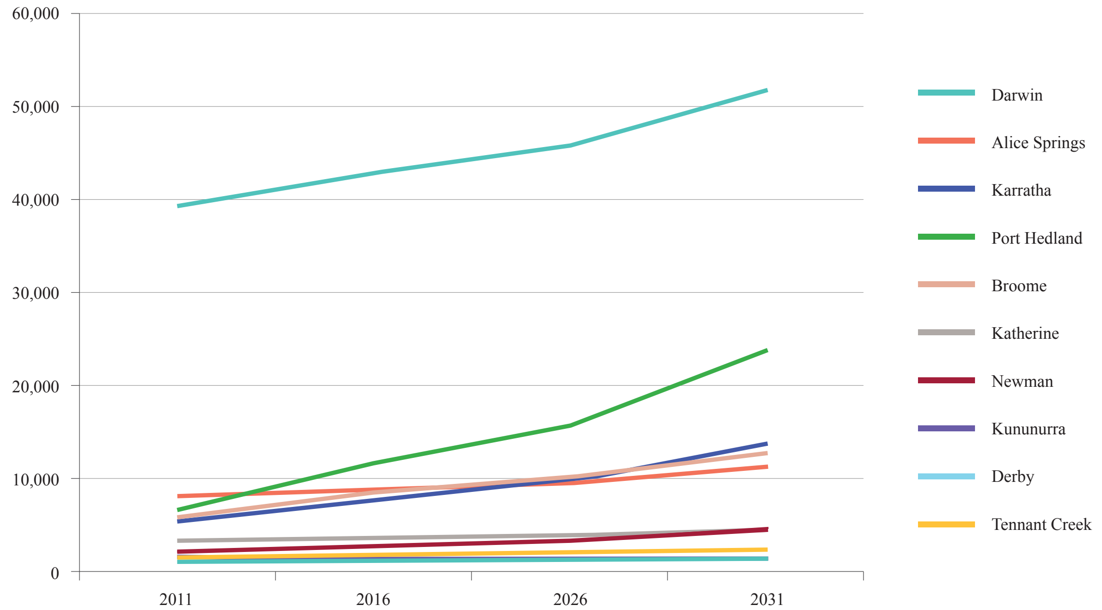
Figure 64: Scenario 3 urban water demand projections, Queensland



Source: Australian Bureau of Statistics, National Water Commission, local government councils, Queensland Department of National Resources and Mines and PwC/GHD Analysis

215. These demand projections are intended to provide a ballpark measure of possible demand, based on historical water usage levels and without the aid of climate and hydrological studies. See notes in Table B.14 for a description of the methodology employed in calculating future water demand projections.

Figure 65: Scenario 3 urban water demand projections, Northern Territory and Western Australia

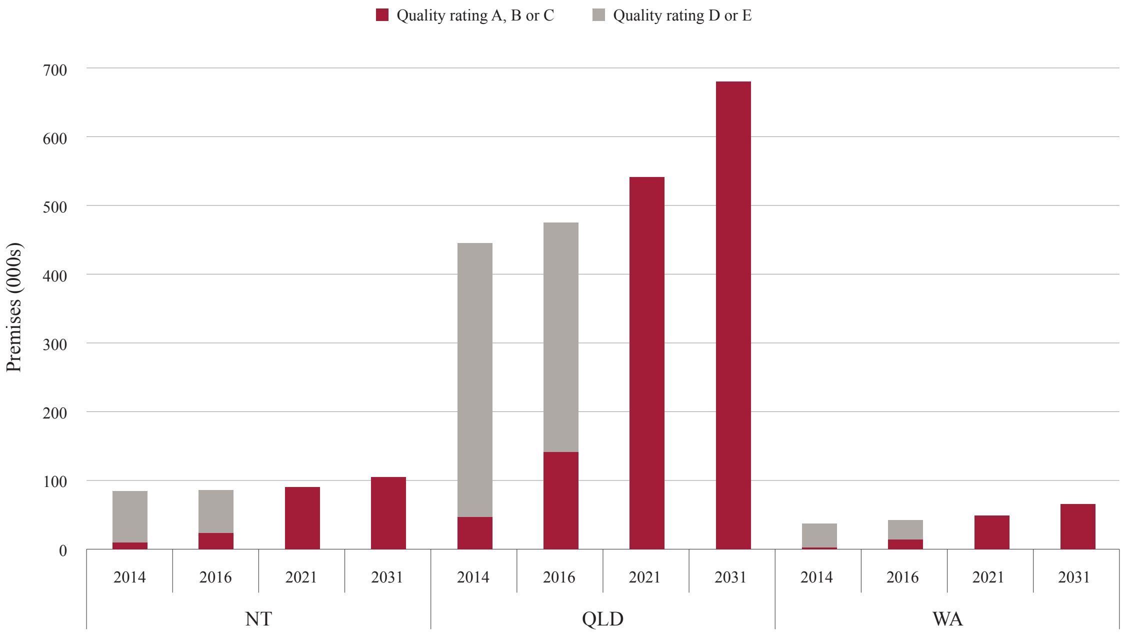


Note: Unlike Queensland and Western Australia, the Northern Territory has no 'northern shift' policy goals. Scenario 3 projections are therefore the same as the baseline.
Source: Australian Bureau of Statistics, National Water Commission, Power and Water Corporation, Water Corporation of Western Australia and PwC/GHD analysis

12.6.4 Communications sector impacts

If the north is to be able to support the high increases in population in Scenario 3, the rollout of the National Broadband Network (NBN) would need to be accelerated. This is shown indicatively in Figure 66, which indicates the number of premises that would need improved broadband service to meet an expectation that Northern Australia will have quality broadband by the 2021 end of NBN rollout. 'Quality broadband' in this instance is regarded as the My Broadband quality ratings A, B and C.

Figure 66: Scenario 3 Broadband expectations – closing the gap



Source: MyBroadband datacube version 3, PwC population projections and GHD analysis

The underlying assumptions are:

- All premises will have 'A', 'B' or 'C' quality broadband by 2021
- The number of premises grows at the same rate as forecast population
- For the period to 2016 a linear growth of premises with 'A', 'B' or 'C' quality broadband is assumed.

Good or acceptable quality may be delivered by a range of media, and this will be determined by NBN Co; however the expectation has been established that all premises should have broadband speeds of at least 25 Mbps. This will be essential for tourism growth, for the agricultural sector, for education and health purposes and to support resources development. Telecommunications growth has assumed major proportions in terms of traffic, users and the proliferation of devices.

As discussed in Section 11, Australian internet protocol (IP) traffic is expected to grow more than three-fold by 2021. The data show that this will be across all media, but that Wi-Fi IP is likely to become the primary medium. Fixed Wired IP traffic will also grow substantially but by 2021 will have reduced in proportion because of major growth in Mobile IP traffic and in M2M, both of the latter from much smaller bases. Increasingly, however, the delivery medium will become less visible to the user, as Wi-Fi bridges the fixed and mobile markets. While much of the discussion on communications and the NBN has been in terms of premises, it is the individual person that is important in Wi-Fi and mobile.

The growth in traffic represents not only growth in population or premises, but also in per capita traffic and in the number and type of devices. It is this that will place pressure on the network. Experience has shown that increased take up by more people can cause the network to fail, with failure likely to be in the transmission network – the backhaul or backbone links. It is therefore important that the NBN and mobile rollouts address this issue explicitly. Moreover, the poor financial returns from rural and remote communications infrastructure, which translates into lack of competition and high prices to the end user, will require attention if the digital divide between Northern Australia and the more heavily populated areas is to be addressed.

12.7 Scenarios in summary

The four scenarios test the impact on infrastructure needs of meeting specific targets for energy exports, agricultural output, tourism and population.

Some of those targets will be more challenging to meet than others. For example, Scenario 4 has lower population growth than the currently expected baseline and Scenarios 1 and 2 include tourist stopovers returning to levels that have already been achieved in the past. However, even to approach the agriculture targets in Scenarios 1 and 2 would require a considerable commitment to irrigated agriculture in northern Australia, with very large scale surface water diversions. Increases in energy exports also require a commitment to associated electricity connections and rail, ports, roads and water infrastructure. The cost of electricity plays a significant role in the overall cost structure for remote mining and resource processing projects and may be able to be addressed through better access to shared networks, particularly in Western Australia, or via changes to the distribution of network charges between remote and other locations. Notwithstanding these issues, the primary investment needed to drive the energy export targets is not the availability and cost of the resources, but the international prices, exchange rate and demand that make their extraction profitable.

12.7.1 Meeting agriculture targets

Agriculture targets may be met by a combination of irrigated agriculture, aquaculture and an expansion of beef cattle production. Increased agricultural productivity is unlikely to contribute to anywhere like the extent necessary to achieve the target output growth over the next twenty years. The potential for beef cattle expansion is limited and the scope for expansion of aquaculture is uncertain, which leaves irrigated agriculture as the major driver of the targeted output growth. In this respect, arable soil and water resources are available to meet the targets, but the cost of water storage and distribution systems will be high. The new irrigated area required to reach the value of production included in Scenario 2 is about nine times the combined areas of the existing Mareebah-Dimulah, Burdekin River and Ord irrigation areas and would require over 10,000 GL a year of water diversion, approximately equal to the sustainable limit for the entire Murray-Darling

Basin. The economics of such developments are expected to be very challenging, particularly where the agriculture project bears the full water and associated infrastructure cost. Demonstrating sufficient financial viability to attract the necessary private sector investment may be difficult for many such projects.

Irrigated agriculture will have associated infrastructure requirements:

- Significant power infrastructure
- Use of under-utilised rail infrastructure
- Local access roads
- Transport and processing facilities for beef cattle.

Water infrastructure to support population growth is of an order of magnitude less than that to support irrigated agriculture. However, as noted by the Northern Territory Government,[216] population in the context of the agriculture scenario target would double in the rural Barkly, Petermann-Simpson and Victoria River SA2s, the greatest absolute population effect in the jurisdiction. This would involve potentially not insignificant infrastructure requirements in roads, power, water and communications, to service the increased population.

12.7.2 Meeting tourism targets

Tourism targets are modest compared to past levels of tourism in northern Australia, so increased flights to most existing airports would be easily accommodated. Most tourism airports do not have direct international flights, but infrastructure is not the constraint here. The identification of additional international airports depends on identifying tourism market opportunities and alignment with airline strategies.

A number of roads have been identified as requiring tourism-driven upgrades (refer to Section 12.5.2.3).

12.7.3 Meeting energy export targets

Infrastructure requirements for meeting energy export targets include pipelines rail, roads (including port access roads for LNG), water supply and electricity. Some of the necessary infrastructure already exists or is being planned (for example options identified for water supply to the Galilee Basin include a pipeline and development of Urannah Dam). Scenarios 1 and 2 bring to the fore the cost of supplied energy for resource projects in remote locations as discussed in Section 8.6 above.

12.7.4 Infrastructure implications of population targets

12.7.4.1 Transport

Scenario 3 includes a large increase in northern population, particularly along the Queensland coastal areas, and would increase the quantities of goods that need to be moved across northern Australia. This would likely lead to some reallocation of container freight to the ports of Broome, Cairns and Darwin with consequent pressure on these ports.

Scenario 4 is unlikely to see a significant change in the routing and scheduling patterns of container ships.

Scenario 3 population growth would also generate proportional increase in vehicle traffic, causing increased urban congestion. A range of congestion management strategies can be considered, including lane widening, bypass routes and improved public transport.

An increased population under Scenario 3 will increase outbound and inbound passenger movements to Northern Australian airports. A number of airports, including Gladstone, Karratha, Port Hedland and Townsville, will likely need expanded terminal facilities and taxiway/apron improvements to handle the additional passengers and associated aircraft movements.

216. Northern Territory Government input to the audit

12.7.4.2 Electricity

The impact of higher or lower population growth is of much less significance for electricity demand compared to large new mining or even irrigated agriculture developments, which can lead to significant and geographically concentrated load increases.

As a consequence, Scenario 3 has a relatively small impact on electricity demand relative to the baseline, although there would still be a need to strengthen supply to some locations including Far North Queensland and the Pilbara.

Scenario 4 implies marginally lower electricity demand, relative to the baseline. It may be difficult to raise awareness of cost of supply issues in an environment where no major new industry investment is taking place.

12.7.4.3 Water

Strong population growth in Scenario 3 in the major Queensland coastal centres and elsewhere (notably Karratha and Port Hedland) will put pressure on existing urban water supply and wastewater services to deliver the same level of service without adequate upgrades and augmentations. While there is no assumed difference between Darwin's population in the baseline and in Scenario 3,[217] there is sufficient population growth in Scenario 1 to trigger similar pressures on urban water supply in Darwin.

12.7.4.4 Communications

Telecommunications growth has assumed major proportions in terms of traffic, users and the proliferation of devices. If the north were to be able to support the high increases in population in Scenario 3, the rollout of the NBN would need to be accelerated. Good or acceptable quality may be delivered by a range of media, and this will be determined by NBN Co. However, the expectation has been established that all premises should have broadband speeds of at least 25 Mbps. This will be essential for tourism growth, for the agricultural sector, for education and health purposes and to support resources development.

217. As a northern jurisdiction, there are no 'northern population shift' directions that are applicable to the Northern Territory, in contrast to the other two jurisdictions.

> "Tourism targets are modest compared to past levels of tourism in northern Australia, so increased flights to most existing airports would be easily accommodated."

Photo courtesy of Pilbara Ports Authority

Concluding issues

The audit raises a number of key issues for improving economic infrastructure to support the development of Northern Australia.

Some of these issues involve addressing sources of market failure that are generally characteristic of the infrastructure industries (see Section 2.4.2). These include: first mover disadvantage; network effects; coordination externalities; and service standard issues arising from a lack of economic scale and the associated high costs of providing service.

In addition, how best to address opportunity gaps, or the 'positive externalities' of infrastructure investment is an important issue for government, as are the pricing and funding of infrastructure improvement, ways to approach prioritisation, and appropriate project evaluation methods in a policy context of furthering economic development.

13.1 Addressing first mover disadvantage

It is characteristic of most infrastructure sectors that the party who seeks a connection to a network or some additional specialised infrastructure (e.g. a new port terminal) bears the full capital cost. This party, the first mover, must satisfy themselves that the cost of the new infrastructure can be recovered through the revenue that it will help to generate, whether this is from access and usage tariffs as an infrastructure owner, or the sale of goods and products. Subsequent users then benefit by paying only a marginal or incremental cost. The model works well when the value of the market opportunity is large enough for the first mover to be able to absorb the infrastructure cost. The first mover gains and so do subsequent users. These are responding to smaller market opportunities that might never have under-written the full cost of the infrastructure. However, some players may deliberately hold off, aiming to 'free ride' on an eventual first mover. And if there is no first mover, no one gains. Where the potential collective net gains are less than the cost of the infrastructure, this is as it should be. But if not, there is a net economic loss.

Examples in Northern Australia of first mover situations include additional passing loops on the Adelaide-Darwin Railway, the costs of which may currently exceed the likely capacity to pay of mining company users and new electricity connections to both the National Electricity Market (Queensland) and the North West Interconnected System (Pilbara).

Arguably, private industry collaboration – through joint ventures, strategic alliances, and other commercial special purpose vehicles – is now becoming more mainstream, reducing the need in some cases for consideration of any government response. Also in some situations the infrastructure owner may agree to delay capital recovery, so that there is, in effect, no first mover disadvantage. Nevertheless, in principle governmental responses to the first mover disadvantage problem include:

- Facilitating cooperation between parties, so that they find it easier to combine to jointly fund the infrastructure investment
- Providing seed funding as a means to motivate industry cooperation to jointly fund the balance of the required investment
- Full government funding.

With the first two approaches, there is risk that still nothing may eventuate, while with the third it is important to ensure that benefits will be widely shared and do not accrue exclusively to an individual business or to a small group of businesses. Road and communications infrastructure in particular may often be of this type. Consideration of associated social and community benefits is also important.

13.2 Acknowledging benefits of more extensive networks

Network effects exist where current users of a network benefit from growth that incorporates new users, by virtue of the additional users and locations to which they are now connected. Thus if national infrastructure networks (e.g. road, electricity, communications) are extended or upgraded in Northern Australia, there are benefits throughout the network, not solely in Northern Australia.

To illustrate, the corrugated and largely unsealed Tanami Road between Alice Springs and Halls Creek is known to cause damage to vehicles even in the dry season and, in all likelihood, deters use. Yet the sealed road alternative, via Katherine, is 1,000 kilometres longer. Sealing the Tanami Road would therefore bring the Kimberley region and south-eastern Australia into much closer effective proximity, with benefits to both. This is not to argue that benefits in this instance necessarily exceed costs, which is a matter for specific evaluation. But it illustrates the importance of identifying and assessing benefits in a wide network context.

For road networks, which are quasi-public goods (i.e. largely non-rival and non-excludable), the government funding role is pervasive and a key issue is accordingly how best to prioritise in a context of limited resources (see Section 13.6). For 'excludable' infrastructure such as communications networks that are privately or corporately provided, the prime issue is a different one – how to design a set of incentives and/or regulatory requirements that result in a minimising of areas of inadequate service, and to do so at competitive prices for the consumer. This would mean incentivising or requiring infrastructure managers to provide infrastructure that may be uneconomic to provide on the basis of the traffic carried by the more remote links themselves, but which once provided benefit users everywhere, not solely those receiving the new connections.

While NBN Co has a mandate to provide high capacity fixed broadband service, there is currently no parallel strategy to ensure mobile quality of service. This could be addressed by extending NBN Co's mandate to cover mobile infrastructure in remote regions. This would then allow testing of whether the forces of competition between and/or incentives on telecommunications carriers are sufficient to provide adequate service for industry and communities in these areas. Where they prove not to be, competitive tendering among telecommunications carriers to provide a subsidised service remains an option.

For networks in all sectors, strengthening resilience and redundancy are also important considerations. Filling of 'missing links' and upgrading of existing alternative links add to overall network connectivity and capacity. Examples identified in this report, again without endorsement in terms of commercial or economic viability, include a gas pipeline connection from the Northern Territory to the eastern states, upgrade of the Hann Highway to Cairns and of the North West Coastal Highway between Perth and Port Hedland, a Mount Isa to Tennant Creek rail connection and and an electricity connection between Port Hedland and Newman.

13.3 Addressing coordination externalities

Sharing infrastructure access and coordinating infrastructure requirements is consistent with the spirit of National Competition Policy, under which access to privately owned nationally significant infrastructure can be 'declared' and vertically integrated infrastructure owners are encouraged to consider requests for access by third parties. However, it has generally proved difficult to implement in Northern Australia.[218]

The cost of infrastructure service can often be inefficiently high when private companies build their own capacity rather than planning in cooperation with other companies to build and share larger, more efficient facilities, or to share interconnection and transmission costs. This has notably been the case in the electricity sector in the Pilbara region, with the apparently perverse results of capacity that exceeds the requirements of the individual company or mine and high costs for other users. The issue also potentially applies in other mining growth regions, including the North West Queensland Mineral Province, the Galilee Basin and possibly the Roper River/McArthur River region in the Northern Territory.

Western Australia has recently used its State Agreement framework, under which the terms and conditions for development of a project are ratified by legislation, to initiate planning and construction of a large privately owned power plant at Port Hedland which will have at least two major customers (Fortescue Metals Group, Horizon Power).[219] The process makes a call on government administrative resources to negotiate and put in place a complex agreement with multiple private parties, but offers benefits in terms of the scale of operation. It does not, however, address the still more difficult issue of establishing a fully coordinated network, notably through a Pilbara-wide shared access regime and possibly the construction of an East Pilbara link between Port Hedland and Newman.

The strategic issue for this region is to investigate under what circumstances there could be an economic case to extend the network and operate it with an open access network regime, connection process and set of market rules to determine customer payments to power generators, as in the National Electricity Market. If such a case exists, for example in an environment of higher energy prices than today and were accepted by government, compensation for losses that mining company energy producers might incur could also be considered.

13.4 The cost of power in northern Queensland

Over 70 per cent of Northern Australia's population live in northern Queensland and the region contributes over 40 per cent of Northern Australia gross value added. The audit's analysis indicates an industry price differential between northern Queensland and southeast Queensland locations, as a result of most of the state's generators being located in more southerly locations, of up to 25 per cent.

The National Electricity Market rules provide weak incentives for generators to locate where they might lower costs for customers. If the next large power station in Queensland were to locate in the north rather than the south, it would lower marginal loss factors and locational transmission charges for northern mining and other companies. Two questions arise here. Firstly, is there a way of reducing the cost of power for the north's industries without increasing the cost by an offsetting amount for those in the south? Net costs to government should be part of this analysis, noting that the uniform electricity tariff that northern (and other regional) residential consumers pay benefits from a government community service obligation subsidy to power retailers. The second question is whether, if generator location in northern Queensland were to indicate an increase in cost for the south, there might still be greater than offsetting benefits on a national basis, through the stimulus to resource and other economic activity in the north?

Both are important questions for the development of Northern Australia.

218. In the rail sector, barriers have included company apprehension about loss of access to capacity that they may possibly require in the future even if not in the present and timing incompatibilities.

219. https://au.news.yahoo.com/thewest/a/24582464/govt-nod-for-pilbara-power-station/

13.5 Recognising and responding to opportunity gaps

Economic infrastructure is fundamentally enabling. It provides essential inputs, access to markets and reduces costs for end user industries. But when and to what extent will industry respond to the opportunity that improved or 'missing link' infrastructure provides? Uncertainty here means that it is often difficult to include these impacts as a major element of the business case for infrastructure projects.

Hindsight is a useful, if slow, teacher. The Adelaide to Darwin Railway, which opened in 2004, has successfully expanded the reach of Darwin as a bulk minerals port, opening up market access and reducing supply chain costs for a number of smaller mines in the central corridor that are unlikely to have eventuated otherwise. Could a future rail connection from Tennant Creek to Mount Isa have similar impact? Certainly the prospectivity of the region (covering phosphate, gas, base metals and other mineral deposits) offers promise for the longer term. However, the connection would not have the essentially 'certain' and hence 'bankable' demand of a major domestic intermodal freight corridor that provided the principal part of the business case for the Adelaide to Darwin line at the time.[220]

Industry cost modelling in a spatial context can be a helpful aid in identifying opportunity gaps. Notably, CSIRO has estimated that land transport costs comprise up to 35 per cent of the market price of livestock, with floods and seasonal road closures preventing stock reaching ports and abattoirs for months of the year.[221] CSIRO has developed a suite of models to help analyse road improvement and other supply chain investments in terms of the industry and economic benefit they offer. Similarly, state governments have been investing in tools to identify and evaluate where resource opportunities that would not otherwise be developed can be realised through enabling investment.

A key part of a response to opportunity gaps should be to analyse and work through the opportunity scenarios as thoroughly as possible as part of the evaluation process (see Section 13.9). Maximum and minimum industry impacts can then be understood, along with the extent of dependence on particular infrastructure options. Ideally, this should take place before an infrastructure investment appraisal is undertaken rather than as part of it, to avoid the latter either taking undue precedence or even skewing the scenario outcomes.

13.6 Infrastructure pricing and funding challenges

Efficient pricing, where pricing reflects both the demand of additional users in the short run and the costs of additional investment in the long run, is very helpful to infrastructure managers and governments in both rationing and funding future infrastructure requirements. It follows that reliance on government investment funding is likely to be greater in those sectors that are furthest from the efficient pricing goal, than in others.

In Northern Australia, as elsewhere, there are differences between sectors. Electricity pricing generally provides for capital cost recovery. Government, however, contributes through community service obligation funding that ensures uniform tariffs for residential use throughout Queensland, Western Australia and urban centres in the Northern Territory. In some contrast, pricing of both urban and bulk water typically covers only operational and administrative costs, without contribution to capital recovery. Pricing in the non-roads transport sector (airports, ports, rail) is highly varied, depending on location and markets served.

The roads sector is a particular case, with no point of use pricing (toll roads aside) – albeit with significant indirect revenue generated, through fuel excise and other taxes and charges – and also without an overarching economic regulatory framework. One consequence is that there is no requirement on road infrastructure managers to justify either to customers or regulators the network's maintenance and renewal investment requirements in the way that occurs, or should occur, in other sectors – and similarly no opportunity to recover these expenses through pricing. Jurisdictions have taken the opportunity of this audit to indicate substantial maintenance backlogs. Reasons for the backlog appear to include an ageing road pavement profile, some recent prioritisation of safety improvements (e.g. road widening) over asset maintenance and renewal and a reported tendency for road freight vehicles to operate more intensively than previously during the wet season, with resulting greater road damage.

220. The business case for the Adelaide to Darwin railway had three demand components – firstly, the domestic containerised freight market between Adelaide and Darwin, secondly, land bridging of container imports from Asia through Darwin to Adelaide and south-eastern Australia and thirdly bulk mineral and livestock exports. With perceived uncertainties over two of these, proved justified in the case of one, project finance was based only on the first component. See Symon (2004). http://www.adelaide.edu.au/saces/publications/papers/issues/EIP7AdelaideDarwinRailway.pdf Accessed 23 September 2014.

221. CSIRO (2013).

These backlogs are likely to represent a priority future call on government funding.

Continuing with and strengthening pricing reform, as required under the COAG National Water Initiative, is important to promote efficiency in use and to provide an accurate signal and potential funding source for needed investment. At the same time, even with success in pricing reform, an at least partial government funding role may be unavoidable for projects in all sectors where: direct benefits are too widely dispersed or insufficiently certain to attract finance backing; or asset lives exceed normal financial market expectations (e.g. for major dams); or where economic scale is too small for commercially viable investment (see Section 13.7). Furthermore, historically, cost-benefit analysis has had limited application in evaluation of investment decisions on water and wastewater projects, or as part of approvals processes. Decisions on augmenting existing assets or investing in new infrastructure have generally been based on considerations on security of supply, levels of service and health consequences.

13.7 Service standard challenges

Standards of infrastructure service are lower in Northern Australia than elsewhere in considerable part because of cost. Small populations, large distances, remoteness from Australia's major population and employment centres and an extreme climate all imply high unit costs of service. Because a low standard of service reduces effective capacity and because a situation of demand exceeding effective capacity is often one where infrastructure upgrade can demonstrate net economic benefits, the case for improving service levels often overlaps with the productivity argument for infrastructure investment. However, this is not always the case.

13.8 Approaching prioritisation

Whereas in the roads sector, government is both policy manager and project funder, in other sectors (e.g. electricity, mobile communications), project decision-making is to a large degree handled by privately owned or corporatised government entities operating within a framework of (government) economic regulation. This goes some way to explaining the preponderance of road critical infrastructure requirements (around one third of the items listed in the Executive Summary table) that the audit has identified.

Prioritisation typically involves a multi-stage process in which options to address a particular problem are first identified, then screened in order to short-list a manageable number of alternatives, and finally evaluated using cost-benefit analysis and related methods. The audit's list of critical infrastructure requirements addresses many different problems, albeit grouped broadly by category (e.g. airports – resource sector, airports – tourism). While it would be challenging to comprehensively prioritise them, some guiding comments may be helpful.

A potential starting point is that Northern Australia faces growing economic opportunities by virtue of proximity to the expanding Asian region, but will be better placed to take advantage of them if well linked to the markets and population centres of southern Australia – helping the north to grow its industries by reducing costs and increasing economic scale. This suggests a high priority to what can be called national and in some cases regional network upgrade and extension initiatives (see also Section 13.2).

Network resilience is a further consideration, where the existence of an alternative route or additional capacity offers some redundancy when the principal route or facility is closed, due to weather emergency, as often in the case of roads, or other reasons.

In addition, maximising the efficiency of existing infrastructure is critical to the development of Northern Australia and arguably equal in importance to new infrastructure, or of greater importance. Key areas for attention in this regard include addressing maintenance backlogs (roads sector) and introducing more cost-reflective pricing where feasible (water sector).

13.9 Evaluating projects for economic development

Cost-benefit analysis is the recognised key tool for evaluating projects as part of the governmental decision-making process. It has unique strengths in providing an absolute measure of value, in the sense of providing an answer to the question of whether a project is better than a 'do nothing' or 'do minimum' alternative. This is a by-product of its distinctive features of, firstly, expressing both costs and benefits in monetary terms and, secondly, 'discounting' future costs and benefits at a rate that reflects either or both of the social opportunity cost of capital or the social time preference rate.

First widely applied in the 1950s and 1960s, cost-benefit analysis is an evolving suite of concepts and methods. A number of issues that are particularly important in an economic development context – and which may possibly be less important in other contexts – are not fully resolved at the present time.

Firstly, the existing level of demand for an infrastructure facility, augmented for future years on the basis of population, economic or other growth rates, generally provides the benchmark against which the impact of a new or improved facility is measured. The method works well for projects that are incremental in character – an additional lane on a highway, extra stations on a railway line, for example – but less well for infrastructure that involves a step change or more from the existing situation.[222] In these situations, either there is no existing demand, or existing demand is a misleading guide to future demand, with the consequence that the assumptions on which a key part of the project impact is based – the so-called 'induced demand' effect – break down.

Secondly, economic development involves, among other things, reshaping the economic geography through policy to build density, for example through growing cities, to reduce physical distance (e.g. by promoting migration to density) and to reduce internal and external economic borders – in all three cases, helping to build larger and more efficient industries.[223]

By reducing economic distance between locations, businesses and workers, efficient transport and communications infrastructure investment is critical to this effort. However, a central tenet of cost-benefit analysis is that returns to scale are constant, i.e. they do not increase with business or industry size. Through the concept of 'wider economic benefits', some recent methodological development has sought to accommodate economies of scale in agglomeration, i.e. the increasing returns to scale in business proximity, whether in cities, regions, or international groupings.[224] However, at the present time this is a quite circumscribed 'add-on' to the cost-benefit method. It does not provide a means to quantitatively recognise the diseconomies resulting from the small scale of many Northern Australia markets.

In most situations, however, including in transport investments where the method is very widely used, cost-benefit analysis should be undertaken as a matter of course. However, scenario analysis, as outlined in Section 13.5, aimed at identifying and measuring the 'positive externalities' of infrastructure investment[225] can help ensure that potentially important and material end-user industry impacts are not overlooked. As in all good quality cost-benefit analyses, potentially material unquantified and intangible effects should be presented along with the quantitative analysis, for careful weighing up by the decision-maker.

Cost-effectiveness analysis is a useful alternative approach where outcomes are seen as primarily social rather than economic, or where the aim is to prioritise investment options to address a 'service standard' rather than economic development objective[226]. This method relaxes the requirement to monetise benefits, instead using a selected outcome indicator, for example, the size of the population served, or the number of services provided. However, wherever the main policy interest is in the economic payoff of alternative investments, cost-benefit analysis should be preferred.

222. See World Bank (2005b) and Rosewell and Venables (2012).

223. World Bank (2009).

224. Department for Transport (2005) and NZ Transport Agency (2013), pp. 405-418.

225. Garnaut Climate Change Review (2008), p.456.

226. See Liu (2000).

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Appendix A: Northern Australia Statistical Area Level 2 regions

SA2 ID	SA2 Name
Queensland	
306011138	Brinsmead
306011139	Clifton Beach – Kewarra Beach
306011140	Freshwater – Stratford
306011141	Redlynch
306011142	Trinity Beach – Smithfield
306011143	Yorkeys Knob – Machans Beach
306021144	Bentley Park
306021145	Cairns City
306021146	Earlville – Bayview Heights
306021147	Edmonton
306021148	Gordonvale – Trinity
306021149	Kanimbla – Mooroobool
306021150	Lamb Range
306021151	Manoora
306021152	Manunda
306021153	Mount Sheridan
306021154	Westcourt – Bungalow
306021155	White Rock
306021156	Whitfield – Edge Hill
306021157	Woree
306031158	Babinda
306031159	Innisfail
306031160	Johnstone
306031161	Tully
306031162	Wooroonooran
306031163	Yarrabah
306041164	Daintree
306041165	Port Douglas
306051166	Atherton
306051167	Herberton
306051168	Kuranda
306051169	Malanda – Yungaburra
306051170	Mareeba
308011190	Central Highlands – East
308011191	Central Highlands – West
308011192	Emerald
308021196	Boyne Island – Tannum Sands
308021197	Callemondah
308021198	Clinton – New Auckland
308021199	Gladstone
308021200	Gladstone Hinterland
308021201	Kin Kora – Sun Valley
308021202	South Trees
308021203	Telina – Toolooa

SA2 ID	SA2 Name
308021204	West Gladstone
308031205	Berserker
308031206	Bouldercombe
308031207	Emu Park
308031208	Frenchville – Mount Archer
308031209	Glenlee – Rockyview
308031210	Gracemere
308031211	Lakes Creek
308031212	Mount Morgan
308031213	Norman Gardens
308031214	Park Avenue
308031215	Parkhurst – Kawana
308031216	Rockhampton – West
308031217	Rockhampton City
308031218	Rockhampton Region – East
308031219	Rockhampton Region – North
308031220	Rockhampton Region – West
308031221	Shoalwater Bay
308031222	The Range – Allenstown
308031223	Yeppoon
312011337	Bowen
312011338	Broadsound – Nebo
312011339	Clermont
312011340	Collinsville
312011341	Moranbah
312021342	Andergrove – Beaconsfield
312021343	East Mackay
312021344	Eimeo – Rural View
312021345	Eungella Hinterland
312021346	Mackay
312021347	Mackay Harbour
312021348	Mount Pleasant – Glenella
312021349	North Mackay
312021350	Ooralea – Bakers Creek
312021351	Pioneer Valley
312021352	Sarina
312021353	Seaforth – Calen
312021354	Shoal Point – Bucasia
312021355	Slade Point
312021356	South Mackay
312021357	Walkerston – Eton
312021358	West Mackay
312031359	Airlie – Whitsundays
312031360	Cape Conway
312031361	Proserpine

SA2 ID	SA2 Name
315011395	Aurukun
315011396	Cape York
315011397	Croydon – Etheridge
315011398	Kowanyama – Pormpuraaw
315011399	Northern Peninsula
315011400	Tablelands
315011401	Torres
315011402	Torres Strait Islands
315011403	Weipa
315021404	Carpentaria
315021405	Mount Isa
315021406	Mount Isa Region
315021407	Northern Highlands
315031408	Barcaldine – Blackall
315031410	Far Central West
315031412	Longreach
318011460	Ayr
318011461	Burdekin
318011462	Charters Towers
318011463	Dalrymple
318011464	Ingham
318011465	Ingham Region
318011466	Palm Island
318021467	Aitkenvale
318021468	Annandale
318021469	Belgian Gardens – Pallarenda
318021470	Bohle Plains
318021471	Condon – Rasmussen
318021472	Cranbrook
318021473	Deeragun
318021474	Douglas
318021475	Garbutt – West End
318021476	Gulliver – Currajong – Vincent
318021477	Heatley
318021478	Hermit Park – Rosslea
318021479	Hyde Park – Pimlico
318021480	Kelso
318021481	Kirwan – East
318021482	Kirwan – West
318021483	Magnetic Island
318021484	Mount Louisa
318021485	Mundingburra
318021486	Northern Beaches
318021487	Oonoonba
318021488	South Townsville – Railway Estate
318021489	Townsville – South
318021490	Townsville City – North Ward

SA2 ID	SA2 Name
318021491	Wulguru – Roseneath
318021491	Wulguru – Roseneath
Northern Territory	
701011001	Darwin Airport
701011002	Darwin City
701011003	East Point
701011004	Fannie Bay – The Gardens
701011005	Larrakeyah
701011006	Ludmilla – The Narrows
701011007	Parap
701011008	Stuart Park
701011009	Woolner – Bayview – Winnellie
701021010	Alawa
701021011	Anula
701021012	Berrimah
701021013	Brinkin – Nakara
701021014	Buffalo Creek
701021015	Charles Darwin
701021016	Coconut Grove
701021017	East Arm
701021018	Jingili
701021019	Karama
701021020	Leanyer
701021021	Lyons (NT)
701021022	Malak – Marrara
701021023	Millner
701021024	Moil
701021025	Nightcliff
701021026	Rapid Creek
701021027	Tiwi
701021028	Wagaman
701021029	Wanguri
701021030	Wulagi
701031031	Howard Springs
701031032	Humpty Doo
701031033	Koolpinyah
701031034	Virginia
701031035	Weddell
701041036	Bakewell
701041037	Driver
701041038	Durack – Marlow Lagoon
701041039	Gray
701041040	Moulden
701041041	Palmerston – North
701041042	Palmerston – South
701041043	Rosebery – Bellamack
701041044	Woodroffe

SA2 ID	SA2 Name
702011045	Charles
702011046	East Side
702011047	Flynn (NT)
702011048	Larapinta
702011049	Mount Johns
702011050	Petermann – Simpson
702011051	Ross
702011052	Sandover – Plenty
702011053	Tanami
702011054	Yuendumu – Anmatjere
702021055	Barkly
702021056	Tennant Creek
702031057	Alligator
702031058	Daly
702031059	Thamarrurr
702031060	Tiwi Islands
702031061	West Arnhem
702041062	Anindilyakwa
702041063	East Arnhem
702041064	Nhulunbuy
702051065	Elsey
702051066	Gulf
702051067	Katherine
702051068	Victoria River
Western Australia	
508041205	Broome
508041206	Derby – West Kimberley
508041207	Halls Creek
508041208	Kununurra
508041209	Roebuck
508061218	Ashburton (WA)
508061219	East Pilbara
508061220	Karratha
508061221	Newman
508061222	Port Hedland
508061223	Roebourne
508061224	South Hedland

Appendix B: Infrastructure configuration, capacity and usage

B.1. Airports

Table B.1: Airport configuration, capacity and demand information

Airport	Operator	No of runways	Main runway length (m)	Main runway width (m)	Terminal size (sqm)	RPT passengers FY13 (000s) (1)	RPT aircraft movements FY13 (000s) (1)	All movements FY13 (000s)	10 year passenger CAGR to FY11
Alice Springs	Alice Springs Airport Pty Ltd	2	2,438	45	9,100	595.8	6.6	23.4	–1.1%
Alpha	Barcaldine Regional Council	1	1,456	30					
Ayers Rock	Voyages Indigenous Tourism Australia Pty Ltd	1	2,599	30		257.2	3.1		–3.4%
Barcaldine	Barcaldine Regional Council	2	1,702	30					
Blackall	Blackall – Tambo Regional Council	2	1,688	30					
Blackwater	BM Alliance Coal Operations	1	1,163	30		0	0		
Broome	Broome International Airport	1	2,458	45	3,120	410.1	5.7	32.4	5.7%
Cairns	Cairns Airport Pty Ltd	1	3,196	45		4156.2	44.9	97.3	2.9%
Clermont	Isaac Regional Council	2	1,311	30					
Cloncurry	Cloncurry Shire Council	2	2,000	30		7.5	0.8		4.5%
Coen	Cook Shire Council	1	1,209	30					
Cooktown	Cook Shire Council	1	1,627	30		8.7	1.3		–5.2%
Darwin	Darwin International Airport Pty Ltd	2	3,354	60	16,000 (2)	1925.0	26.3	90.9	4.5%
Derby–Curtin	Department of Defence and Shire of Derby/ West Kimberley	3	3,049	45		42.0	1.0		20.3%
Elcho Island	Marthakal Yolngu Airline	1	1,440	30		7.4	0.6		–5.0%
Emerald	Central Highlands Regional Council	2	1,900	30		295.9	6.5		15.7%
Fitzroy Crossing	Shire of Derby/ West Kimberley	1	1,300	30					
Gladstone	Gladstone Airport Corporation	1	1,945	45		457.6	9.8		9.0%
Gove	Nhulunbuy Corporation Ltd	1	2,208	45		105.1	2.7		–4.3%
Groote Eylandt	Groote Eylandt Mining Co.	1	1,901	30		34.7	2.7		7.2%
Halls Creek	Aerodrome Management Services	2	14,775	30					
Hamilton Island	Great Barrier Reef Airport Pty Ltd	1	1,764	45		446.7	3.7	11.1	3.8%
Horn Island	Torres Shire Council	2	1,389	30					
Hughenden	Flinders Shire Council	2	1,644	30					
Julia Creek	McKinlay Shire Council	1	1,402	30					

Airport	Operator	No of runways	Main runway length (m)	Main runway width (m)	Terminal size (sqm)	RPT passengers FY13 (000s) (1)	RPT aircraft movements FY13 (000s) (1)	All movements FY13 (000s)	10 year passenger CAGR to FY11
Karratha	Shire of Roebourne	1	2,280	45	4,700	815.9	8.7	33.0	14.8%
Kununurra	Shire of Wyndham East–Kimberley	1	1,829	30		92.0	2.4		3.7%
Learmonth	Department of Defence (Air Force Headquarters) and Shire of Exmouth	1	3,047	45		90.9	1.9		13.3%
Lockhart River	Lockhart River Aerodrome Company Pty Ltd	1	1,500	30		0	0		
Longreach	Longreach Airport Pty Ltd	1	1,936	30		30.0	1.3		5.9%
Mackay	Mackay Airport Pty Ltd	2	1,981	45		1,115.9	14.9	42.1	14.0%
Milingimbi	Milingimbi Community Inc.	1	1,410	30 (18 sealed)					
Moranbah	BM Alliance Coal Operations	1	1,524	30		149.5	4.1		11.8% (5 year CAGR)
Mount Isa	Mount Isa Airport Pty Ltd	1	2,560	45		263.7	6.2		4.9%
Mungalalu–Truscott	Mungalalu Truscott Airbase Pty Ltd	1	1,800	30		0	0		
Newman	Shire of East Pilbara	1	2,072	30		439.8	4.7		19.3%
Onslow	Shire of Ashburton	1	1,900	30		0	0		
Paraburdoo	Pilbara Iron	1	2,132	45		266.1	3.5		18.2%
Port Hedland	Port Hedland International Airport	2	2,500	45	2,800	512.6	6.0		16.0%
Port Keats	Victoria Daly Shire Council	1	1,410	23					
Proserpine	Whitsunday Regional Council	1	2,073	45		235.1	1.9		10.5%
Ramingining	Ramingining Community Council Inc.	1	1,380	18					
Richmond	Richmond Shire Council	1	1,524	30					
Rockhampton	Rockhampton Regional Council	2	2,568	45		711.1	14.1	37.2	9.6%
Tennant Creek	Tennant Creek Airport Pty Ltd	2	1,959	30		0	0		
Tindal	RAAF	1	2,744	45		0	0		
Townsville	RAAF and Townsville Airport Pty Ltd	2	2,438	45	13,000	1,569.7	27.5	71.1	8.3%
Weipa	Rio Tinto Alcan	1	1,645	30		68.1	1.7		7.2%

Notes: BITRE advises that passengers and RPT aircraft movements at the airports where no data are shown total approximately 90,000 and 27,000 respectively. Commercial confidentiality considerations preclude individual airport reporting. The new Darwin terminal size is 27,000 sq. m.

Source: Air Services Australia, BITRE (2013), airport master plans, audit consultation and GHD analysis.

B.2. Ports

Table B.2: Key port specialisation features and constraints

Name	Operator	Type of berth	Number of berths	Handling Equipment	Averate transfer rate (tph)(2)	Channel depth (m LAT)
Abbot Point	North Queensland Bulk Ports Corporation	Dry bulk	2	2 dry bulk ship loaders	5,900	17.0
Barrow Island	Chevron Australia Pty Ltd	Liquid bulk Barge/RoRo	1 18	1 submarine pipeline Ships gear/mobile equipment	2,200 m3/hr	12
Bing Bong	McArthur River Mining	Dry bulk	1	1 dry bulk ship loader	1050	3.5
Broome	Broome Port Authority	Non–specialised	12	Ships gear/mobile equipment	–	13
Cairns	Ports North	Dry bulk Liquid bulk Passenger Non–specialised (3)Barge/RoRo	1 2 6 6 2	1 dry bulk ship loader 3 bulk liquid pipelines – Ships gear/mobile equipment Ships gear/mobile equipment	1,600 N/A – – –	8.3
Cape Flattery	Ports North	Dry bulk	1	1 dry bulk ship loader	2,000	14.1
Cape Preston	CITIC Pacific Ltd	Dry bulk		Not available	N/A	N/A
Cooktown	Ports North	Passenger	1	Not available	N/A	4
Dampier	Dampier Port Authority	Dry bulk Liquid bulk Non–Specialised (3) Barge/RoRo	6 6 7 3	6 dry bulk ship loaders 6 bulk liquid berths Ships gear/mobile equipment Ships gear/mobile equipment	6,750 N/A –	12.2
Darwin	Darwin Port Corporation	Dry Bulk Liquid Bulk Passenger Non–Specialised	1 1 4 5	1 dry bulk ship loader 1 bulk liquid pipeline – Ships gear/mobile equipment	2,000 N/A	14
Gladstone	Gladstone Ports Corporation Limited	Dry Bulk Liquid Bulk Non–Specialised	10 1 4	11 dry bulk ship loaders 4 ship unloaders 4 bulk liquid pipelines 1 bulk liquid unloading pipeline Ships gear/mobile equipment	6,000 400 –	16.3
Gove	Rio Tinto Alcan Gove Pty Ltd	Dry Bulk Liquid Bulk Non–Specialised	1 1 2	1 dry bulk ship loader 2 bulk liquid pipelines Ships gear/mobile equipment	N/A	14
Hay Point	North Queensland Bulk Ports Corporation Limited	Dry Bulk	6	5 dry bulk ship loaders	7,200	14.9
Karumba	Ports North	Dry Bulk Non–Specialised	1 8	1 dry bulk ship loader Ships gear/mobile equipment	2,000	3.7

Name	Operator	Type of berth	Number of berths	Handling Equipment	Averate transfer rate (tph)(2)	Channel depth (m LAT)
Lucinda	Port of Townsville Limited	Dry Bulk	1	1 dry bulk ship loader	1,800	13.2
Mackay	North Queensland Bulk Ports Corporation Limited	Dry Bulk Liquid Bulk Non–Specialised	2 1 1	3 dry bulk ship loaders 5 bulk liquid pipelines Ships gear/mobile equipment	1,200 400	8.6
Milner Bay	Groote Eylandt Mining Company	Dry Bulk	1	1 dry bulk ship loader	460	24.4
Mourilyan	Ports North	Non–Specialised	1	1 dry bulk ship loader 1 bulk liquid pipeline	2,300	9.6
Onslow, Thevenard Island, Airlie Island	Onslow: Onslow Salt Pty Ltd Airlie Island: Apache Energy Thevenard Island: Chevron	Dry Bulk Liquid Bulk	1 2	1 dry bulk ship loader 2 bulk liquid/submarine pipelines	1,500	10.8 (Onslow) 15.6 (Thevenard)
Port Hedland	Port Hedland Port Authority	Dry Bulk Non–Specialised	12 4	15 dry bulk ship loaders 3 liquid bulk pipelines Ships gear/mobile equipment	10,200	14.8
Port Melville	Ezion Offshore Logistics Hub (Tiwi) Pty Ltd	Dry Bulk		Not available	N/A	N/A
Port Walcott (incl. Cape Lambert)	Robe River Mining	Dry Bulk	6	2 dry bulk ship loaders Ship gear/mobile equipment	11,000	14
Quintell Beach	Ports North	Barge	1	Ship gear/mobile equipment	–	–
Rockhampton	Gladstone Ports Corporation Limited	Liquid Bulk Non–Specialised	1 2	1 bulk liquid pipeline Ship gear/mobile equipment		7.9
Skardon River	Ports North	Dry Bulk	1	Ship gear/mobile equipment	Not Available	4
Thursday Island	Ports North	Non–Specialised Passenger Fuel	1 1 1	Ship gear/mobile equipment – 1 fuel pipeline	Not Available	3.1 4.3 3
Townsville	Port of Townsville Limited	Dry Bulk Bulk Liquids Non–Specialised	4 1 4	4 dry bulk ship loaders 2 gantry cranes 5 bulk liquid pipelines Ship gear/mobile equipment	1,900 400	11.7
Weipa	North Queensland Bulk Ports Corporation Limited	Dry Bulk Bulk Liquids Non–Specialised	2 1 1	2 dry bulk ship loaders 1 bulk liquid pipeline Ship gear/mobile equipment	6,400	11.5
Wyndham	Cambridge Gulf Ltd	Dry Bulk Non–Specialised	1 1	1 dry bulk ship loader Ships gear/mobile equipment	625	7.9

Notes: (1) The number of berths for a port is based on the information published by the operator. The length of each defined berth is variable depending on the primary purpose of the berth. As such, certain ship types will occupy multiple berths on a continuous berth face.
(2) The average transfer rate is the weighted average maximum/design transfer rate. The achievable transfer rate for loaders is influenced by the nature of the commodity being loaded or unloaded, and the capability of the individual ships servicing the market. Furthermore, the loading sequence of vessels, prevailing weather conditions, cargo availability and channel depth will influence the achievable load rate and loader/berth availability.
(3) A number of non–specialised berths have liquid bulk pipelines installed.

Source: Various port handbooks, industry sources and publicly available information. N/A indicates not available from these sources.

Table B.3: Port demand growth and infrastructure drivers

Name	TEU container volume FY13	Cruise visit days FY13	Total throughput (million tonnes)		Key infrastructure developments/triggers (potential and planned by project/region and commodity group)
			FY13	10 year CAGR to FY13	
Abbot Point	0	0	17.7	3.3%	Bowen and Galilee basins development (coal)
Barrow Island	0	0	N/A	N/A	North–West shelf developments (oil/gas) The Gorgon Project (LNG)
Bing Bong	0	0	0.4 (dry)	N/A	McArthur River Mine (lead/silver/zinc) Roper Bar mine (iron ore) Tennant Creek development (phosphate)
Broome	4,439	11	0.3	4.5%	Browse and Canning Basin development (LNG) Population and tourism growth in the region
Cairns	15,761	43	1.1	–1.3%	Population and tourism growth in the region (container imports and cruise ships)
Cape Flattery	0	0	1.7	0.1%	Cape Flattery mine (silica sand)
Cooktown	0	2	Not Available	Not Available	Population and tourism growth in the region (cruise ships)
Dampier	0	0	180.4	6.9%	Pilbara region developments (iron ore) Browse and Canning Basin development (LNG)
Darwin	8,882 (FY12)	41	4.3%	15%	Agricultural expansion around East Kimberley Tennant Creek development (phosphate) Cattle export (livestock) McArthur River Mine (lead/silver/zinc) Roper Bar mine (iron ore) Alice Springs area development (oil, gas, rare earth metals) Population and tourism growth in the region (container imports and cruise ships)
Gladstone	6,194	0	85.3	4.6%	Bowen, Galilee and Surat basin developments (coal) LNG developments in the area
Gove	0	0	Not available	Not available	Rio Tinto's Gove mining operations (bauxite)
Hay Point	0	0	96.5	2.6%	Bowen Basin development (coal)

Name	TEU container volume FY13	Cruise visit days FY13	Total throughput (million tonnes) FY13	Total throughput (million tonnes) 10 year CAGR to FY13	Key infrastructure developments/triggers (potential and planned by project/region and commodity group)
Karumba	0	0	0.9	–0.9%	Tennant Creek development (phosphate) Cloncurry area developments (copper, gold, lead, magnetite, zinc)
Lucinda	0	0	0.4	–3.0%	Agricultural expansion around the Burdekin, Flinders and Gilbert rivers
Mackay	0	38	3.3	5.1%	Bowen and Galilee basins development (coal) Agricultural expansion around the Burdekin, Flinders and Gilbert rivers Tourism growth in the Mackay/Whitsunday region
Milner Bay	0	0	N/A	N/A	GEMCO mining developments (manganese)
Mourilyan	0	0	0.5	–3.8%	Agricultural expansion around the Burdekin, Flinders and Gilbert rivers
Port Hedland	1,492	4	288.4	13.4%	Browse and Canning Basin development (LNG) Pilbara region developments (iron ore)
Port Melville	–	–	N/A	N/A	Forestry industry development on the Tiwi Islands Oil, gas and mineral sands industry in the region Potential development of an agricultural precinct on the Islands
Port Walcott	0	0	89.0	N/A	Pilbara region developments (iron ore)
Quintell Beach	0	0	0.001	0.04%	Community port servicing a growing population
Rockhampton	1,568	0	0.3	8.5%	Bowen Basin developments (coal)
Thursday Island	0	5	0.07	0.2%	Population growth in the area and tourism
Townsville	50,173	4	12.1	2.1%	Bowen and Galilee basins development (coal) Cloncurry area developments (copper, gold, lead, magnetite, zinc) Tennant Creek development (phosphate) Population growth in the area (container imports)
Weipa	0	0	29.0	8.2%	Developmental role for the South of Embley project (bauxite)
Wyndham	0	0	1.9	N/A	Agricultural expansion around East Kimberley/Ord (agriculture)

Source: Ports Australia and GHD analysis. N/A indicates not available from these sources.

B.3. Rail

Table B.4: Rail network configuration, capacity and usage

Rail line/network	Manager	Section	Traffic	Length (km)	Gauge	Single or duplicated	Axle loading (tonnes)	Allowable train length (m)	Current trains per day	Tonnes FY13
Blackwater System	Aurizon	Gregory, Rolleston, Minerva – Gladstone	coal	1,108	Narrow	Mostly duplicated (7 sections still pending)	26.5	1,727	72	50
Central West System	Queensland Rail	Emerald – Winton	grain, livestock, containerised freight, passengers	596	Narrow	Single with crossing/passing loops	15.75	N/A	N/A	N/A
Central West System	Queensland Rail	Emerald – Clermont	grain, livestock, containerised freight, passengers	123	Narrow	Single with crossing/passing loops	15.75	N/A	N/A	N/A
Tablelands System	Queensland Rail	Kuranda Scenic Railway (Cairns–Kuranda)	Tourist and Travel Passengers	34	Narrow	Single with crossing/passing loops	15.75	N/A	N/A	N/A
	Queensland Rail	Gulflander (Croydon–Normanton)	Tourist and Travel Passengers	153	Narrow	Single	8.8	N/A	1	N/A
	Queensland Rail	Savannahlander (Cairns–Forsayth)	Tourist and Travel Passengers	229	Narrow	Single	5 Railmotors	N/A	1	N/A
Fortescue Railway	Fortescue Metals Group	Chichester – Port Hedland, Solomon – Port Hedland	iron ore	620	Standard	Combination of single and duplicated track (main line is duplicated)	40	2,700	11–13	155
Goldsworthy Railway	BHP Billiton	Yarrie and Finucane Sections	iron ore	208	Standard	Single	32 (Yarrie) 40 (Finucane)	N/A	4	N/A
Goonyella System	Aurizon	Gregory, North Goonyella, Blair Athol – Hay Point	coal	978	Narrow	Majority Duplicated	26.5	2,082	96	68
Mount Isa Line	Queensland Rail	Stuart – Mount Isa (& Flynn – Phosphate Hill)	fertiliser, acid, fuel, refined metals and concentrates, livestock, passengers	1,032	Narrow	Single with passing/balloon loops	20	1,000	N/A	N/A
Mount Newman Railway	BHP Billiton	Newman – Port Hedland	iron ore	426	Standard	Combination of single and duplicated track (main line is duplicated)	37	3,750	14–16	N/A

Rail line/network	Manager	Section	Traffic	Length (km)	Gauge	Single or duplicated	Axle loading (tonnes)	Allowable train length (m)	Current trains per day	Tonnes FY13
Newlands System	Aurizon	Newlands – Abbot Point	coal	320 (includes Goonyella Connection)	Narrow	Single with passing loops (some duplication)	26.5	1,402	40	17
North Coast Line	Queensland Rail	Nambour – Cairns	containerised and industrial freight, minerals, sugar grain, passengers	425 (South) 1,041 (North)	Narrow	Single with around 130 passing loops	20	650	N/A	N/A
Pilbara Rail (former Hamersley and Robe River railways	Rio Tinto	Pilbara Mines – Dampier Pilbara Mines – Cape Lambert	iron ore	1,500	Standard	Combination of single and duplicated track	37.5	2,400	N/A	N/A
Tarcoola to Darwin Railway	Genesee & Wyoming	Tarcoola – Darwin	intermodal, ores, grain, gypsum, passenger	2,244	Standard	Single with 16 passing loops	23	1,800	18 (per week)	N/A

Source: Aurizon (2013) and Information Packs, BITRE (2012), Fortescue Metals Group and Genesee and Wyoming web sites, Queensland Rail Information Packs and web site. N/A indicates not available from these sources.

B.4. Roads

Table B.5: Roads in scope – Queensland

Road name	Length (km) (1)	Unsealed (km)	Number of closures (2010 – 2014)	Weighted Average closure duration (hrs)	Total number of crashes resulting in casualties (2007 – 2014)	Annual average daily traffic (2012) (2)	Heavy vehicle use proportion (2012) (2)	Extended design domain standard proportion	Heavy vehicle use combination
Barkly Highway	323	0	3	19	45	1,727	22%	72%	Up to Type 2 RT
Bruce Highway (2)	1,142	0	114	24	248	11,502	14%	64%	Up to 25m B–Double
Burke Developmental Road	409	0	59	594	12	193	18%	81%	Up to Type 2 RT
Capricorn Highway	574	0	71	46	56	4,223	18%	41%	Type 1 RT and 2RT
Captain Cook Highway	75	0	14	20	570	14,813	6%	37%	Up to 23m B–Double
Dysart – Middlemount Road	68	0	5	7	16	1,945	16%	15%	Up to Type 1 RT
East Evelyn Road	11	0	0	0	12	590	23%	37%	Up to 25m B–Double
El Arish – Mission Beach Road	19	0	2	18	21	2,805	8%	0%	Up to 25m B–Double
Fitzroy Developmental Road	235	55	36	45	54	1,095	22%	60%	Up to Type 1 RT
Flinders Highway	774	0	44	25	37	1,780	22%	65%	Up to Type 2 RT
Gladstone – Mount Larcom Road	32	0	1	19	60	7,453	24%	34%	Up to 25m B–Double
Gregory Developmental Road	610	115	37	49	32	870	25%	36%	Up to Type 2 RT
Gregory Highway	120	0	10	32	33	1,983	21%	24%	Type 1 RT and 2 RT
Gulf Developmental Road	444	0	38	168	18	199	22%	61%	Up to Type 2 RT
Halifax – Lucinda Point Road	9	0	0	0	2	1,015	6%	0%	No B–Double or RTs
Hay Point Road	14	0	1	3	21	4,397	7%	7%	No B–Double or RTs
Ingham– Halifax–Bermerside Road	10	0	23	59	9	1,060	11%	6%	Up to 25m B–Double
Karumba Developmental Road	41	0	12	269	5	511	17%	100%	Up to Type 2 RT
Kennedy Developmental Road (4)	920	143	2	17	7	170	35%	79%	Up to Type 2 RT

Road name	Length (km) (1)	Unsealed (km)	Number of closures (2010 – 2014)	Weighted Average closure duration (hrs)	Total number of crashes resulting in casualties (2007 – 2014)	Annual average daily traffic (2012) (2)	Heavy vehicle use proportion (2012) (2)	Extended design domain standard proportion	Heavy vehicle use combination
Kennedy Highway	243	0	2	18	90	4,010	14%	52%	Type 2 RT and 25m– B–Double
Landsborough Highway	619	0	49	21	19	522	30%	61%	Up to Type 2 RT
Mackay – Slade Point Road	12	0	4	28	134	14,113	6%	68%	No B–Double or RTs
Millaa Milla – Malanda Road	4	0	0	0	8	2,606	14%	8%	Up to 25m B–Double
Mourilyan Harbour Road	9	0	0	0	4	2,360	8%	32%	No B–Double or RTs
Mulligan Highway	183	0	8	32	32	1,420	21%	28%	Up to Type 1 RT
Palmerstone Highway	55	0	0	0	25	1,750	14%	30%	Up to 25m B–Double
Peak Downs Highway	266	0	37	13	66	6,212	14%	42%	Up to Type 1 RT
Peninsula Developmental Road	527	377	19	1011	25	139	26%	96%	Type 1 RT and 2 RT
Proserpine – Shute Harbour Road	33	0	6	13	111	6,687	7%	90%	No B–Double or RTs
Rockhampton – Yeppoon Road	33	0	1	28	250	11,000	7%	89%	Up to 25m B–Double
Townsville Port Access Road	7	0	0	0	2	5,000	30%	100%	Up to Type 2 RT
Tully Mission Beach Road	23	0	5	17	15	2,931	9%	13%	Up to 25m B–Double

Notes:

1. *Road length is based on road section information provided to the audit.*
2. *Annual average daily traffic is calculated as a simple average of section data provided to the audit. The number of vehicles per day may substantially deviate from the mean depending on the road in analysis (e.g. Bruce Highway highest traffic volumes are around 50,000 vehicles per day in Rockhampton, Mackay, Townsville and Cairns regions, while lowest traffic volumes are around 3,000 vehicles per day (St Lawrence, Proserpine, Bowen and Ingham regions).*
3. *Queensland Transport and Main Roads has noted that closure data reflect reported closures and are not an exhaustive or fully accurate record of road closures on the network. Where a road is not accessible by maintenance inspectors, because access roads are impassable, the road is not necessarily listed as being closed.*
4. *Although length displayed is 920km, the table information is based only on 95km between Mount Garnet and The Lynd section of Kennedy Developmental Road. The 143km unsealed section is between The Lynd and Hughenden, also known as the Hann Highway.*

Source: Queensland Transport and Main Roads data and GHD analysis.

Table B.6: Northern Territory road configuration, performance and usage information

Road name	Length (km) (1)	Unsealed (km)	Number of lanes	Restriction or closure (2012) (2)	Closure or restriction events of 7 days or longer (2012) (2)	Months in which restriction or closure occured (2012) (2)	Annual average daily traffic (2012)	Heavy vehicle use proportion (2012)	8 year CAGR (2004–2012)
Arnhem Highway	223	0	Two	Restriction	No	Mar	4,109	22%	3.9%
Barkly Highway	434	0	Two	Restriction	Yes	Dec	245	38%	1.5%
Berrimah Road	9	0	Two	None	No	None	7,868	20%	6.5%
Buntine Highway	483	147	Two, one	Restriction and closure	Yes	Jan – Jul	51	30%	4.6%
Carpentaria Highway (4)	270	0	Two (narrow)	Restriction and closure	Yes	Feb – Apr, Sep – Dec	80	27%	1.8%
Central Arnhem Road	632	583	Single dirt	Restriction	Yes	Feb – Apr, Sep – Dec	149	15%	1.9%
Gimbat Road (3)	14	14	–	Restriction and closure	Yes	Jan – May	73	No Data	3.1%
Henry Wrigley Drive (3) (5)	1	0	Two	None	No	None	10,115	No Data	6.5%
Kakadu Highway	207	0	Two	None	No	Jan	348	14%	–0.3%
Larapinta Drive	321	196	–	Restriction and closure	Yes	Mar	4,883	6%	0.6%
Lasseter Highway	244	0	Two	None	No	None	343	27%	–1.2%
Luritja Road	161	0	–	Restriction and closure	Yes	Mar	179	28%	–1.5%
Maningrida – Ramingining (3)	160	–	Dirt	Restriction	Yes	Jan – Jul	23	No Data	4.6%
Mcmillans Road (5)	14	0	–	–	–	–	14,400	No Data	–1.9%
Namatjira Drive	157	52	–	Restriction and closure	Yes	Mar	74	9%	0.6%
Plenty Highway	296	402	Single, dirt	Restriction and closure	Yes	Mar–May	109	15%	0.5%
Port Keats Road	184	182	–	Restriction and closure	Yes	Jan – May, Nov – Dec	49	72%	0.3%
Roper Highway (3)	206	72	Two, single (narrow)	None	No	None	66	19%	3.3%
Stuart Highway	1,786	0	Two	Restriction	Yes	Jan – Apr, Dec	6,582	25%	2.0%

Road name	Length (km) (1)	Unsealed (km)	Number of lanes	Restriction or closure (2012) (2)	Closure or restriction events of 7 days or longer (2012) (2)	Months in which restriction or closure occured (2012) (2)	Annual average daily traffic (2012)	Heavy vehicle use proportion (2012)	8 year CAGR (2004–2012)
Tablelands Highway	377	0	Two, single (narrow)	Restriction and closure	Yes	Jan – Dec	51	37%	2.2%
Tanami Road	703	522	Two, single	Restriction and closure	Yes	Jan, Apr	72	47%	3.0%
Tiger Brennan Drive (5)	12	0	–	None	No	None	13,348	No Data	1.0%
Tjukaruru Road	189	189	Dirt	Restriction and closure	Yes	Feb – Mar, May–Jun	23	13%	1.1%
Vanderlin Drive (5)	8	0	–	–	–	–	18,437	No Data	1.2%
Victoria Highway	469	0	–	None	No	None	1,548	22%	1.2%

Note

(1) *Road length is based on road section information provided to the audit.*

(2) *Restrictions and closures occurring due to traffic incidents or road works have not been included in the analysis.*

(3) *2011 data for Gimbat Road, Henry Wrigley Drive, Maningrida Access, Roper Highway AADT.*

(4) *2010 data for Carpentaria Highway AADT.*

(5) *Heavy vehicle use is not available for urban roads.*

Source: Territory Asset Management Services (2012), Northern Territory Department of Transport data and GHD analysis.

Table B.7: Roads in scope – Western Australia

Road name	Length in scope (km)	Unsealed (km)	Number of closures (2003–2012)	Average length of closures (hrs) (2012)	Annual average daily traffic (2012)	Heavy vehicle use proportion (2012)	9 year CAGR (2003–2012)
Broome Highway	41	0	1	0	2,796	16%	4.1%
Burrup Peninsula (1)	9	0	1	0	4,166	23%	8.9%
Cable Beach Road East	0	0	0	0	N/A	N/A	N/A
Cable Beach Road West	0	0	0	0	N/A	N/A	N/A
Dampier Road	26	0	2	0	5,121	14%	11.7%
Derby Highway	43	0	0	0	2,838	14%	7.3%
Former Great Northern Highway (2)	1	0	0	0	5,365	9%	5.1%
Gibb River Road	647	502	185	0	110	21%	–7.7%
Great Northern Highway	2,451	0	60	15	1,557	36%	–0.4%
Jigal Drive	0	0	0	0	N/A	N/A	N/A
Karijini Drive	109	0	0	0	473	39%	15.5%
Karratha Tom Price Road	114	0	6	0	3,487	33%	12.7%
Madigan Road	6	0	1	0	2,186	40%	20.3%
Marble Bar Road	433	169	103	0	566	53%	5.9%
Nanutarra Munjina Road	417	172	46	22	177	33%	15.6%
North West Coastal Highway	813	0	50	34	1,283	34%	7.4%
Onslow Road	79	0	9	0	553	48%	18.4%
Pannawonica Road	46	0	8	0	228	29%	5.4%
Paraburdoo Tom Price Road	131	0	6	0	470	22%	5.3%
Point Samson Roebourne Road	18	0	2	0	2,837	22%	8.8%
Port Hedland Road	10	0	0	0	9,349	16%	3.8%
Ripon Hills Road (1)	131	0	23	0	213	71%	12.9%
Victoria Highway	88	0	0	0	1,552	15%	0.6%

Notes:
(1) 2003 to 2010 data AADT
(2) 2007 to 2010 data AADT

Source: Government of Western Australia, Main Roads Western Australia, IRIS data and GHD analysis. N/A indicates data not available.

Table B.8: Projected road demand 2012 – 2032 Queensland

Road name	2012	2022	2032	Projected 20 year CAGR
Barkly Highway	1,727	1,953	2,180	1.2%
Bruce Highway	11,502	14,219	16,936	2.0%
Burke Developmental Road	193	251	310	2.4%
Capricorn Highway	4,223	6,679	9,136	3.9%
Captain Cook Highway	14,813	16,102	17,390	0.8%
Dysart – Middlemount Road	1,945	2,754	3,564	3.1%
East Evelyn Road	590	620	649	0.5%
El Arish – Mission Beach Road	2,805	2,946	3,086	0.5%
Fitzroy Developmental Road	1,095	1,642	2,190	3.5%
Flinders Highway	1,780	2,102	2,424	1.6%
Gladstone – Mount Larcom Road	7,453	11,179	14,905	3.5%
Gregory Developmental Road	870	1,048	1,225	1.7%
Gregory Highway	1,858	2,525	3,192	2.7%
Gulf Developmental Road	199	239	279	1.7%
Halifax – Lucinda Point Road	1,015	1,045	1,076	0.3%
Hay Point Road	4,397	5,662	6,927	2.3%
Ingham – Halifax – Bermerside Road	1,060	1,272	1,484	1.7%
Karumba Developmental Road	511	562	613	0.9%
Kennedy Developmental Road	170	178	187	0.5%
Kennedy Highway	4,010	4,673	5,337	1.4%
Landsborough Highway	522	647	772	2.0%
Mackay – Slade Point Road	14,113	16,502	18,891	1.5%
Millaa Milla – Malanda Road	2,606	2,736	2,867	0.5%
Mourilyan Harbour Road	2,360	3,068	3,776	2.4%
Mulligan Highway	1,420	1,550	1,680	0.8%
Palmerstone Highway	1,750	2,030	2,310	1.4%
Peak Downs Highway	6,212	8,342	10,471	2.6%
Peninsula Developmental Road	139	240	341	4.6%
Proserpine – Shute Harbour Road	6,687	7,295	7,904	0.8%
Rockhampton – Yeppoon Road	11,000	13,310	15,620	1.8%
Townsville Port Access Road	5,000	6,000	7,000	1.7%
Tully Mission Beach Road	2,931	3,224	3,517	0.9%

Source: Department of Transport and Main Roads data and GHD analysis.

B.5. Energy

Table B.9: Capacity of electricity supply systems in FY11

Power station	Capacity FY11 (MW)	Fuel type
National Electricity Market north Queensland:		
Barcaldine Power Station	55	Natural Gas Pipeline
Barron Gorge	66	Water
Collinsville	190	Black Coal
Gladstone	1,680	Black Coal
Inkerman Mill	11	Bagasse
Invicta Mill	50	Bagasse
German Creek	45	Waste Coal Mine Gas
ISIS Central Sugar Mill Co–generation Plant	25	Bagasse
Kalamia Mill	9	Bagasse
Kareeya	86	Water
Kareeya 5	7	Water
Mackay GT	34	Diesel
Macknade Mill	8	Bagasse
Maryborough	8	Bagasse
Moranbah Generation Project	13	Waste Coal Mine Gas
Moranbah North	46	Waste Coal Mine Gas
Mount Stuart	424	Kerosene aviation fuel
Mulgrave	13	Bagasse
Oaky Creek	20	Waste Coal Mine Gas
Pioneer Sugar Mill	68	Bagasse
Plane Creek Mill	14	Bagasse
Proserpine	17	Bagasse
Racecourse Mill	48	Bagasse
South Johnstone	19	Bagasse
Stanwell	1,460	Black coal
Tableland	7	Bagasse
Victoria Mill	24	Bagasse
Windy Hill	12	Wind
Yabulu	244	Coal Seam Methane
Yarwun	154	Natural Gas Pipeline
Total National Electricity Market	***4,856***	
Mount Isa:		
Ernest Henry	32	Liquid fuel
Lady Annie copper mine	1	Liquid fuel
Mica Creek	325	Natural gas
Mount Gordon mine	2	Liquid fuel
Mount Isa – Mines Station	45	Natural gas
Mount Isa Fertilisers	10	Natural gas
Project X41, Mount Isa	39	Natural gas
Total Mount Isa	***454***	
Darwin–Katherine Integrated System:		
Channel Island	232	Dual natural gas/liquid fuel Natural gas
Weddell	86	Natural gas
Pine Creek	27	Dual natural gas/liquid fuel
Katherine	21	Dual natural gas/liquid fuel
LMS Shoal Bay	1	Landfill gas
Berimah	10	Liquid fuel
Total Darwin–Katherine Integrated System	***367***	
Alice Springs:		
Ron Goodin	60	Dual natural gas/liquid fuel/ Natural gas
Brewer	9	Dual natural gas/liquid fuel
Owen Springs	4	Dual natural gas/liquid fuel
Uterne	1	Solar
Total Alice Springs	***74***	
Tennant Creek:		
Tennant Creek	18	Dual natural gas/liquid fuel/ Natural gas/ Liquid fuel
North–West Interconnected System:		
Dampier	120	Natural gas
Cape Lambert	105	Natural gas
Port Hedland	105	Natural gas
Karratha	70	Natural gas
Total North–West Interconnected System	***400***	
Other in–scope Queensland*	44	
Other in–scope Northern Territory*	174	
Other in–scope Western Australia*	114	

**Not including southern Queensland and Western Australia or generation capacity in areas not within the scope of this study.*

Source: Australian Energy Market Operator (2012), Australian Energy Regulator (2009), Bureau of Resources and Energy Economics (2013), Utilities Commission (2012)

Table B.10: Base year and 'business as usual' forecast electricity peak demand

	Actual		Forecasts			
	FY11 MW	FY16 MW	FY21 MW	FY26 MW	FY31 MW	20 year CAGR
National Electricity Market:						
Far North zone	306	254	248	238	228	–1.5%
Ross zone	412	400	384	368	352	–0.8%
North zone	408	515	535	597	641	2.3%
Central West zone	508	519	521	497	473	–0.4%
Gladstone zone	1,172	1,226	1,236	1,240	1,241	0.3%
Sub–total	2,806	2,914	2,924	2,939	2,934	0.2%
Mount Isa	350	380	430	430	430	1.0%
Isolated communities	35	37	37	38	38	0.4%
Total Queensland	***3,191***	***3,331***	***3,391***	***3,407***	***3,402***	***0.3%***
Darwin–Katherine Integrated System	287	313	341	362	373	1.3%
Alice Springs	56	55	54	54	53	–0.3%
Tennant Creek	7	7	8	8	8	0.7%
Darwin–Katherine, Alice Springs and Tennant Creek	350	376	403	423	434	1.1%
Isolated communities	139	82	85	88	91	–2.2%
Total Northern Territory	***489***	***458***	***488***	***511***	***525***	***0.3%***
Karratha	50	86	104	126	149	5.5%
Port Hedland	65	79	75	78	81	1.1%
Sub–total	115	166	179	204	229	3.4%
Other communities	71	90	106	123	139	3.4%
Total Western Australia	***186***	***256***	***286***	***327***	***369***	***3.4%***

Source: Powerlink Queensland, Sims Review (2009), Power and Water Corporation and Horizon Power.

Table B.11: Base year and 'business as usual' forecast annual energy consumption

	Actual		Forecasts			
	FY11 GWh	**FY16 GWh**	**FY21 GWh**	**FY26 GWh**	**FY31 GWh**	**20 year CAGR %p.a.**
National Electricity Market:						
Far North zone	1,810	1,739	1,750	1,694	1,640	–0.5%
Ross zone	3,219	3,157	3,189	3,117	3,046	–0.3%
North zone	2,879	2,901	3,210	3,851	4,342	2.0%
Central West zone	3,491	3,843	3,865	3,755	3,649	0.2%
Gladstone zone	10,118	10,695	10,695	10,698	10,699	0.3%
Sub–total	21,517	22,335	22,709	23,115	23,375	0.4%
Mount Isa	2,239	2,431	2,751	2,751	2,751	1.0%
Isolated communities	230	241	244	247	250	0.4%
Total Queensland	***23,986***	***25,007***	***25,704***	***26,112***	***26,376***	***0.5%***
Darwin–Katherine, Alice Springs and Tennant Creek	1,747	1,764	1,813	1,848	1,871	0.3%
Isolated communities	914	540	557	576	595	–2.2%
Total Northern Territory	***2,661***	***2,304***	***2,370***	***2,424***	***2,466***	***–0.4%***
Karratha	218	330	408	507	610	5.1%
Port Hedland	293	321	299	293	284	–0.2%
Sub–total	511	651	707	801	894	2.8%
Other communities	282	352	411	470	530	3.2%
Total Western Australia	***793***	***1,003***	***1,118***	***1,271***	***1,424***	***2.9%***

Source: Powerlink Queensland, Sims Review (2009), Power and Water Corporation and Horizon Power.

B.6. Water

Table B.12: Key capacity and utilisation metrics for Queensland urban water sector

Water service providers (Major LGA)	Estimated LGA+ population served FY11	Number of water treatment plants•	Length of water mains (km)*	Total water sourced in FY11 (ML)	Total urban water supplied FY11 (ML)	Current water restrictions in place	Estimated historical average water use per person (kL)	Two–part tariff water charges
Townsville Water	184,030	4 (1)	2,525	35,995	31,680	Level 1	279a	Yes
Cairns Water and Waste	172,982	13 (9)	2,375	32,668	26,880	Permanent	183a	Yes
Water and Waste Services (Mackay)	107,000	15 (11)	1,164	23,642	12,553	Levels 1 & 2	226a	Yes
Fitzroy River Water (Rockhampton)	97,088	4	1,341	21,031	17,807	No	281a	Yes
Gladstone Regional Council	57,663	8	663	11,604	7,951	No	201a	Yes
Tablelands Regional Council	39,736	31 (16)	529	9,106	5,991	Level 1	320a	N/A
Whitsunday Regional Council	36,771	8 (4)	470	ND	5,030	Level 2	172b	Yes
Central Highlands Regional Council	31,960	20 (7)	416	4,682	5,321	Yes	234b	N/A
Cassowary Coast Regional Council	26,936	11 (6)	915	5,972	5,835	Level 1	219a	N/A
Isaac Regional Council	23,188+	8 (1)	245	6,043*	6,294*	Yes	334c	N/A
Mount Isa City Council	23,500	0	155	n/a	6,335	Level 3	368b	Yes
Burdekin Shire Council	13,573	8 (5)	296	3,948	3,948	No	374a	N/A
Charters Towers Regional Council	12,434+	6 (1)	216	5,412*	4,236*	No	339d	N/A
Hinchinbrook Shire Council	12,310	5 (1)	243	2,646	1,933	No	230a	N/A

*Notes: * FY13 ** FY12 # FY10 figures; + LGA population has been estimated based on Statistical Area Level 2 2011 to Local Government Area 2011 Correspondence Table 3, ABS (2012) Australian Statistical Geography Standard (ASGS): Correspondences, Cat. No. 1270.0.55.006; @ Total number of water treatment plants that provides full water treatment, further treatments and disinfection only (brackets indicates disinfection only plants); a Historical average water use between FY10 and FY13; b Historical average water use between FY11 and FY13; c Historical average water use for FY12 and FY13; d Historical average water use for FY11.*

Source: National Performance Report, local government councils' web sites, Queensland Water Directorate – Statewide Water Information Management, stakeholder inputs and GHD analysis. N/A indicates not available from these sources.

Table B.13: Key capacity and utilisation metrics for the Northern Territory and northern Western Australia urban water sector

UCL	Population served FY11	Water treatment plants / method	Length of water mains (km)	Total water sourced in FY11 (ML)	Total urban water supplied FY11 (ML)	Current water restrictions in place	Estimated historical average water use per person (kL)	Two–part tariff water charges
Darwin	118,000	Chlorine & fluoridation	1,358	39,068	32,292	No	313	Yes
Alice Springs	24,208	Chlorine	386	7,659	6,537	No	316	Yes
Katherine	9,186	Coagulation/ clarification, aeration, sand filters, chlorine and fluoridation	100	3,079	2,667	No	335	Yes
Nhulunbuy	3,933	Disinfected	N/A	N/A	N/A	N/A	N/A	Yes
Tennant Creek	3,062+	No disinfection	148	1,264	1,071	No	413	Yes
Broome	11,700	N/A	185	5,736	5,736	No	200	Yes
Derby	3,100	N/A	54	1,342	1,342	No	196	Yes
Karratha	14,700	N/A	174	5,162	5,162	No	185	Yes
Kununurra	3,800	N/A	63	1,405	1,405	No	214	Yes
Newman	5,500	N/A	53	1,832	1,832	No	201	Yes
Port Hedland [a]	13,600	N/A	232	10,342	10,342	No	204 [b]	Yes
Tom Price	3,134	N/A	N/A	Private supply	N/A	N/A	N/A	N/A

Notes:

** FY13 **FY12 #FY10; + Population in UCL estimated by PwC; a Includes South Hedland; b Average of Port Hedland (211 kL) and South Hedland (197 kL);*

Source: Power and Water Corporation, National Water Commission, Water Corporation of WA and GHD analysis. N/A indicates not available from these sources.

Table B.14: Northern Australia urban water demand projections for 2016, 2021 and 2031

Water service providers (Major LGA) / UCL	LGA/UCL population[3] served FY11	Water demand FY11 (ML)	Estimated water use per person FY11 (kL)	Estimated water demand FY16 (ML)	Estimated water demand FY21 (ML)	Estimated water demand FY31 (ML)	Estimated Population served[4] FY31	Current water restrictions in place
Townsville Water [1]	184,030	35,995	279	56,740	64,045	79,459	285,106	Level 1
Cairns Water and Waste [1]	172,982	32,668	183	32,849	36,444	43,895	240,232	Permanent
Water and Waste Services [1] (Mackay)	107,000	23,642	226	27,322	30,538	37,504	179,685	Levels 1 and 2
Fitzroy River Water [1] (Rockhampton)	97,088	21,031	281	30,581	33,503	39,887	164,444	No
Gladstone [1]	57,663	11,604	201	12,853	15,427	20,270	100,698	No
Tablelands [1]	39,736	9,106	320	13,388	14,280	15,720	55,796	Level 1
Whitsunday [1]	36,771	5,030	172	6,147	6,828	7,958	46,384	Level 2
Central Highlands [1]	31,960	5,321	234	7,732	8,397	9,595	40,999	Yes
Cassowary Coast [1]	26,936	5,972	219	5,915	6,020	6,157	29,894	Level 1
Isaac [1]	23,188	8,107	334	8,622	9,575	11,366	34,016	Yes
Mount Isa [1]	23,500	6,335	368	8,552	8,938	9,683	26,331	Level 3
Darwin [2]	118,000	32,292	331	42,679	45,740	51,523	155,621	No
Alice Springs [2]	24,208	7,659	316	8,384	9,229	10,956	34,628	No
Katherine [2]	9,186	3,079	335	3,334	3,668	4,354	12,991	No
Tennant Creek [2]	3,062	1,264	413	1,387	1,526	1,811	4,387	No
Broome [2]	11,700	5,736	490	8,529	10,050	12,514	27,850	No
Derby [2]	3,100	1,342	433	1,404	1,465	1,590	3,673	No
Kununurra [2]	3,800	1,405	370	1,693	1,768	1,950	5,273	No
Karratha [2]	14,700	5,162	351	5,814	6,459	7,570	21,556	No
Newman [2]	5,500	1,832	333	1,775	2,036	2,456	7,344	No
Port Hedland [2]	13,600	6,445	474	7,855	8,636	10,022	21,147	No

Notes:
1. Water demand estimated based on population serviced in LGA, 2. Water demand estimated based on population served in UCL, 3 Both UCL and LGA population have been estimated by PwC, while LGA population has been aggregated based on Statistical Area Level 2 2011 to Local Government Area 2011 Correspondence Table 3, ABS (2012) Australian Statistical Geography Standard (ASGS): Correspondences, Cat. No. 1270.0.55.006, 4 Estimated population served in FY31 takes into account the percentage of total population that receives water supply services at a given location.

Appendix C Scenario methodology and population impacts

Methodology for translating scenarios into economic and population projections for audit regions

In most cases, the opportunities in the 2030 Vision are yet to be defined and their impacts on population are unknown. A number of assumptions and rules of thumb were required to translate the agriculture, tourism, resource and population targets into scenarios. We use a simple and transparent methodology to disaggregate the projected growth to the 217 SA2s which considers historical trends, targeted plans for specific regions, stakeholder consultations, and learnings from other studies.

Methodology for scenarios 1 and 2 – industry

Figure C.1 shows the methodology for translating the agriculture opportunities identified in the 2030 Vision to population impacts by SA2.

The policy targets are converted into an economic output target for the Agriculture, Fisheries and Forestry Industry in FY31 of $14,906 million under Scenario 1 and $7,452 million under Scenario 2 (1 in Figure C.1). The difference between the economic output target and baseline economic projections is converted to total direct and indirect employment in the economy based on employment multipliers from established Input–Output table (2).[225] The share that each of the SA2s receives of the additional employment is determined by each SA2's current share of Agriculture GVA in FY13, supplemented by desktop research, consultations and land use information. After employees are distributed to each of the SA2s, a family multiplier is used to identify the additional population in each SA2 (4).[226] This assumes that employees live and work in the same SA2, which is likely to hold true for Agriculture Industry employees outside of the greater metropolitan areas.

Figure C.2 shows the methodology for translating the tourism opportunities identified in the 2030 Vision to population impacts by SA2.

The policy targets are converted into an international tourist stopover target of 2.8 million in Scenario 1 and 2.0 million in Scenario 2. The share of additional tourist stopovers that each region receives is based on the SA2's share of Northern Australia international visitor stopovers in FY13. Stakeholders indicated that there would only be a handful of new tourist destinations emerging by 2031, but that these would not attract a significant share of international tourist stopovers. This is largely because Northern Australia's competitive advantage as a leisure destination lies in its unique natural environments and outback experiences. As a result, no adjustments were made for new destinations for international tourists.

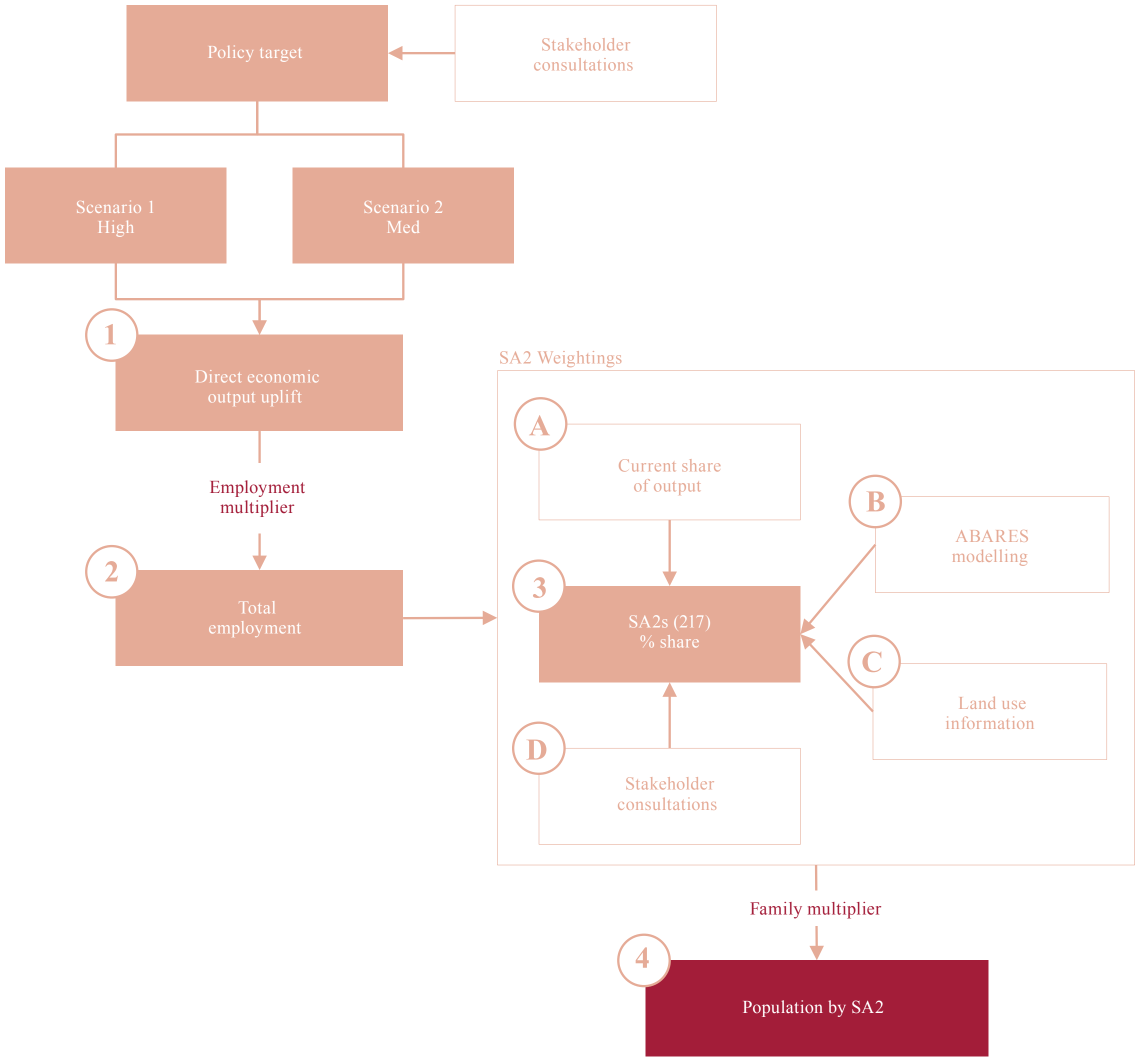
Each stopover is converted into a direct economic impact using a quasi–tourism industry estimate of economic output. The tourism sector differs from other industries in that its contribution to economic production is not readily apparent. Tourism is defined by consumption and implicitly included in the core national accounts within other production industries such as Accommodation and Food Services, Retail Trade, Arts and Recreation, and Transport, Postal and Warehousing industries. The study adopted a proxy for the tourism industry using:

- The ABS Tourism Satellite Account (TSA), which provides an estimate of the direct GVA of tourism in each core industry
- Tourism Research Australia (TRA) data on tourist stopovers (international and domestic) and expenditure (international and domestic)

225. I–O multipliers are based on some limiting assumptions and while they serve as a useful rule of thumb for the purposes of this analysis to identify potential population uplift under a number of industry growth scenarios, readers should take care in interpreting the results. Some of the limitations of I–O multipliers include: no supply side constraints, prices are fixed, ratios for intermediate inputs and production are fixed, households and governments do not have budget constraints, and households consume goods and services in exact proportion to their initial budget shares. These are explored further in Australian Bureau of Statistics (2013a).

226. The study applies family multipliers to convert additional employment into resident population. At the time of the ABS Census 2011, there were 9,430,530 employed persons (full time and part–time) and 21,507,717 people in Australia. For every employed person, there is on average 1.28 additional people.

Figure C.1: Agriculture scenario methodology



Source: PwC analysis.

The ratios from TRA data applied to ABS TSA data were used to estimate the GVA by industry for each SA2 international tourist stopover. This figure is multiplied by the target number of SA2 stopovers in each of the Scenarios to determine the economic output uplift in each tourism–related industry.

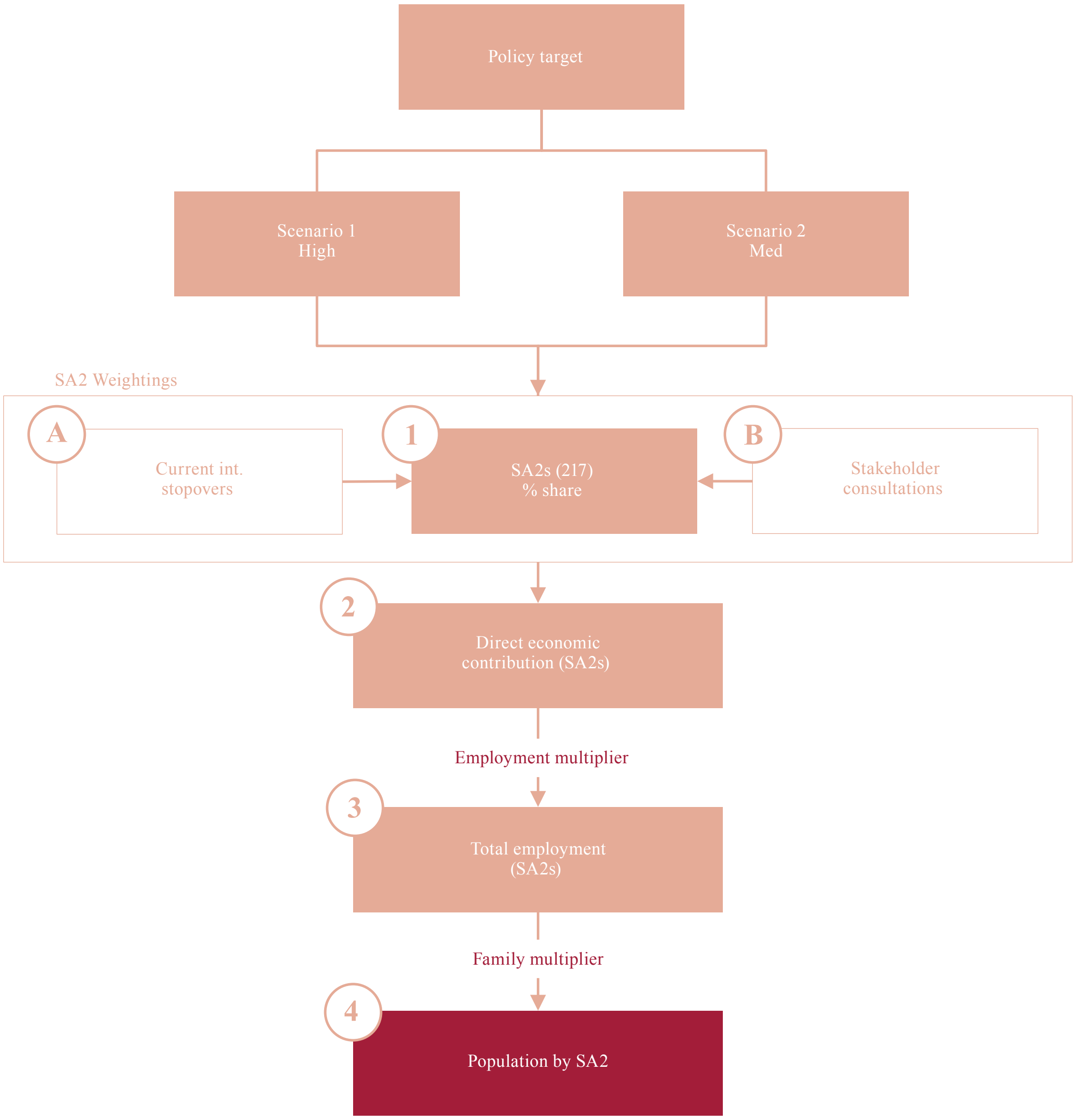
As per the Agriculture methodology outlined previously, the change in economic output compared to baseline economic growth is translated into total direct and indirect employment in in the SA2 based on employment multipliers and additional population based on a family multiplier.

Figure C.3 shows the methodology for translating the energy opportunities identified in the 2030 Vision to population impacts by SA2.

The unique nature of the mining workforce and their residential location means that the methodology for the regional distribution of growth in Northern Australia differs to the other sectors. The estimated construction and operations employees for publicly announced energy projects, projects in feasibility stage, and committed projects are identified from BREE's annual Resources and Energy Major Projects List. This list is cross referenced against information from stakeholder consultations to minimise gaps.

Scenario 1 assumes that all energy projects proceed to operations. In Scenario 2, the probability that projects proceed to operations is weighted by their stage, time frame and project value.

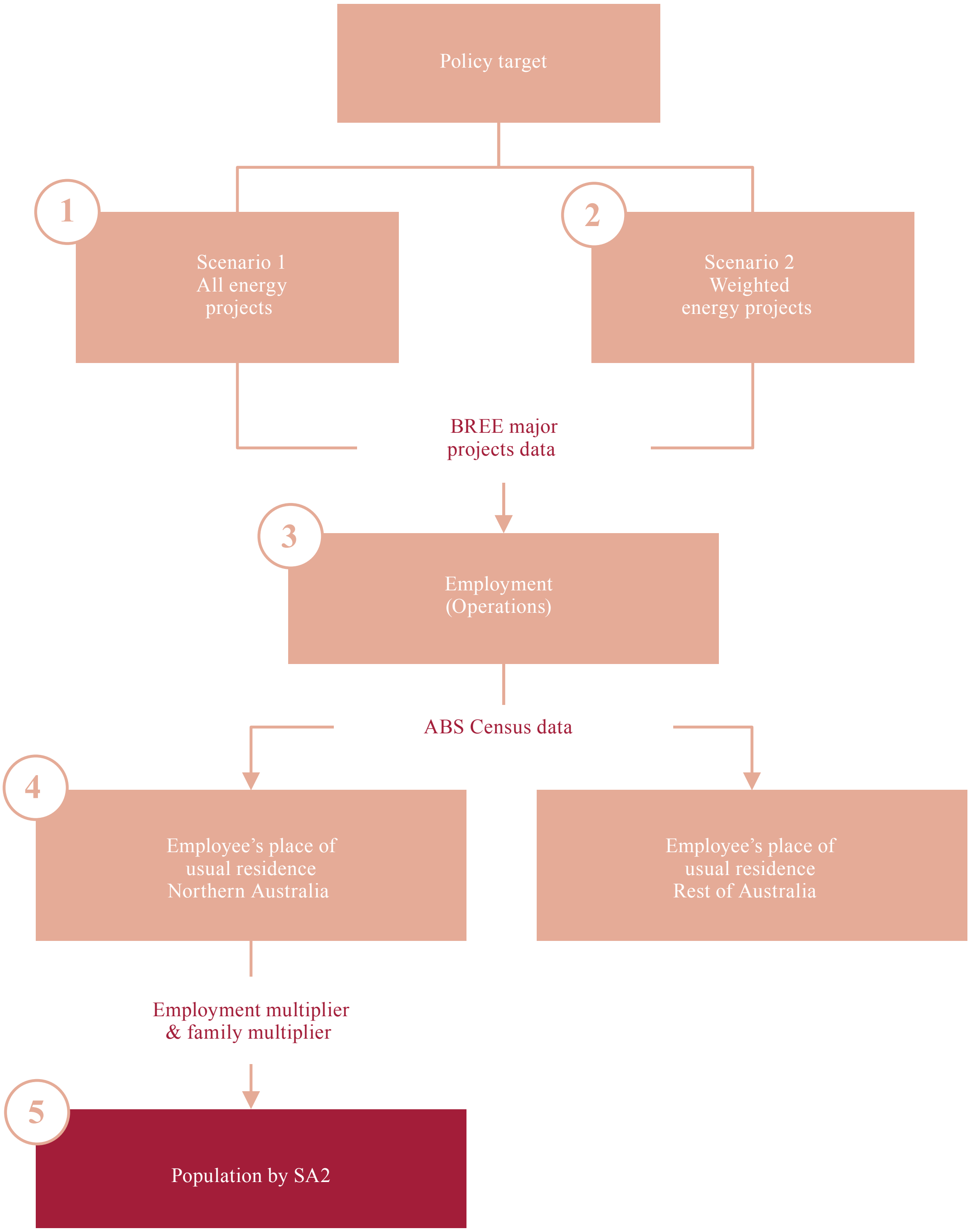
Figure C.2: Tourism scenario methodology



Source: PwC analysis.

A significant proportion of the mining workforce is from transient FIFO workers. FIFO and resident workers have a different impact on the population, as FIFO workers are excluded from the resident population. This study used previous studies of FIFO workers to derive the population impacts from the FIFO and resident workforce (including family multipliers).

Figure C.3: Energy scenario methodology



Source: PwC analysis

Methodology for scenarios 3 and 4 – population shift

High population growth

For northern Western Australia, the audit identified the FY11 population for each of the SA2s in the Pilbara region and the target population in FY35. For our study years FY16, FY21 and FY31, interpolation between the years FY11 to FY35 (linear) was used to arrive at scenario population in FY16, FY21 and FY31.For the purposes of developing the population growth scenario for the Northern Australia infrastructure audit, the following simplifying assumptions were made:

- For SA2s other than Karratha, Port Hedland and Newman, the population target was distributed to each SA2 based on their relative shares of the Pilbara population in the baseline
- All population growth is from migration from areas outside of Northern Australia unless the target indicates otherwise (e.g. FY35 target for other SA2s in the Pilbara is a fall from FY11, but the net impact in the Pilbara is positive and that growth is from outside Northern Australia). As a result – there is no direct impact on the Northern Territory or northern Queensland population.

For northern Queensland, population in the Rest of Queensland was doubled in line with the Queensland Plan from around 1.46 million in FY11 to 2.93 million by FY44. The populations for FY16, FY21 and FY31 are derived using a linear trend line between those two points. The study then applied the SA2 shares of the Rest of Queensland population from the baseline population projections to the scenario population projections in FY16, FY21 and FY31 (the shares differ for each year).

Low population growth

This scenario adopts the ABS population projections series which correspond with the following assumptions.[227]

- Low net overseas migration (NOM) into Queensland, Western Australia and the Northern Territory. Annual levels of NOM have fluctuated considerably in Australia over the past 25 years. The level has been as low as 30,000 in FY93 to a high of 300,000 in FY09. The low NOM assumption is based on maintaining NOM at around 200,000 (the observed average in the years FY10 to FY12). Each state's proportion of NOM is based on an average of the last three years of NOM data.
- Small interstate flows into Queensland and Western Australia, where net interstate migration has been historically positive, and large interstate flows out of the Northern Territory, where net interstate migration has been negative in the most recent three years. The movement of people between Australia's states and territories is influenced by many factors such as varying economic opportunities, lifestyle choices, and more. These factors can be difficult to anticipate, and the aim of this scenario is to model a possible situation where there is a reversal in the 'northern shift' in population.
- Medium assumptions relating to mortality and fertility for Queensland, Western Australia and the Northern Territory. Future levels of fertility and mortality can be modelled to a higher degree of accuracy, so deviations from the medium level assumptions (generally a continuation of trends) are less likely.

Table C.1 compares the NOM and net internal migration (NIM) assumptions in Scenario 4 to the baseline.

227. The ABS population projections test three assumptions about fertility, two assumptions about mortality, three assumptions about net overseas migration and three assumptions about net interstate migration. The above assumptions can be combined to create 54 sets of population projections. Three main series have been selected from these to provide a range, labelled Series A, Series B and Series C. Scenario 4 adopts Series 48 for Queensland and Western Australia, and Series 46 for the Northern Territory.

228. *Ord River Diversion Dam Engineering Heritage Marker Ceremony, 2013,* Commonwealth Government and Institute of Engineers

Table C.1: Scenario 4 assumptions regarding net overseas migration (NOM) and net internal migration (NIM)

Assumptions (long term, each year)	Queensland	Western Australia	Northern Territory
NOM: Baseline	46,560	47,280	2,160
NOM: Scenario 4	38,800	39,400	1,800
Difference	**– 7,760**	**– 7,880**	**– 360**
NIM: Baseline	12,000	6,000	– 1,000
NIM: Scenario 4	6,000	2,000	– 2,000
Difference	**– 6,000**	**– 4,000**	**– 1,000**

Source: PwC analysis of Australian Bureau of Statistics (2013a).

C.2. Scenario population impacts by region

Table C.2: Top 30 regions ordered by absolute population uplift in 2031, Scenario 1

	Baseline Population			Additional Population			Scenario 1 Population		
SA2 Name	**2016**	**2021**	**2031**	**2016**	**2021**	**2031**	**2016**	**2021**	**2031**
Barcaldine – Blackall	5,606	5,597	5,566	4,459	9,296	16,798	10,065	14,894	22,365
Broadsound – Nebo	11,112	12,270	14,359	2,822	13,318	16,470	13,934	25,588	30,829
Burdekin	8,419	8,558	8,829	4,582	8,979	16,147	13,001	17,538	24,977
Central Highlands – West	9,672	10,125	10,760	4,477	8,844	15,022	14,149	18,970	25,782
Cairns City	11,241	12,268	14,484	33,172	35,780	13,759	44,412	48,048	28,243
Collinsville	4,439	4,953	5,566	2,749	8,536	12,170	7,189	13,489	17,737
Northern Highlands	3,757	3,736	3,720	3,605	6,783	11,727	7,362	10,519	15,448
Bowen	9,887	11,084	12,749	2,183	10,789	11,506	12,070	21,873	24,255
Moranbah	10,561	11,833	14,340	1,251	10,000	11,128	11,812	21,833	25,468
Clermont	4,131	4,552	5,314	2,156	7,110	10,008	6,287	11,662	15,323
Far Central West	2,495	2,460	2,419	2,716	5,545	9,975	5,210	8,005	12,394
Tully	10,644	10,794	11,131	5,123	7,511	9,096	15,766	18,305	20,227
Longreach	4,235	4,159	4,028	2,376	5,030	8,953	6,610	9,189	12,981
Dalrymple	4,076	4,162	4,244	2,123	4,161	7,481	6,199	8,323	11,725
Carpentaria	5,650	5,918	6,414	2,099	4,117	7,398	7,749	10,035	13,812
Barkly	3,377	3,720	4,415	2,807	4,417	6,126	6,184	8,137	10,541
Central Highlands – East	8,342	8,547	8,822	1,930	3,821	6,065	10,272	12,368	14,887
Mount Isa Region	4,135	4,187	4,304	1,586	3,109	5,587	5,721	7,297	9,892
Emerald	16,064	18,276	22,520	2,145	4,088	5,447	18,209	22,365	27,967
Edmonton	11,329	12,527	15,086	12,319	13,371	5,354	23,649	25,898	20,440
Airlie – Whitsundays	12,498	13,929	16,658	12,182	13,193	5,181	24,680	27,123	21,839
Ingham Region	6,850	6,791	6,624	1,442	2,832	5,076	8,292	9,623	11,700
Croydon – Etheridge	1,286	1,331	1,420	1,281	2,509	4,516	2,567	3,840	5,936
Johnstone	7,676	7,682	7,707	1,280	2,516	4,505	8,955	10,198	12,212
Gladstone Hinterland	12,737	15,584	20,055	2,256	3,088	4,450	14,992	18,672	24,504
Boyne Island – Tannum Sands	12,341	17,978	27,485	1,843	2,757	4,361	14,184	20,735	31,845
Petermann – Simpson	2,660	2,925	3,473	9,755	10,583	4,314	12,415	13,508	7,787
Karratha	19,156	21,281	24,939	4,111	4,699	4,289	23,268	25,981	29,228
Kununurra	9,887	10,328	11,387	2,133	3,257	4,266	12,020	13,585	15,653
Victoria River	3,176	3,496	4,151	1,238	2,372	4,221	4,414	5,868	8,372
Sum of the above	**237,439**	**261,054**	**302,971**	**134,202**	**222,412**	**251,397**	**371,641**	**483,466**	**554,368**
Total	**1,363,762**	**1,498,059**	**1,767,846**	**224,165**	**343,811**	**374,022**	**1,587,926**	**1,841,870**	**2,141,868**
Top 30 as % of total	***17%***	***17%***	***17%***	***60%***	***65%***	***67%***	***23%***	***26%***	***26%***

Table C.3: Top 30 regions ordered by absolute population uplift in 2031, Scenario 2

	Baseline Population			Additional Population			Scenario 1 Population		
SA2 Name	**2016**	**2021**	**2031**	**2016**	**2021**	**2031**	**2016**	**2021**	**2031**
Broadsound – Nebo	11,112	12,270	14,359	954	4,788	6,774	12,066	17,058	21,134
Moranbah	10,561	11,833	14,340	669	4,197	6,471	11,230	16,030	20,811
Bowen	9,887	11,084	12,749	1,270	4,619	5,878	11,157	15,703	18,627
Barcaldine – Blackall	5,606	5,597	5,566	842	3,905	5,185	6,448	9,503	10,751
Karratha	19,156	21,281	24,939	2,841	3,474	3,617	21,998	24,756	28,556
Longreach	4,235	4,159	4,028	471	2,624	3,574	4,706	6,783	7,602
Boyne Island – Tannum Sands	12,341	17,978	27,485	1,029	2,149	3,362	13,370	20,127	30,846
Collinsville	4,439	4,953	5,566	651	2,400	2,946	5,090	7,354	8,513
Emerald	16,064	18,276	22,520	1,384	2,354	2,825	17,448	20,630	25,345
Clermont	4,131	4,552	5,314	539	2,097	2,724	4,670	6,650	8,038
Cairns City	11,241	12,268	14,484	30,405	30,269	2,700	41,645	42,537	17,184
Gladstone Hinterland	12,737	15,584	20,055	1,121	1,966	2,523	13,857	17,550	22,578
Far Central West	2,495	2,460	2,419	496	1,932	2,401	2,991	4,393	4,821
Clinton – New Auckland	13,950	14,580	18,910	1,159	1,738	2,310	15,109	16,318	21,220
South Hedland	11,858	13,034	15,126	1,283	1,659	2,153	13,141	14,693	17,279
Central Highlands – West	9,672	10,125	10,760	1,118	2,051	2,023	10,790	12,177	12,783
East Pilbara	8,315	9,463	11,332	969	1,326	1,695	9,285	10,789	13,026
Roebourne	7,654	8,501	9,966	839	1,101	1,431	8,493	9,603	11,397
Gladstone	7,560	8,933	10,451	1,733	2,164	1,373	9,294	11,097	11,824
Central Highlands – East	8,342	8,547	8,822	643	1,192	1,312	8,985	9,739	10,134
Newman	5,521	6,333	7,639	597	805	1,086	6,118	7,137	8,726
West Gladstone	6,091	7,447	8,795	506	888	1,074	6,597	8,334	9,869
Humpty Doo	8,992	9,636	10,859	123	852	1,061	9,115	10,488	11,920
Edmonton	11,329	12,527	15,086	11,240	11,215	1,045	22,569	23,742	16,130
Port Hedland	5,440	5,983	6,943	1,209	1,377	1,041	6,648	7,361	7,984
Airlie – Whitsundays	12,498	13,929	16,658	11,143	11,117	1,035	23,641	25,046	17,693
Kin Kora – Sun Valley	4,540	5,075	7,924	377	605	968	4,917	5,680	8,892
Burdekin	8,419	8,558	8,829	768	1,348	924	9,186	9,906	9,753
Telina – Toolooa	6,581	6,992	7,031	547	835	860	7,129	7,827	7,890
Petermann – Simpson	2,660	2,925	3,473	8,869	8,841	839	11,529	11,766	4,312
Sum of the above	**237,439**	**261,054**	**302,971**	**85,796**	**115,889**	**73,210**	**349,224**	**410,776**	**425,638**
Total	**1,363,762**	**1,498,059**	**1,767,846**	**147,190**	**186,964**	**98,123**	**1,510,952**	**1,685,023**	**1,865,969**
Top 30 as % of total	***17%***	***17%***	***17%***	***58%***	***62%***	***75%***	***23%***	***24%***	***23%***

Table C.4: Top 30 regions ordered by absolute population uplift in 2031, Scenario 3

	Baseline Population			Additional Population			Scenario 1 Population		
SA2 Name	**2016**	**2021**	**2031**	**2016**	**2021**	**2031**	**2016**	**2021**	**2031**
Port Hedland	5,440	5,983	6,943	8,610	17,528	35,489	14,050	23,511	42,432
Karratha	19,156	21,281	24,939	4,724	9,473	19,562	23,881	30,754	44,501
Deeragun	25,013	33,156	52,789	1,445	3,296	8,514	26,458	36,453	61,303
Newman	5,521	6,333	7,639	2,114	3,241	5,810	7,636	9,574	13,450
Gordonvale – Trinity	11,945	19,214	33,114	690	1,910	5,340	12,635	21,124	38,455
Yeppoon	20,201	23,333	31,253	1,167	2,320	5,040	21,368	25,653	36,293
Boyne Island – Tannum Sands	12,341	17,978	27,485	713	1,787	4,433	13,054	19,765	31,917
Eimeo – Rural View	13,873	18,086	26,681	802	1,798	4,303	14,674	19,884	30,984
Mount Isa	22,543	23,581	25,583	1,302	2,344	4,126	23,846	25,925	29,709
Townsville – South	5,756	11,285	22,552	333	1,122	3,637	6,088	12,407	26,189
Emerald	16,064	18,276	22,520	928	1,817	3,632	16,992	20,093	26,152
Trinity Beach – Smithfield	15,442	18,100	21,891	892	1,800	3,530	16,335	19,899	25,422
Gladstone Hinterland	12,737	15,584	20,055	736	1,549	3,234	13,473	17,133	23,289
Townsville City – North Ward	11,242	14,311	20,013	649	1,423	3,228	11,891	15,733	23,241
Andergrove – Beaconsfield	17,033	18,300	19,982	984	1,819	3,223	18,017	20,119	23,205
Gracemere	11,263	14,069	19,382	651	1,399	3,126	11,914	15,467	22,508
Clinton – New Auckland	13,950	14,580	18,910	806	1,450	3,050	14,756	16,029	21,960
Mount Louisa	10,121	13,138	17,987	585	1,306	2,901	10,706	14,444	20,888
Redlynch	13,605	15,102	17,177	786	1,501	2,770	14,391	16,604	19,947
Airlie – Whitsundays	12,498	13,929	16,658	722	1,385	2,687	13,220	15,314	19,344
Kirwan – West	16,509	16,595	16,569	954	1,650	2,672	17,463	18,245	19,242
Mount Pleasant – Glenella	11,662	12,883	16,084	674	1,281	2,594	12,335	14,164	18,678
Sarina	12,752	13,615	15,666	737	1,354	2,527	13,489	14,969	18,192
Condon – Rasmussen	11,418	12,666	15,219	660	1,259	2,454	12,078	13,926	17,674
Edmonton	11,329	12,527	15,086	655	1,245	2,433	11,984	13,773	17,519
Clifton Beach – Kewarra Beach	11,688	12,581	14,784	675	1,251	2,384	12,363	13,832	17,168
Ooralea – Bakers Creek	6,536	9,298	14,725	378	924	2,375	6,913	10,223	17,100
Cairns City	11,241	12,268	14,484	649	1,220	2,336	11,890	13,488	16,820
Broadsound – Nebo	11,112	12,270	14,359	642	1,220	2,316	11,754	13,490	16,675
Moranbah	10,561	11,833	14,340	610	1,176	2,313	11,171	13,009	16,653
Sum of the above	**390,551**	**462,154**	**604,868**	**36,273**	**72,849**	**152,038**	**426,824**	**535,004**	**756,906**
Total	**1,363,762**	**1,498,059**	**1,767,846**	**71,713**	**135,045**	**259,906**	**1,435,475**	**1,633,104**	**2,027,751**
Top 30 as % of total	***28.6%***	***30.9%***	***34.2%***	***50.6%***	***53.9%***	***58.5%***	***29.7%***	***32.8%***	***37.3%***

Table C.5: Top 30 regions ordered by absolute population decline in 2031, Scenario 4

	Baseline Population			Additional Population			Scenario 1 Population		
SA2 Name	**2016**	**2021**	**2031**	**2016**	**2021**	**2031**	**2016**	**2021**	**2031**
Deeragun	25,013	33,156	52,789	(91)	(711)	(3,005)	24,921	32,446	49,784
Gordonvale – Trinity	11,945	19,214	33,114	(44)	(412)	(1,885)	11,901	18,802	31,229
Yeppoon	20,201	23,333	31,253	(74)	(500)	(1,779)	20,127	22,833	29,474
Broome	19,797	23,327	29,046	(185)	(615)	(1,680)	19,611	22,713	27,365
Boyne Island – Tannum Sands	12,341	17,978	27,485	(45)	(385)	(1,565)	12,296	17,592	25,920
Eimeo – Rural View	13,873	18,086	26,681	(51)	(388)	(1,519)	13,822	17,698	25,162
Mount Isa	22,543	23,581	25,583	(82)	(505)	(1,456)	22,461	23,075	24,127
Karratha	19,156	21,281	24,939	(179)	(561)	(1,443)	18,977	20,721	23,496
Katherine	11,386	12,527	14,872	(167)	(496)	(1,292)	11,219	12,031	13,580
Townsville – South	5,756	11,285	22,552	(21)	(242)	(1,284)	5,735	11,043	21,268
Emerald	16,064	18,276	22,520	(59)	(392)	(1,282)	16,005	17,884	21,238
Trinity Beach – Smithfield	15,442	18,100	21,891	(56)	(388)	(1,246)	15,386	17,712	20,645
Gladstone Hinterland	12,737	15,584	20,055	(47)	(334)	(1,142)	12,690	15,250	18,913
Townsville City – North Ward	11,242	14,311	20,013	(41)	(307)	(1,139)	11,201	14,004	18,874
Andergrove – Beaconsfield	17,033	18,300	19,982	(62)	(392)	(1,138)	16,971	17,908	18,845
Gracemere	11,263	14,069	19,382	(41)	(302)	(1,103)	11,222	13,767	18,279
East Arnhem	9,592	10,559	12,535	(141)	(418)	(1,089)	9,451	10,141	11,446
Clinton – New Auckland	13,950	14,580	18,910	(51)	(312)	(1,076)	13,899	14,267	17,833
Mount Louisa	10,121	13,138	17,987	(37)	(282)	(1,024)	10,084	12,856	16,963
Redlynch	13,605	15,102	17,177	(50)	(324)	(978)	13,555	14,779	16,199
Airlie – Whitsundays	12,498	13,929	16,658	(46)	(299)	(948)	12,452	13,631	15,710
Humpty Doo	8,992	9,636	10,859	(132)	(382)	(943)	8,860	9,254	9,916
Kirwan – West	16,509	16,595	16,569	(60)	(356)	(943)	16,448	16,239	15,626
Mount Pleasant – Glenella	11,662	12,883	16,084	(43)	(276)	(916)	11,619	12,607	15,168
Sarina	12,752	13,615	15,666	(47)	(292)	(892)	12,705	13,323	14,774
South Hedland	11,858	13,034	15,126	(111)	(344)	(875)	11,747	12,691	14,251
Condon – Rasmussen	11,418	12,666	15,219	(42)	(271)	(866)	11,376	12,395	14,353
Edmonton	11,329	12,527	15,086	(41)	(268)	(859)	11,288	12,259	14,227
Clifton Beach – Kewarra Beach	11,688	12,581	14,784	(43)	(270)	(842)	11,645	12,312	13,943
Ooralea – Bakers Creek	6,536	9,298	14,725	(24)	(199)	(838)	6,512	9,099	13,887
Sum of the above	**408,301**	**482,551**	**629,540**	**(2,112)**	**(11,220)**	**(37,047)**	**406,189**	**471,331**	**592,493**
Total	**1,363,762**	**1,498,059**	**1,767,846**	**(8,405)**	**(37,690)**	**(110,246)**	**1,355,357**	**1,460,368**	**1,657,600**
Top 30 as % of total	***29.9%***	***32.2%***	***35.6%***	***25.1%***	***29.8%***	***33.6%***	***30.0%***	***32.3%***	***35.7%***

Table C.6: Energy scenario projects considered

Project	Company	State	Location	SA3	Type	Estimated Start Up	PA	FS	C
Abbot Point Coal T3 (part of Alpha Coal Project)	GVK	QLD	Bowen	Bowen Basin – North	Expansion	2016		Y	
Alpha Coal Project	GVK – Hancock Coal	QLD	120 km SW of Clermont	Bowen Basin – North	New Project	2017		Y	
Arrow LNG Plant (trains 1 and 2)	Shell / Petro China	QLD	Gladstone	Gladstone – Biloela	New Project	2018		Y	
Australia Pacific LNG (trains 1 and 2)	Origin / ConocoPhillips / Sinopec	QLD	Gladstone	Gladstone – Biloela	New project	2015			Y
Byerwen Coal Project	QCoal / JFE Steel Corporation	QLD	20 km W of Glenden	Bowen Basin – North	New Project	2015		Y	
Carmichael Coal Project (mine and rail)	Adani	QLD	160 km NW of Clermont	Bowen Basin – North	New Project	2017		Y	
China First Coal project (Galilee Coal Project)	Waratah Coal	QLD	36 km NE of Jericho	Outback – South	New Project	2018+		Y	
Dingo West	Bandanna Energy	QLD	6 km W of Dingo	Central Highlands (Qld)	Expansion	2016		Y	
Drake Coal project	QCoal	QLD	17 km S of Collinsville	Bowen Basin – North	New Project	2015		Y	
Dudgeon Point	NQBP / Adani	QLD	40 km N of Mackay	Mackay	New Project	2018+		Y	
Eaglefield	Peabody Energy	QLD	36 km N of Moranbah	Bowen Basin – North	Expansion	2018+		Y	
Fitzroy Terminal	Mitchell Group	QLD	50 km S of Rockhampton	Rockhampton	New Project	2016		Y	
Gladstone LNG	Santos / Petronas / Total / Kogas	QLD	Gladstone	Gladstone – Biloela	New Project	2015			Y
Gorgon LNG	Chevron / Shell / ExxonMobil	WA	Barrow Island	Pilbara	New Project	2015			Y
Grosvenor underground	Anglo American	QLD	8 km N of Moranbah	Bowen Basin – North	New Project	2014			Y
Grosvenor West	Carabella Resources	QLD	10km NW of Moranbah	Bowen Basin – North	New Project	2016		Y	
Ichthys LNG	Inpex Holdings / Total	NT	Darwin	Litchfield	New Project	2017			Y
Jax	QCoal	QLD	15 km S of Collinsville	Bowen Basin – North	New Project	2018+		Y	
Kevin's Corner	GVK	QLD	Galilee Basin	Outback – South	New Project	2018		Y	
Lake Vermont	Jellinbah, Marubeni, Sojitz, AMCI	QLD	20 Km N of Dysart	Bowen Basin – North	Expansion	2013			Y

Project	Company	State	Location	SA3	Type	Estimated Start Up	PA	FS	C
Minyango	Caledon Resources Limited	QLD	15 km N of Cook	Central Highlands (Qld)	New Project	2015		Y	
Moura Link – Aldoga Rail	Aurizon	QLD	Moura/ Surat to Mount Larcom	Gladstone – Biloela	New Project	2018+		Y	
Orion Downs	U & D Mining	QLD	60 km SE of Emerald	Central Highlands (Qld)	New Project	2014		Y	
Project China Stone	MacMines Austasia	QLD	190 km NW of Moranbah	Bowen Basin – North	New Project	2017	Y		
Queensland Curtis LNG project	BG Group, CNOOC	QLD	Gladstone	Gladstone – Biloela	New Project	2014			Y
Rolleston (phase 1)	Glencore Xstrata, Sumisho, IRCA	QLD	16 W of Rolleston	Central Highlands (Qld)	Expansion	2014			Y
South Galilee Coal Project (3 phases)	Bandanna Energy	QLD	180 km W of Emerald	Outback – South	New Project	2015		Y	
Styx	Waratah Coal	QLD	N of Rockhampton	Rockhampton	New Project	2018+	Y		
Talwood Coking Coal Project	Aquila Resources	QLD	40 km N of Moranbah	Bowen Basin – North	New Project	2016	Y		
Taroborah	Shenhuo International	QLD	22 km W of Emerald	Central Highlands (Qld)	New Project	2016		Y	
Teresa	Linc Energy	QLD	17 km N of Emerald	Central Highlands (Qld)	New Project	2016		Y	
Togara North	Glencore Xstrata	QLD	40 km S of Comet	Mackay	New Project	2017	Y		
Wards Well	BHP Billiton Mitsubishi Alliance (BMA)	QLD	29km SW of Glenden	Bowen Basin – North	New Project	2017		Y	
Washpool coal project	Aquila Resources	QLD	60 km NE of Emerald	Central Highlands (Qld)	New Project	2018+		Y	
Wheatstone LNG	Chevron / Apache / KUFPEK / Shell	WA	145 km NW of Dampier	Pilbara	New Project	2016			Y
Wiggins Island Coal Terminal (stage 2 and 3)	Wiggins Island Coal Export Terminal	QLD	Gladstone	Gladstone – Biloela	New Project	2018+	Y		
Winchester South	Rio Tinto	QLD	40 km S of Moranbah	Bowen Basin – North	New Project	2016	Y		
Wongai Project	Aust–Pac Capital	QLD	150km NW of Cooktown	Central Highlands (Qld)	New Project	2018+		Y	
Yarwun Coal Terminal (Stage 1)	Metro Coal / 3TL	QLD	Gladstone	Gladstone – Biloela	New Project	2018+	Y		

PA = Publicly announced
FS = Feasibility stage
C = Committed

Appendix D
Government investment in Ord, Burdekin irrigation schemes

Ord Irrigation Scheme

In 1959 the Commonwealth Government made a grant of five million pounds (about $140 million at 2013 prices) to the Western Australian Government, most of which was for constructing irrigation channels, pumping stations, the Ord River Diversion Dam and the support town of Kununurra. In the initial stage about 10,000 acres (4,500 hectares) of land was cleared and graded for farms irrigated through the 25 kilometre main (M1) channel and more than 55 kilometres of subsidiary channels.

In July, 1960, Christiani Nielsen Clough, a joint venture by a Danish and a Perth based company, won a contract worth 2.9 million pounds (about $78 million at 2013 prices) to construct the dam. Another contract of 763,000 pounds (more than $20 million) was awarded to Vickers Hoskins of Perth for the prefabrication of the radial gates which give the dam its distinctive appearance.[228]

Building on this initial government investment, the Ord–East Kimberley Expansion Project has seen a further investment of $517 million comprising:

1. East Kimberley Development Package – $195 million from the Commonwealth Government, of which the Western Australian Government delivered $177.9 million of projects
2. Ord Irrigation Expansion Project – $322 million from the Western Australian Government's Royalties for Regions fund.[229]

To date governments have effectively invested over $650 million in bringing water and opportunity to approximately 30,000 hectares of irrigation development and a range of social infrastructure and social programs. The advancement of further development of the Ord is likely to see further significant investment from the state, Northern Territory and Commonwealth Governments.

Burdekin Irrigation Area

The Commonwealth Government provided $197.4 million (1982–83 to 1992–93) towards expenditure on the Burdekin Falls Dam and associated infrastructure, under the National Water Resources (Financial Assistance) Act 1978. Commonwealth funding was provided by way of annual non–repayable grants that reimbursed the Queensland Government's expenditure on the Burdekin Falls Dam and associated infrastructure.

In addition to the Commonwealth's financial contribution to advancing the project, the Queensland Government committed $389.6 million expenditure on the scheme from a mix of funding sources, including debenture loans and Consolidated Fund budget allocations.

All funds were deposited in the Queensland WRC Construction Trust Fund (subsequently the Burdekin Water Supply Construction Fund), from which expenditures on the scheme were made.[230]

229. WA Department of State Development http://www.dsd.wa.gov.au/8161.aspx – accessed 7/2/2014)

230. *Burdekin Haughton Water Supply Scheme: Assessment of Certain Pricing Matters relating to the Burdekin River Irrigation Area,* QCA 2003

Appendix E
Consultation

The following organisations have been consulted either individually on in the context of meetings with government policy agencies in Canberra, Brisbane, Darwin and Perth in March/April, June and July 2014.

Type of organisation	Jurisdiction	Organisation
Government department/agency	Commonwealth	Communications
	Queensland	Agriculture, Fisheries and Forestry
		Energy and Water Supply
		Natural Resources and Mines
		Science, Innovation and Arts
		State Development and Infrastructure Planning
		Tourism Queensland
		Transport and Main Roads
	Northern Territory	Corporate and Information Services
		Mines and Energy
		Primary Industry and Fisheries
		Tourism NT
		Transport
		Treasury and Finance
		Chief Minister's
		Community Services (Remote Indigenous Program Office)
	Western Australia	Mines and Petroleum
		Premier and Cabinet
		Regional Development
		State Development
		Tourism Western Australia
		Transport
		Treasury
		Water
Research	Commonwealth	Australian Bureau of Statistics
		Australian Bureau of Agricultural and Resource Economics and Sciences
		Bureau of Infrastructure, Transport and Regional Economics
		Bureau of Resources and Energy Economics
		CSIRO Livestock Logistics Team
Regional development	Queensland	Mackay Regional Council
		Mount Isa Chamber of Commerce
		Mount Isa Council
		Mount Isa to Townsville Economic Development Zone
		North Queensland Land Council
		Regional Development Australia Far North Queensland and Torres Strait
		Regional Development Australia Mackay Whitsunday
		Regional Development Australia Townsville and NW Queensland
		Townsville City Council
		Townsville Enterprise

Type of organisation	Jurisdiction	Organisation
Regional development	Northern Territory	Alice Springs Town Council
		Northern Territory Chamber of Commerce (Alice Springs)
	Western Australia	Kununurra Chamber of Commerce and Industry
		Kimberley Land Council
		Ord Irrigation Cooperative
		Pilbara Development Commission
		Port Hedland Council
		Shire of Broome
		Shire of Wyndham East Kimberley
Infrastructure manager	Commonwealth	NBN Co
	Queensland	Aurizon
		Cairns International Airport
		Cairns Regional Council
		Gladstone Ports Corporation
		Mackay Regional Council
		Mount Isa Water Board
		North Queensland Bulk Ports
		Ports North
		Port of Townsville
		Powerlink Queensland
		Queensland Airports
		Queensland Rail
	Queensland	SunWater
	Northern Territory	Darwin Ports Corporation
		Genesee & Wyoming (SA)
		NT Airports (Alice Springs and Darwin airports)
		Power and Water Corporation
		Voyages Indigenous Tourism (Ayers Rock Airport)
	Western Australia	Broome International Airport
		Horizon Power
		Kununurra Airport
		Port Hedland International Airport
		Port Hedland Port Authority
		Water Corporation of Western Australia
		Wyndham Port
Infrastructure user	Queensland	Aurizon
		AustralAsia Railway Corporation
		Pacific National
		Queensland Road Transport Association
	Northern Territory	Northern Territory Road Transport Association

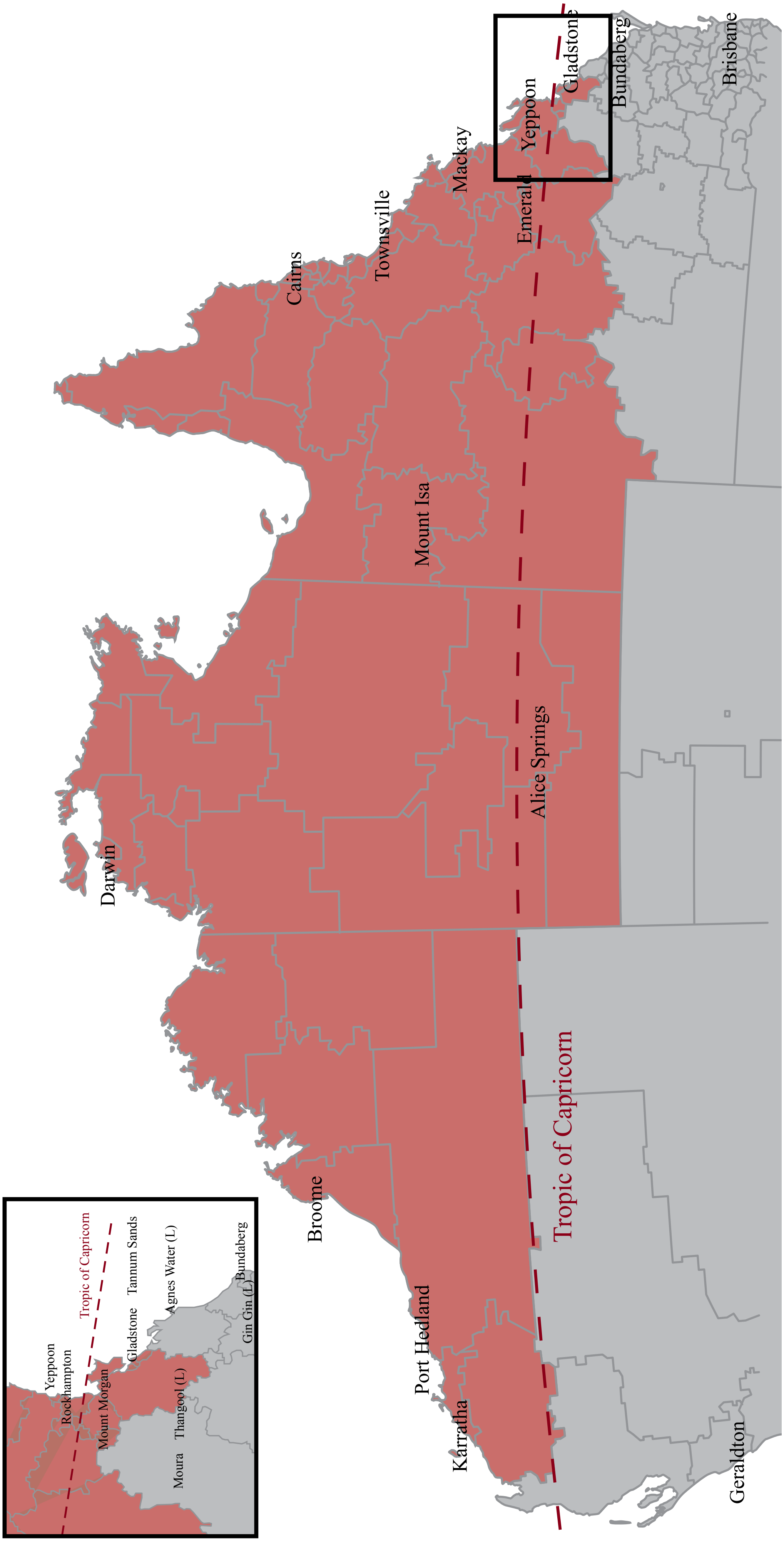
Figures

Figures *(continued)*

Tables

Tables *(continued)*

Maps

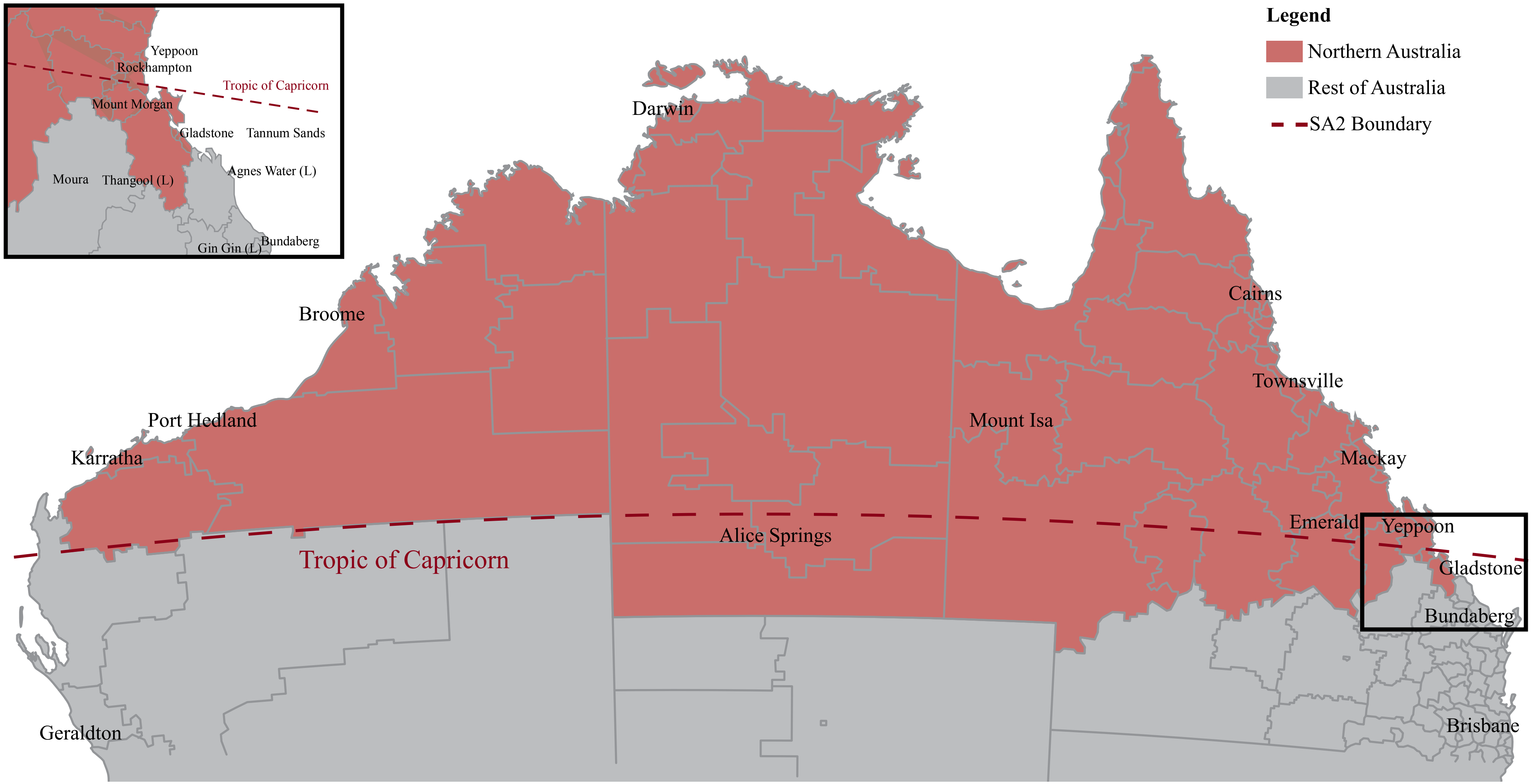


Map 1: Northern Australia in the audit

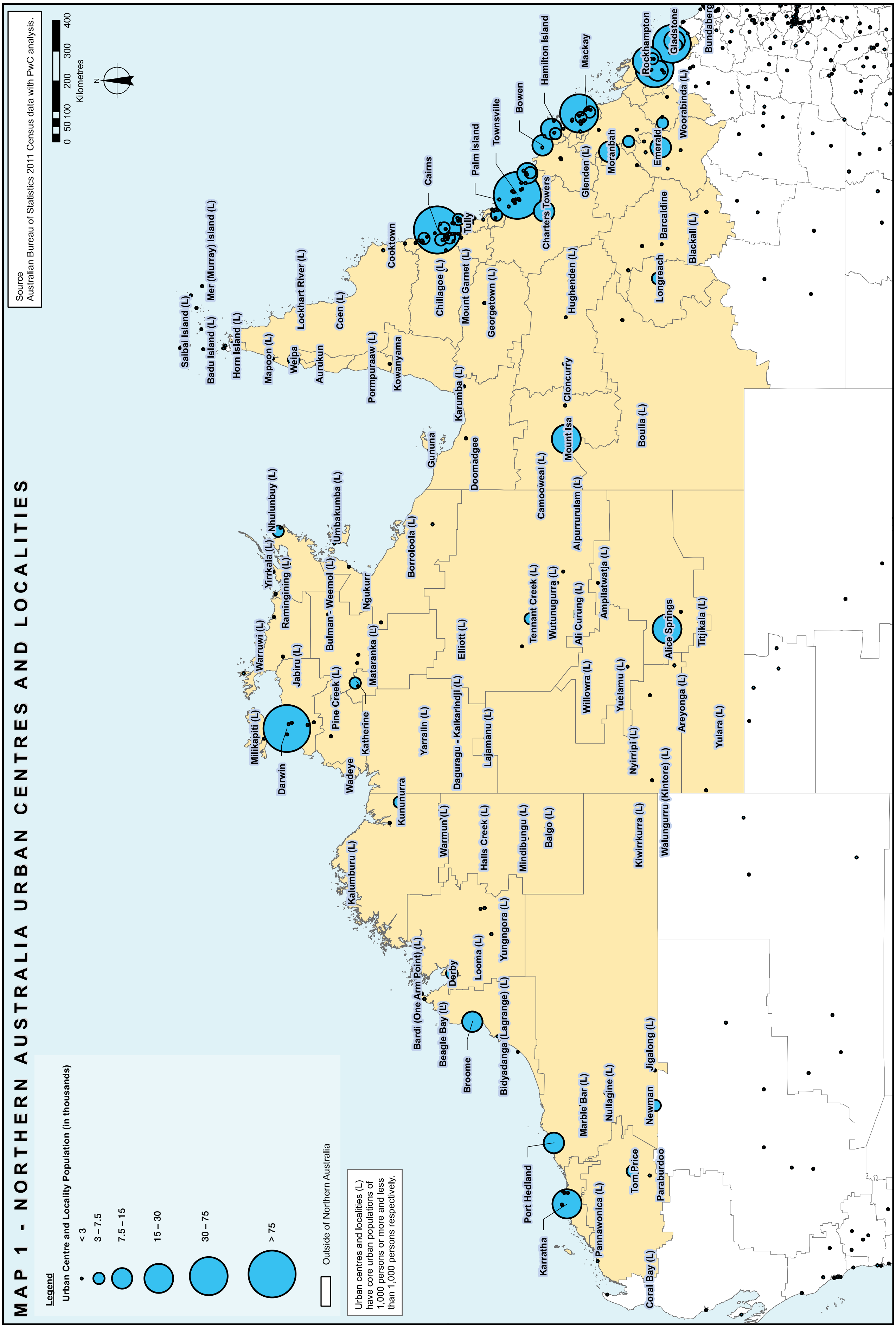
Inset

Map 2: Map showing Northern Australia area used in the Northern Australia infrastructure audit

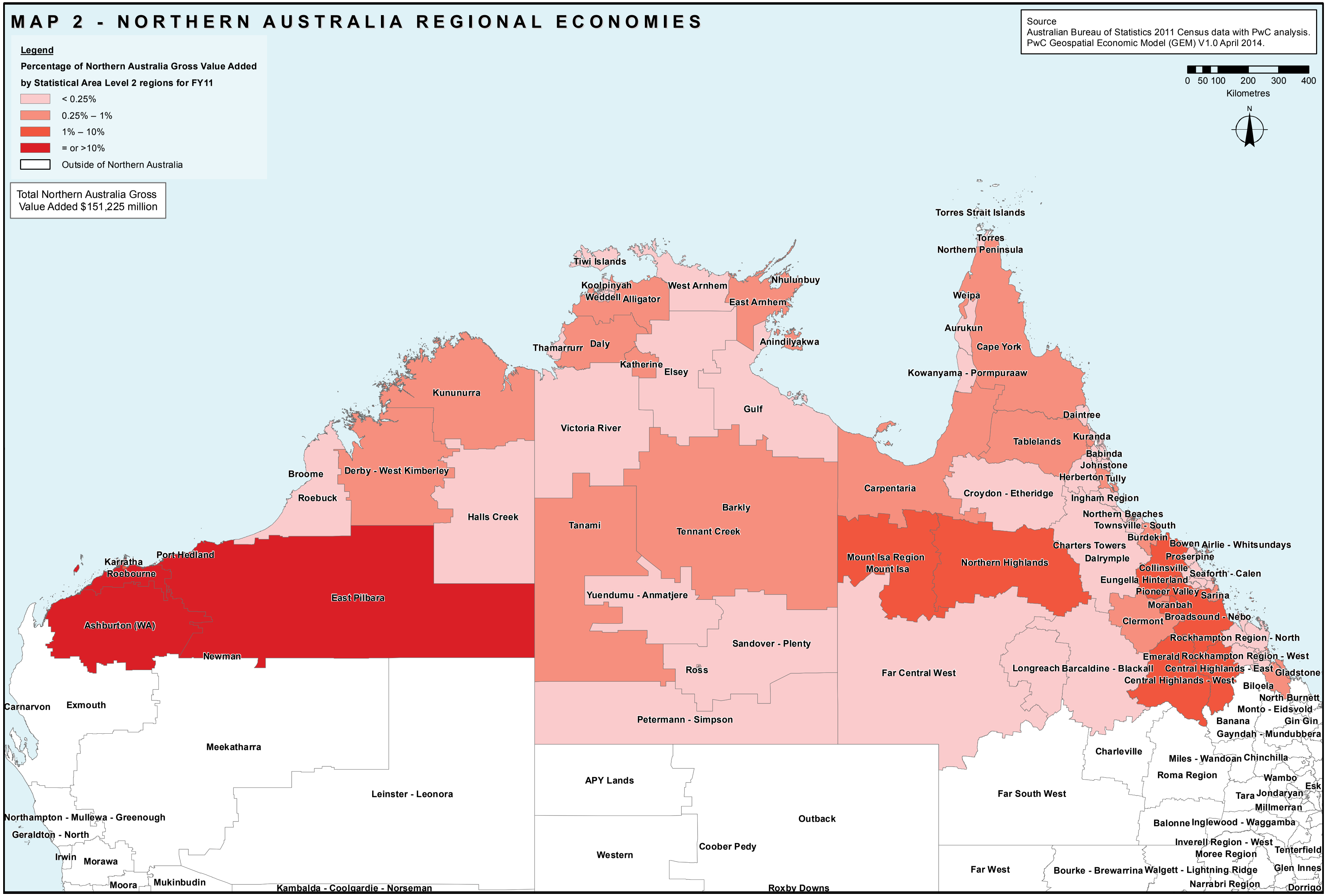
Inset



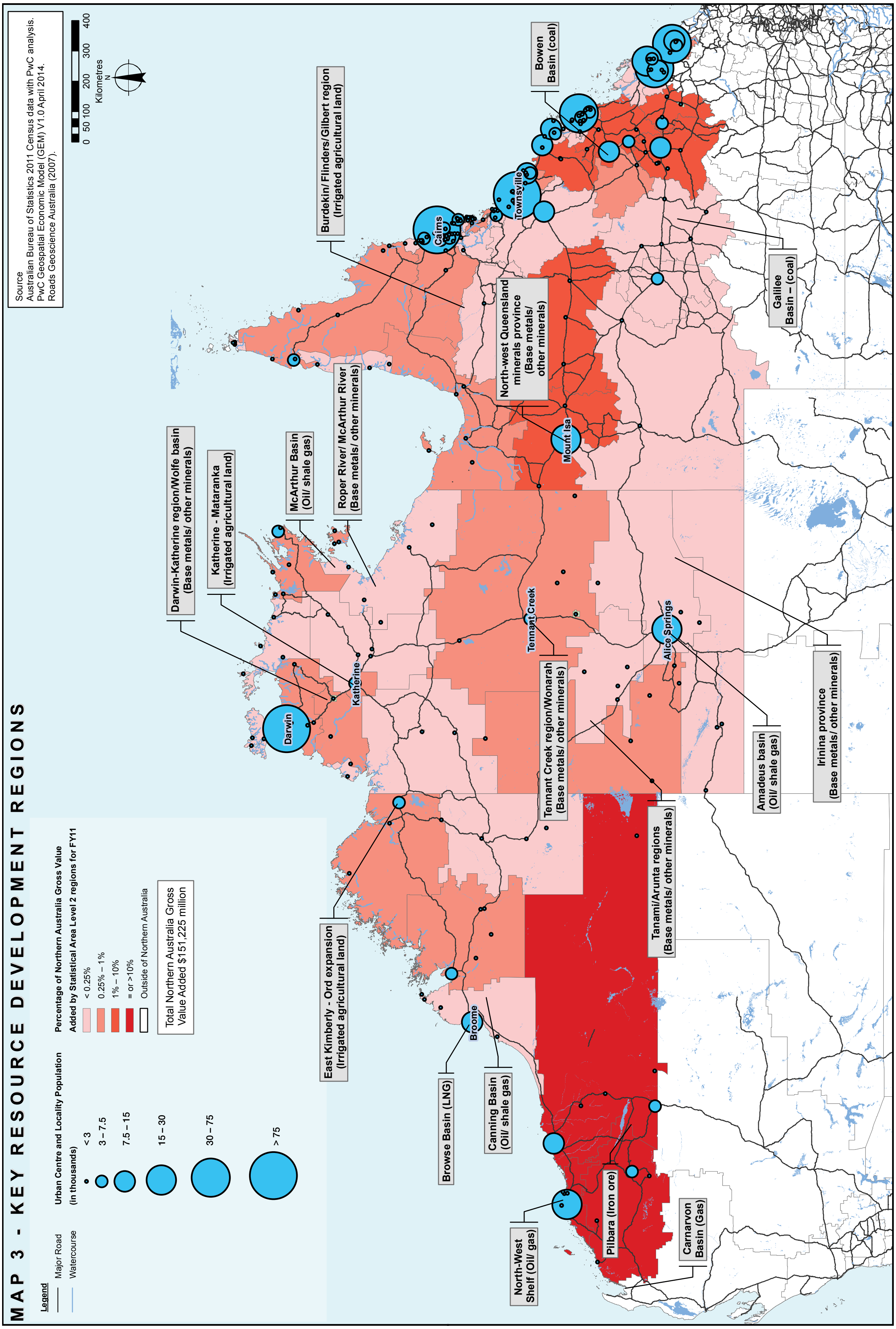
Map 3: Northern Australia urban centres and localities

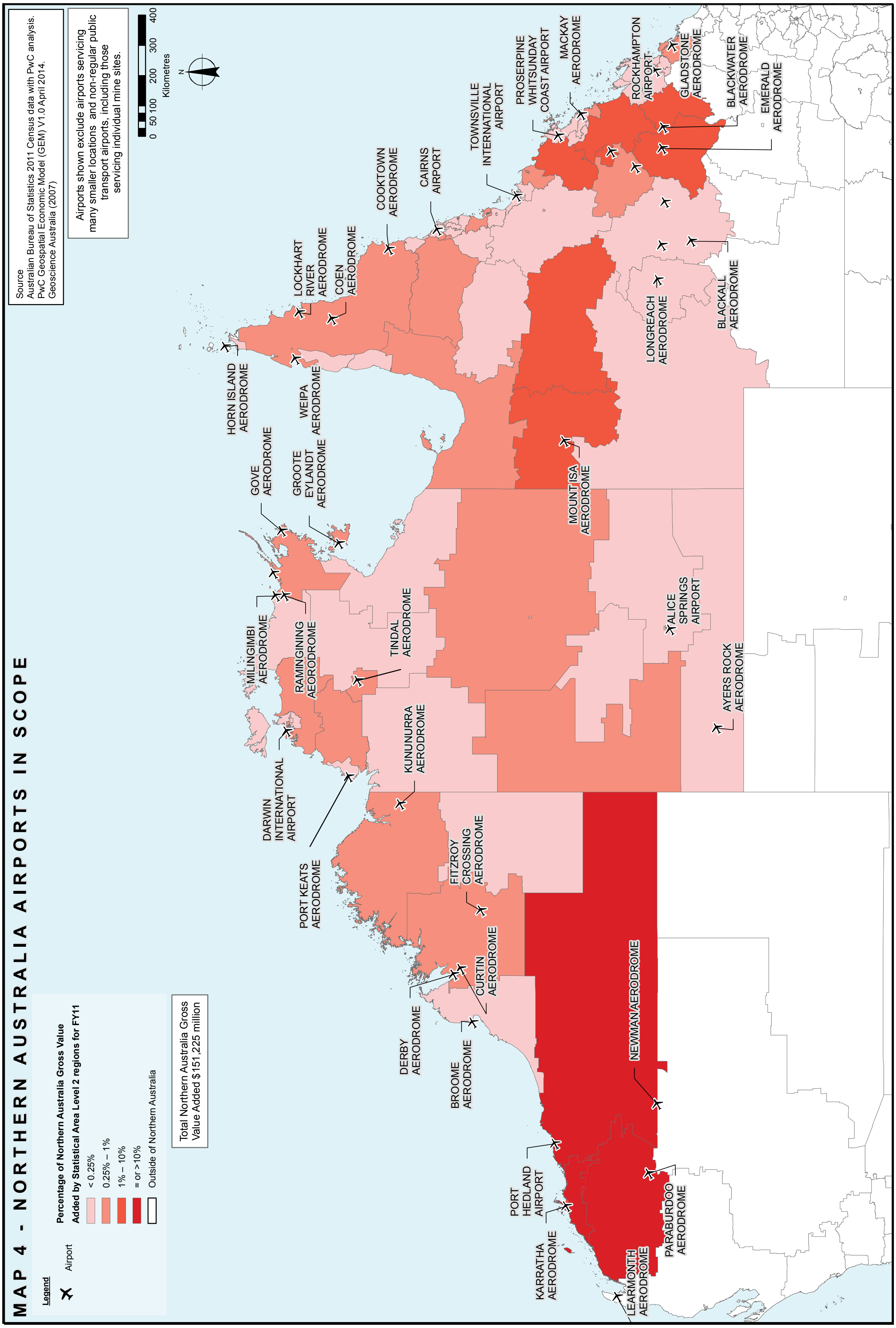


Map 4: Northern Australia regional economies



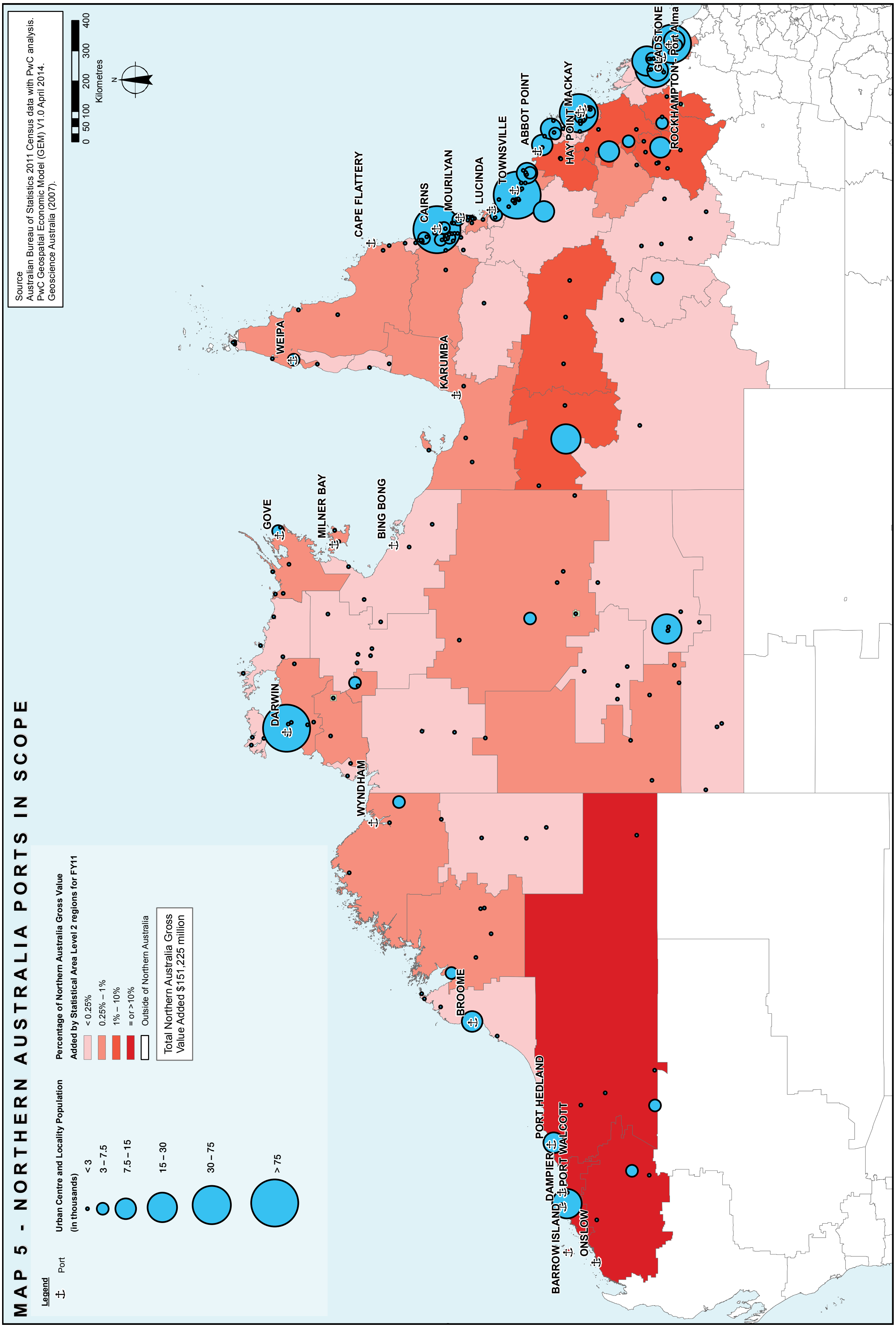
Map 5: Key resource development regions



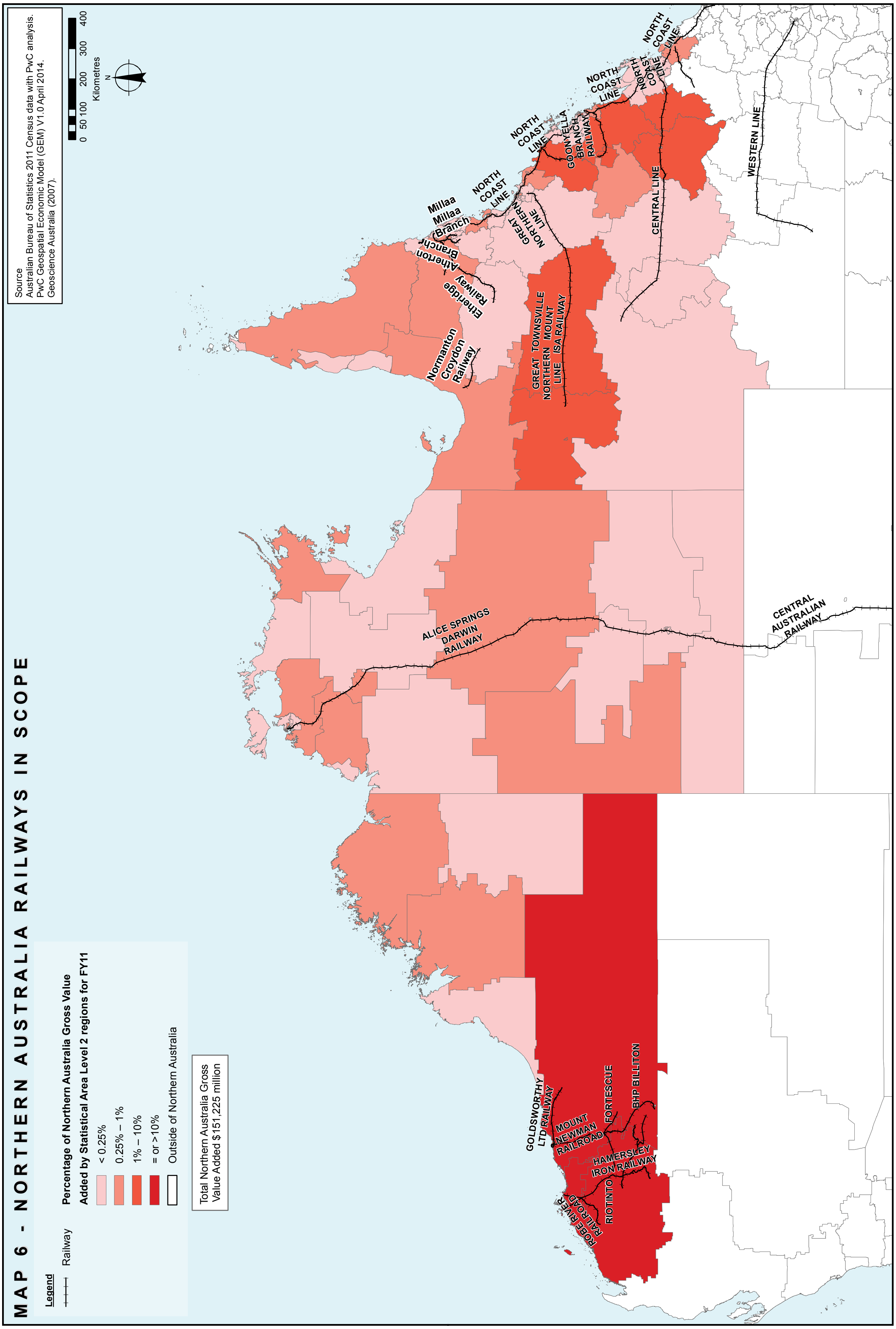


Map 6: Northern Australia airports in scope

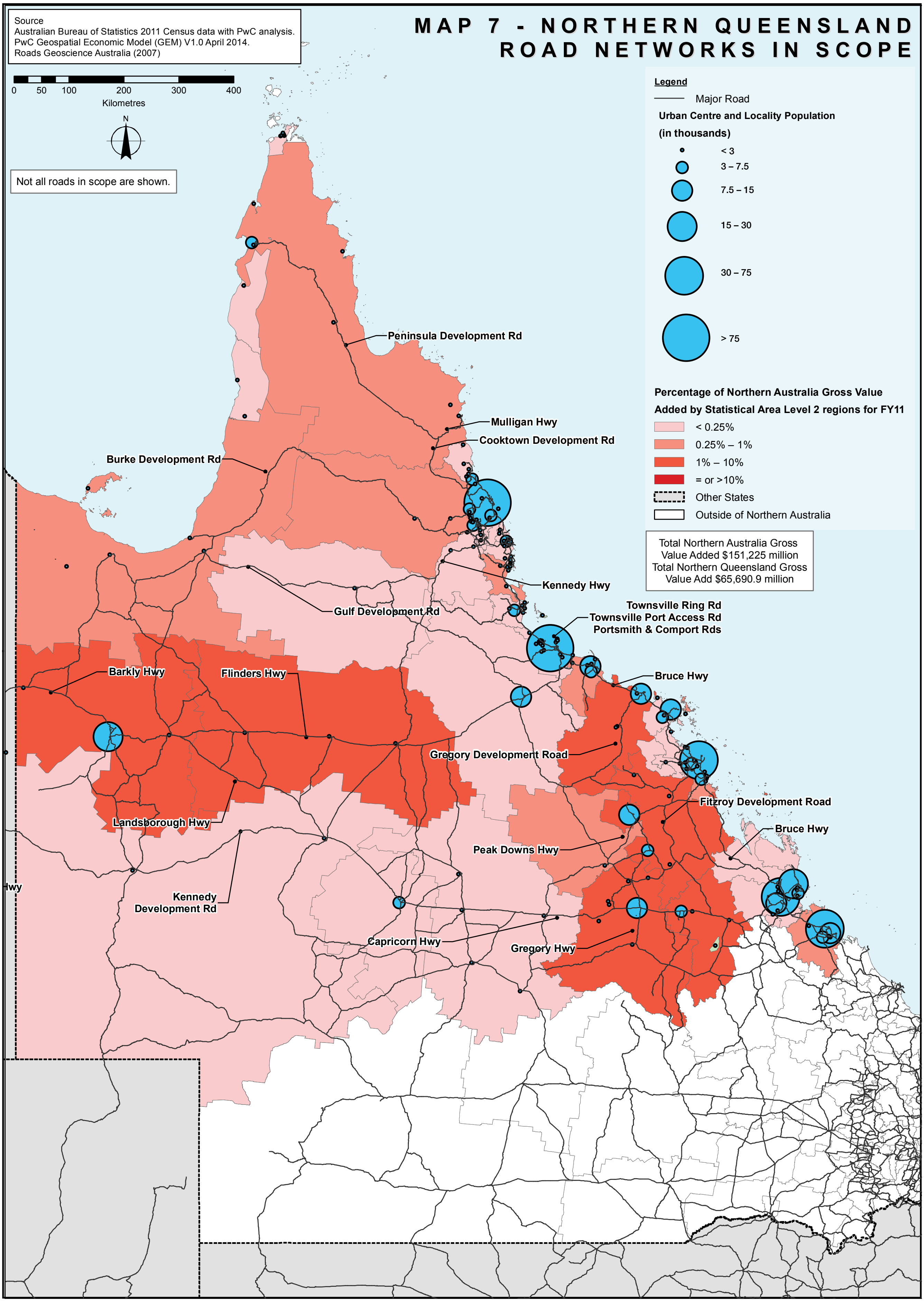
Map 7: Northern Australia ports in scope



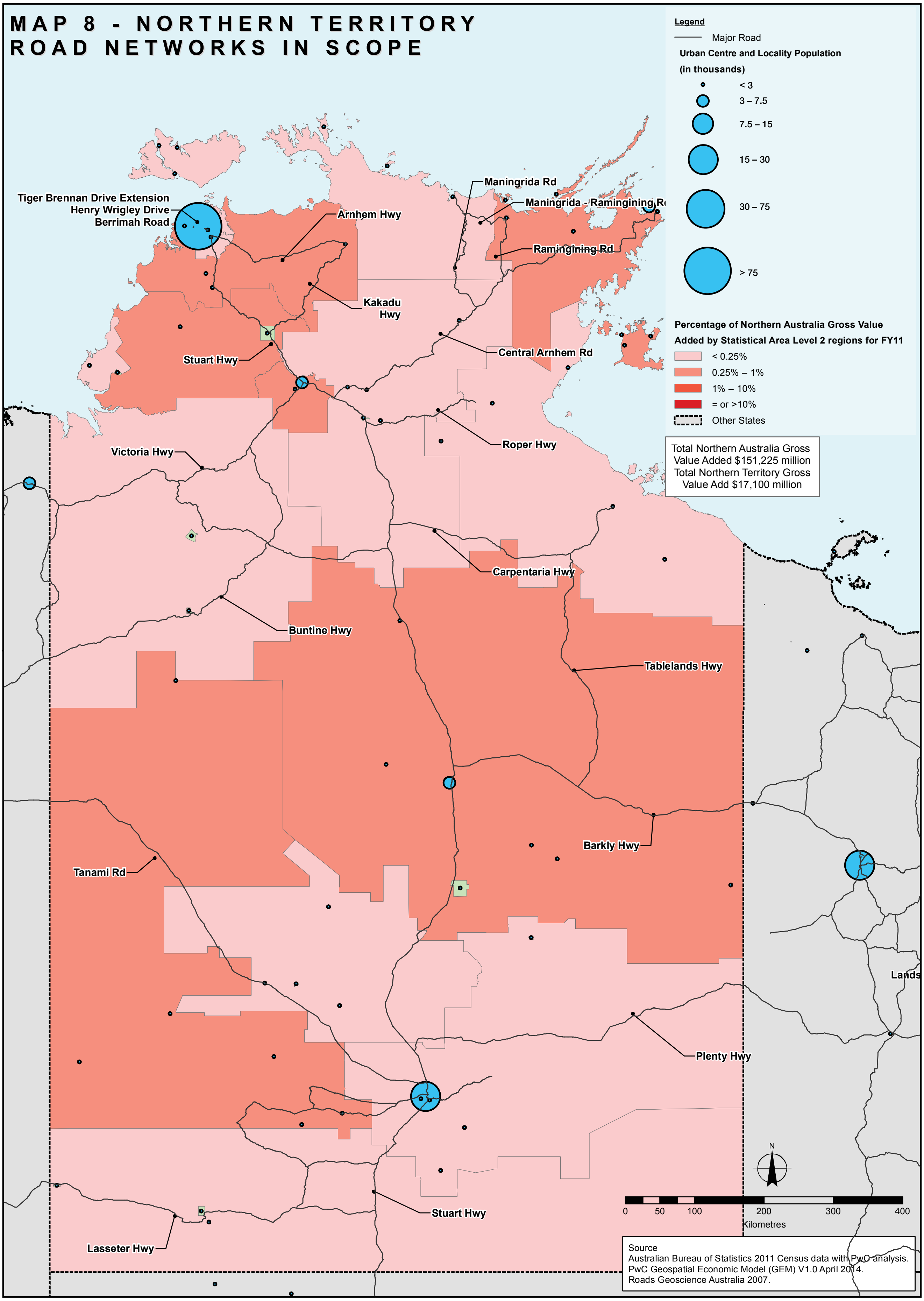
Map 8: Northern Australia railways in scope

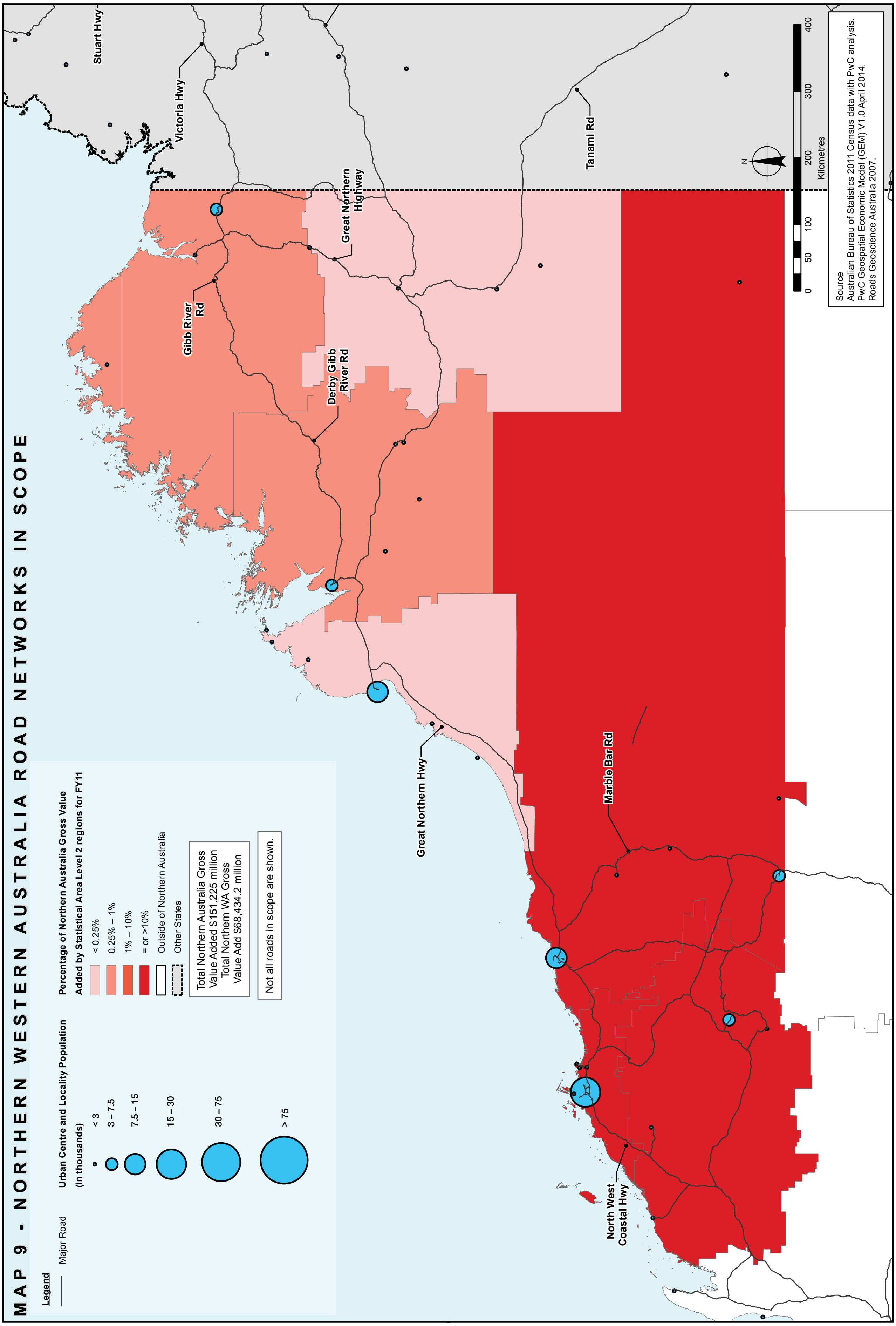


Map 9: Queensland roads in scope



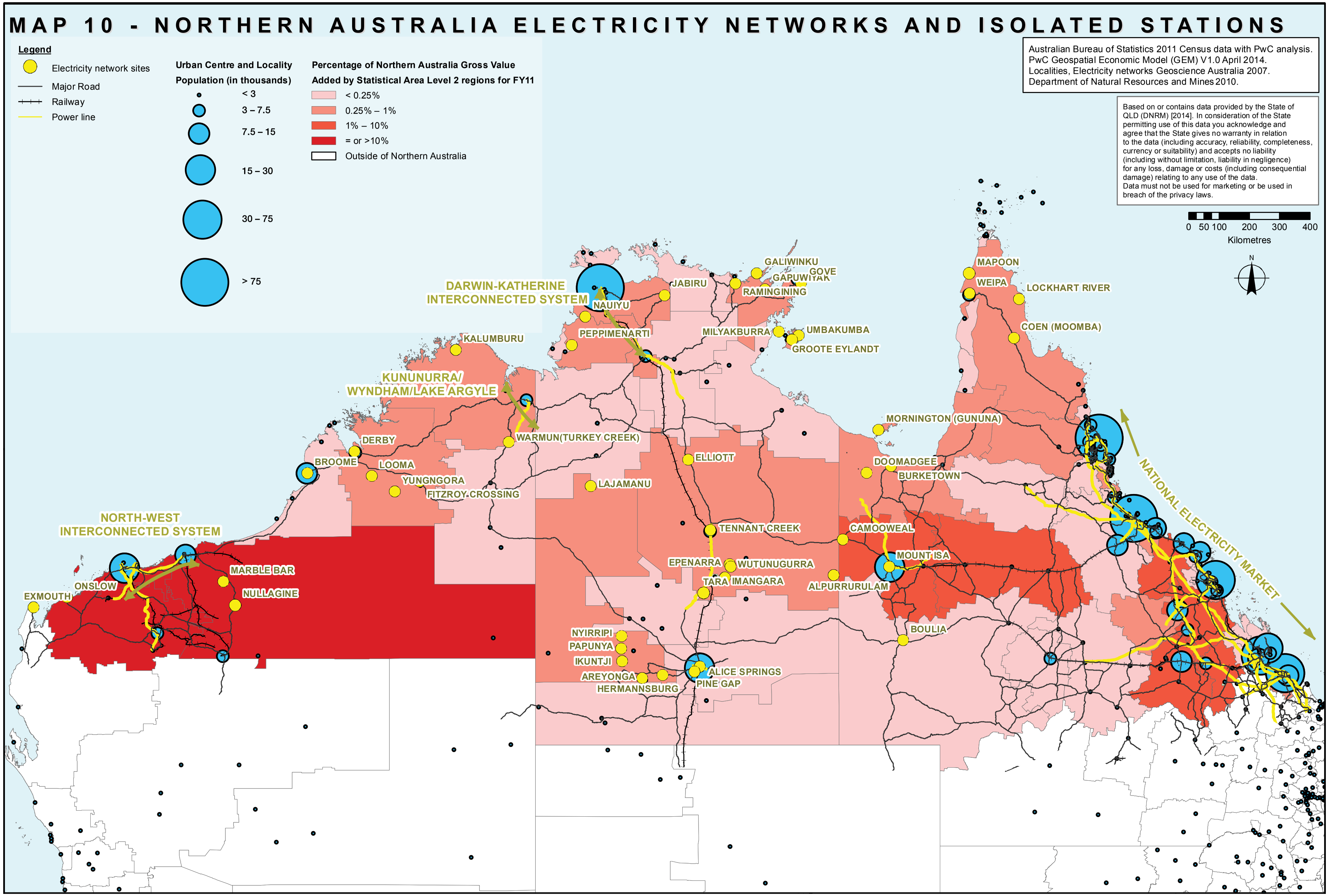
Map 10: Northern Territory roads in scope



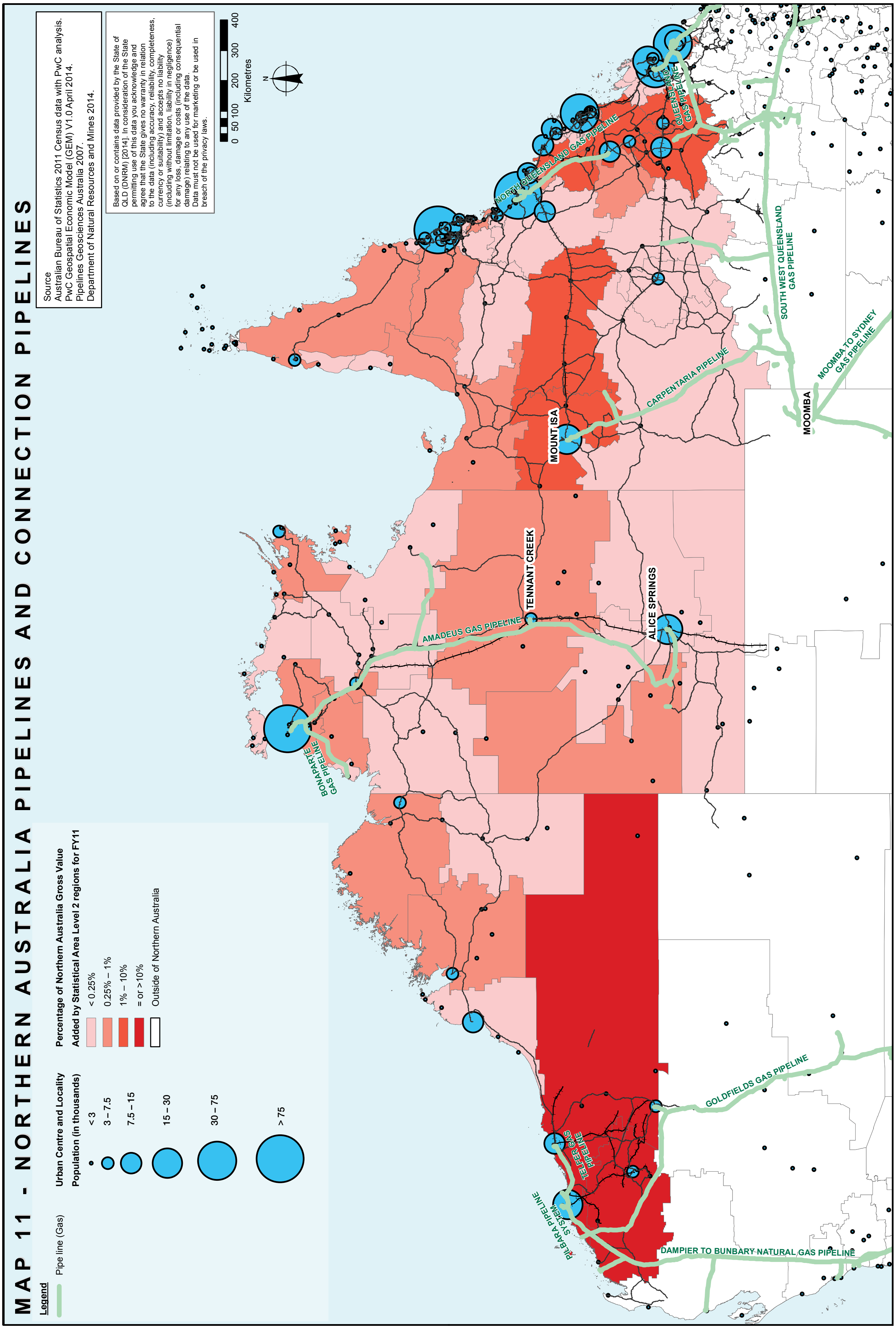


Map 11: Northern Western Australia roads in scope

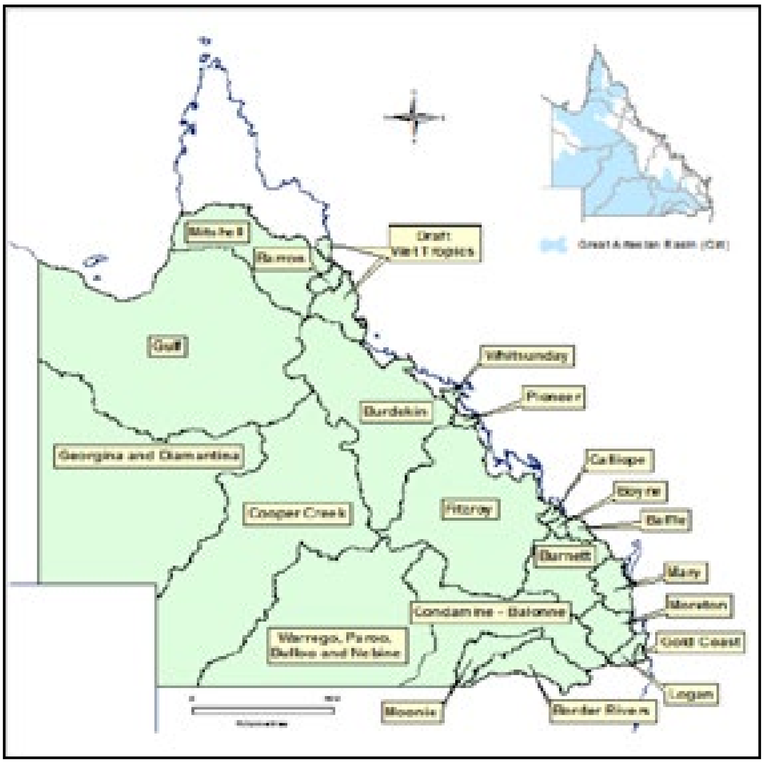
Map 12: Northern Australia electricity networks and isolated stations



Map 13: Northern Australia pipelines and connection pipelines



Map 14: Map of Queensland catchment areas



Note: Cape York, to the north of Mitchell and Barron is shown in white as there is no Resource Operations Plan.
Source: Queensland Department of Natural Resources and Mines

Map 15: Northern Territory water allocation plan areas

Source: Northern Territory Department of Land Resource Management

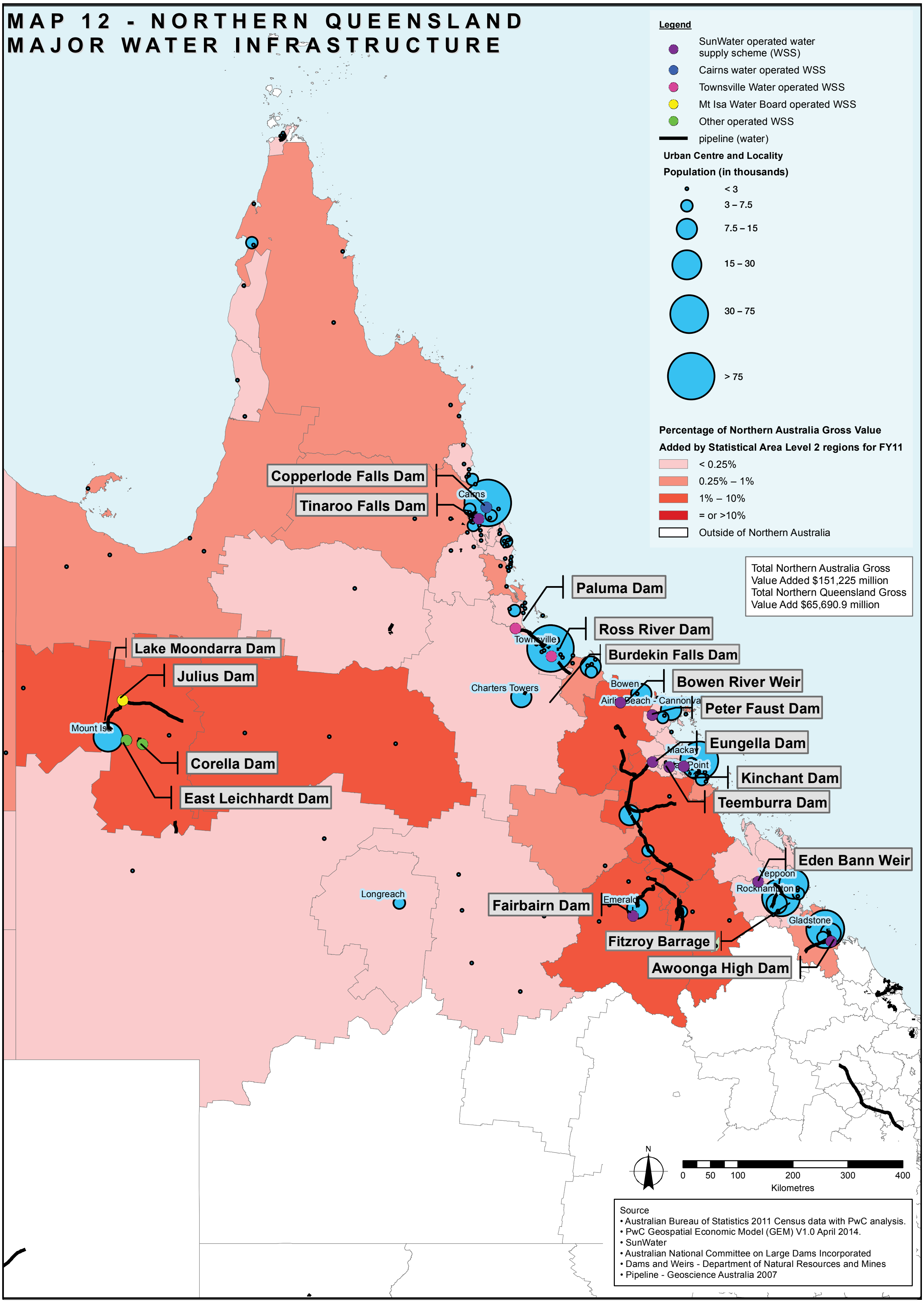
Map 16a: Western Australia groundwater proclamation areas

Source: WA Department of Water

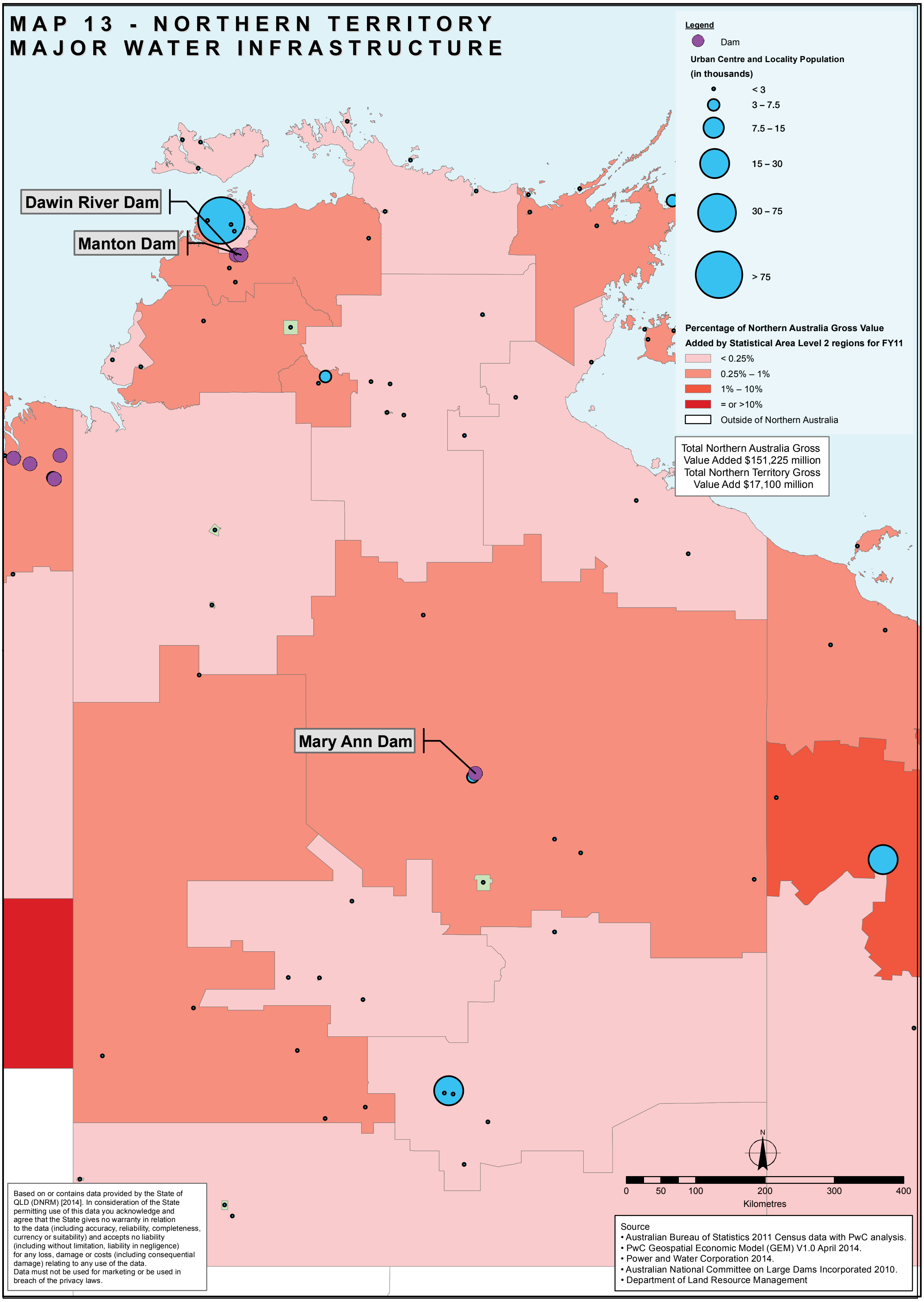
Map 16b: Western Australia surface water proclamation areas

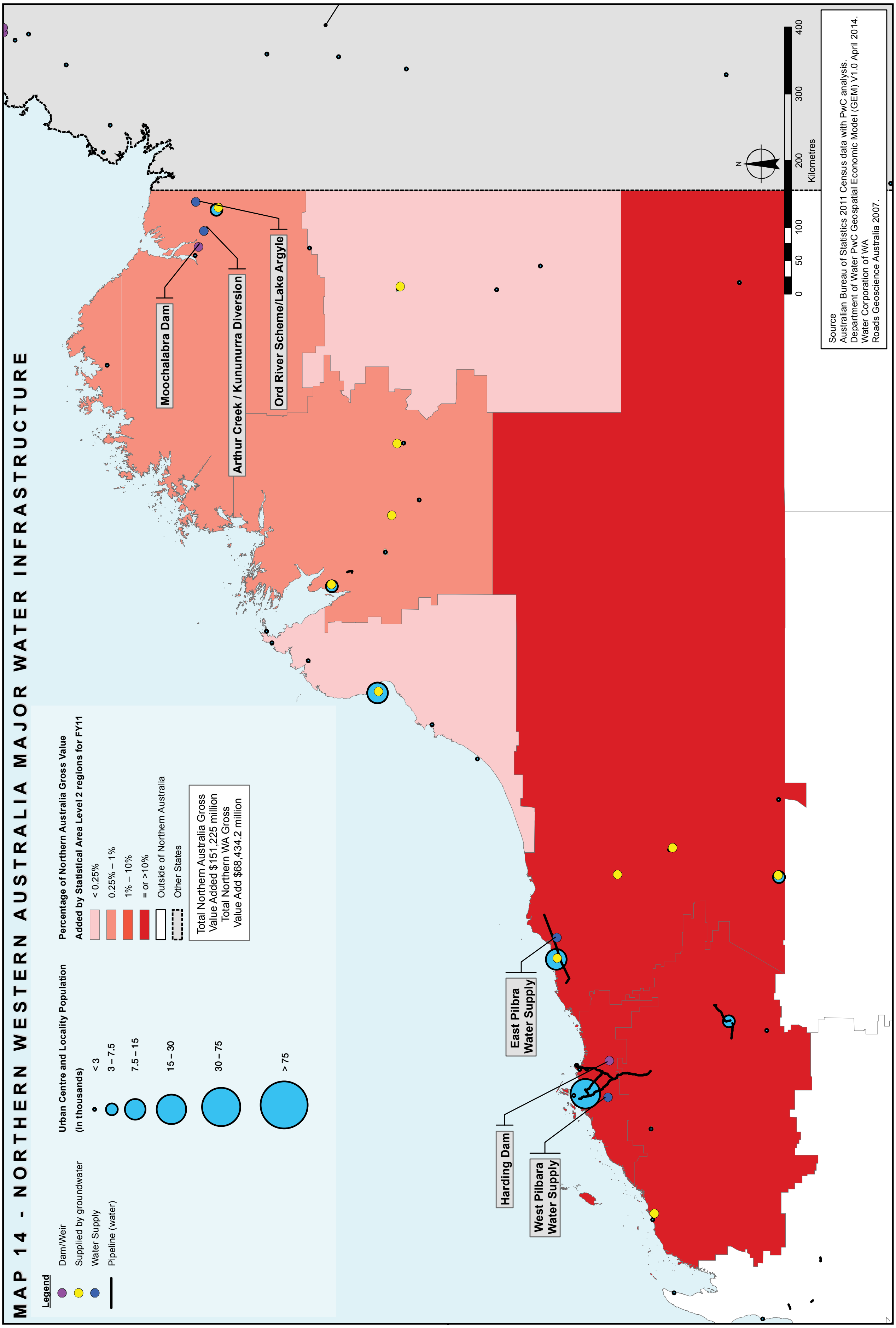
Source: WA Department of Water

Map 17: Northern Queensland major water infrastructure



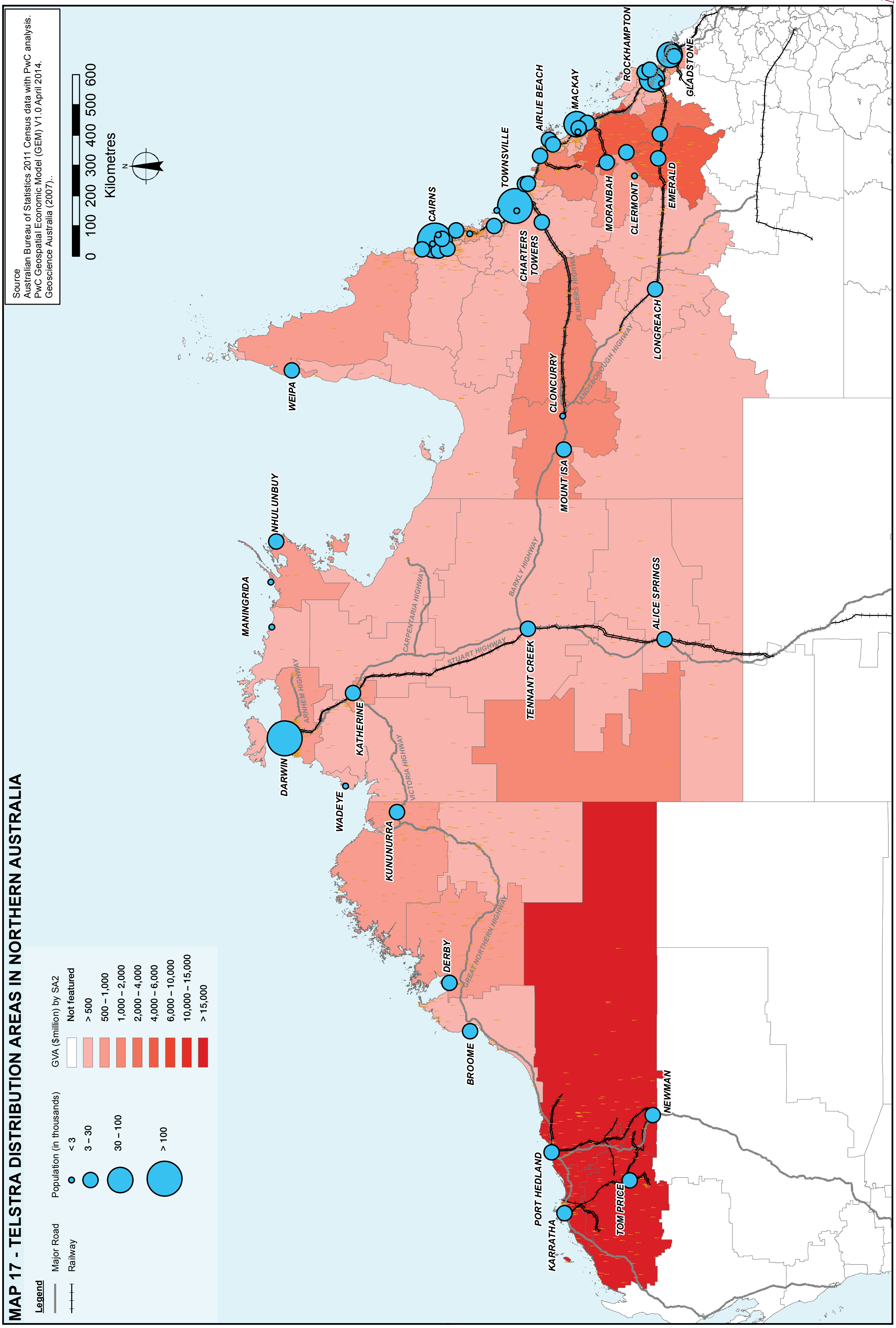
Map 18: Northern Territory major water infrastructure



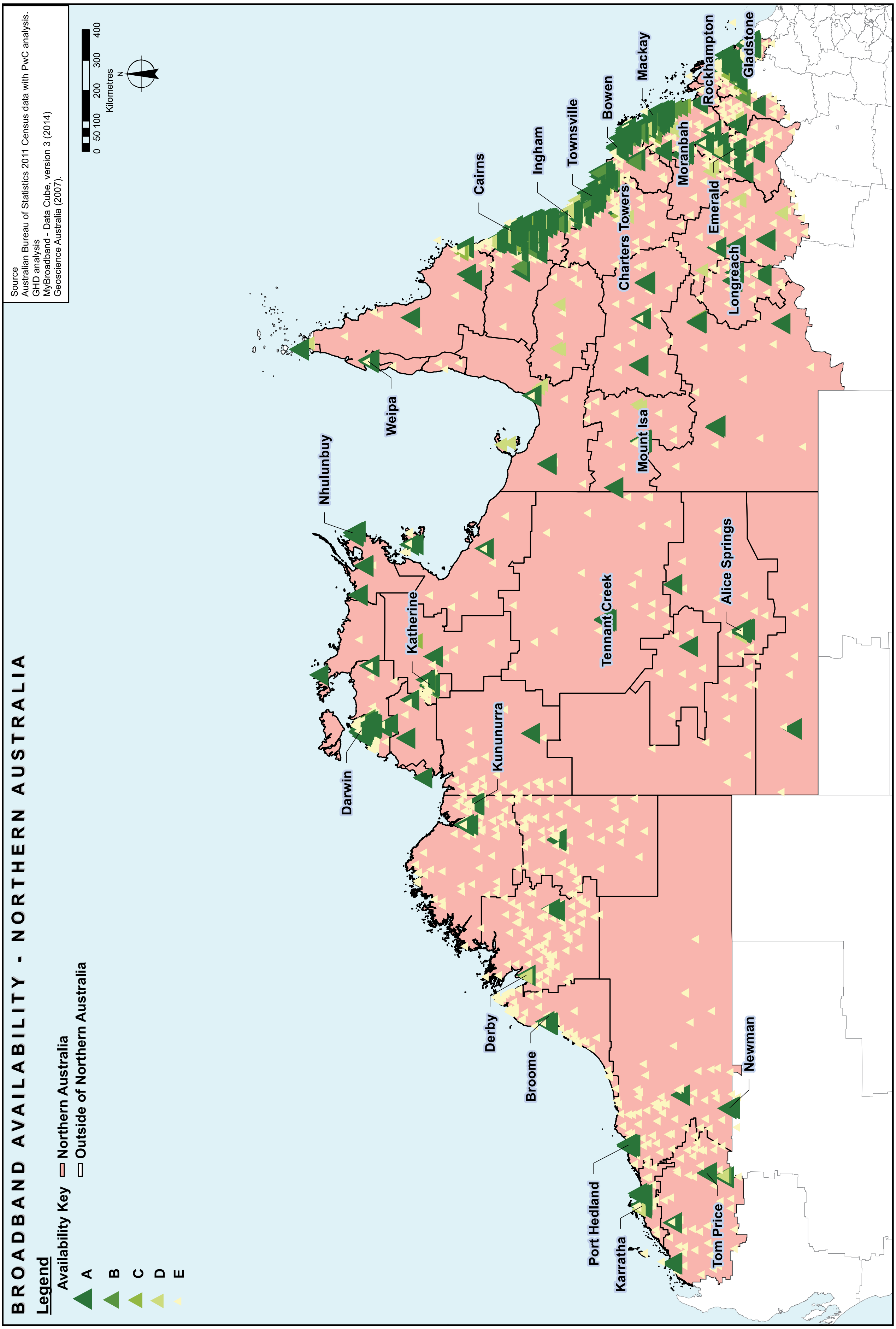


Map 19: Northern Western Australia major water infrastructure

Map 20: Telstra Distribution Areas

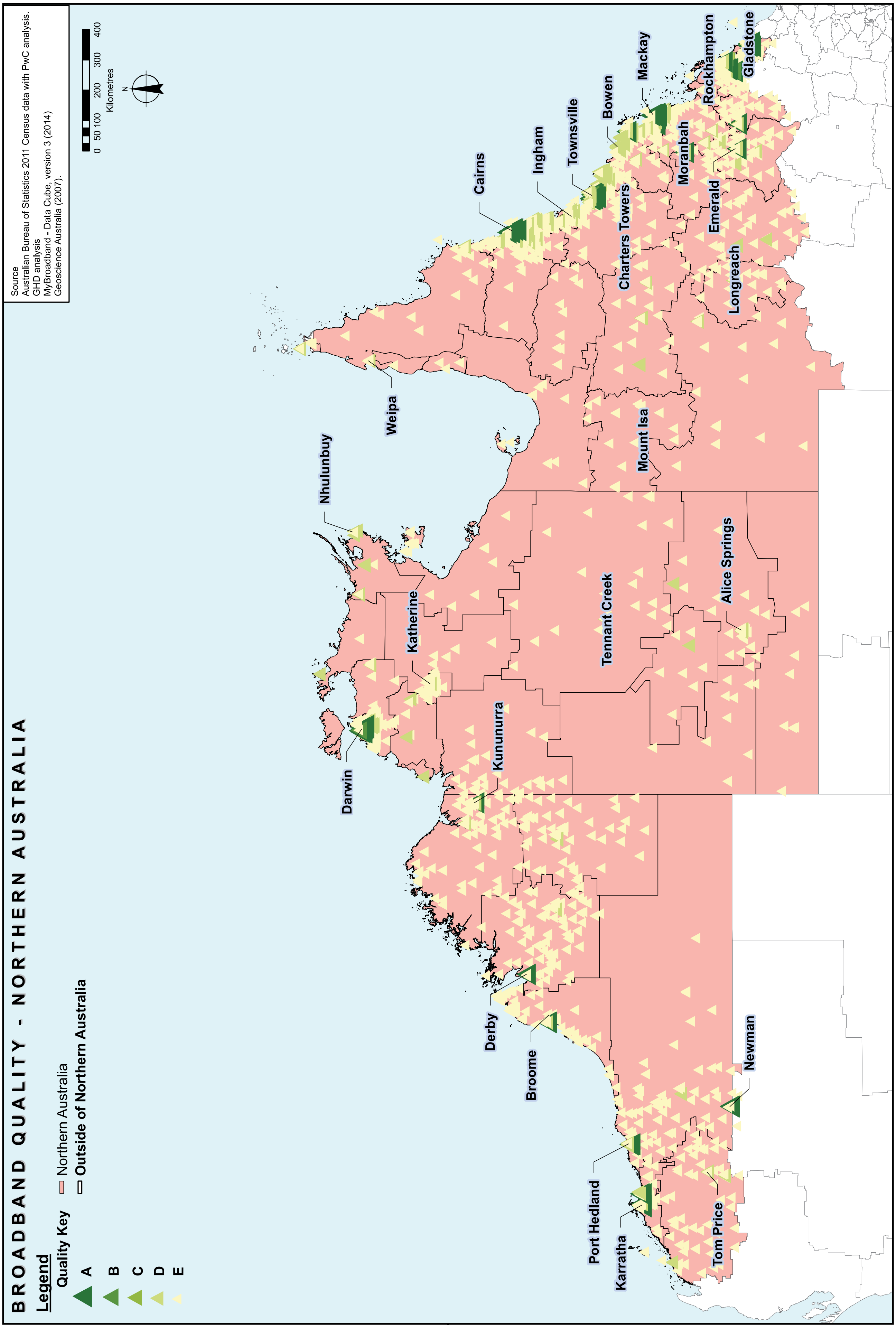


Map 21:

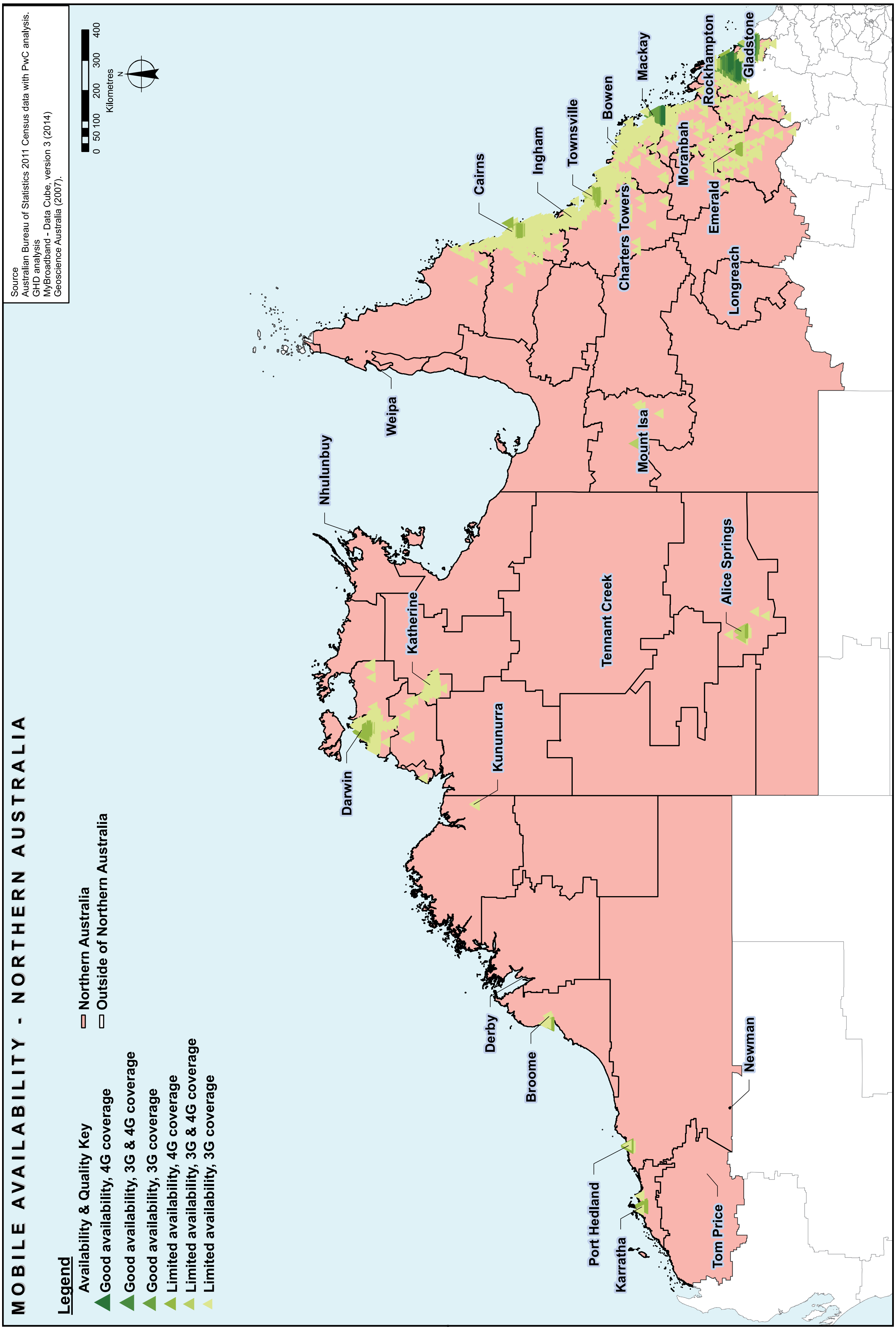


Broadband availability 2014

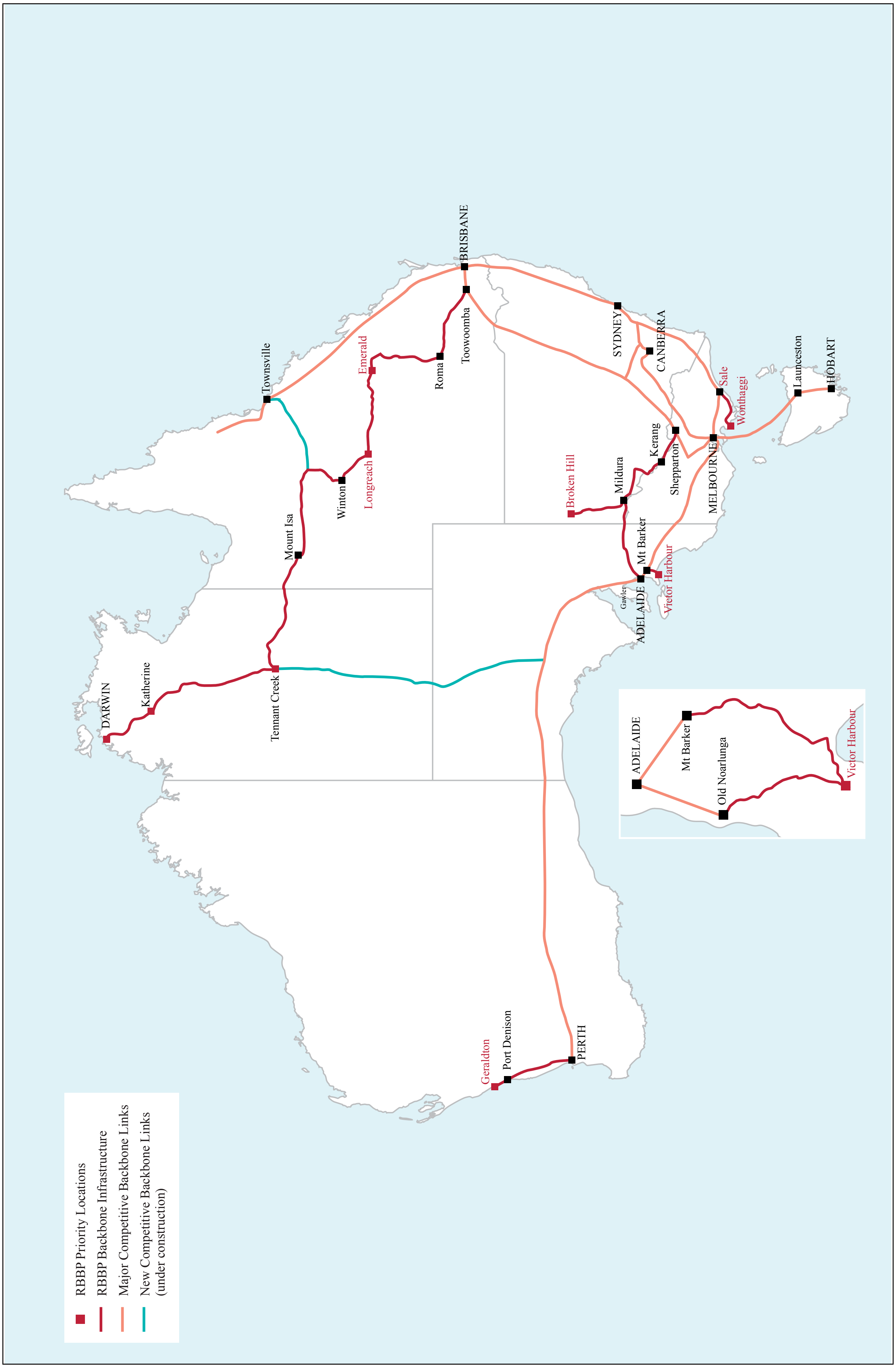
Map 22: Broadband quality 2014



Map 23: Mobile broadband quality and availability across Northern Australia

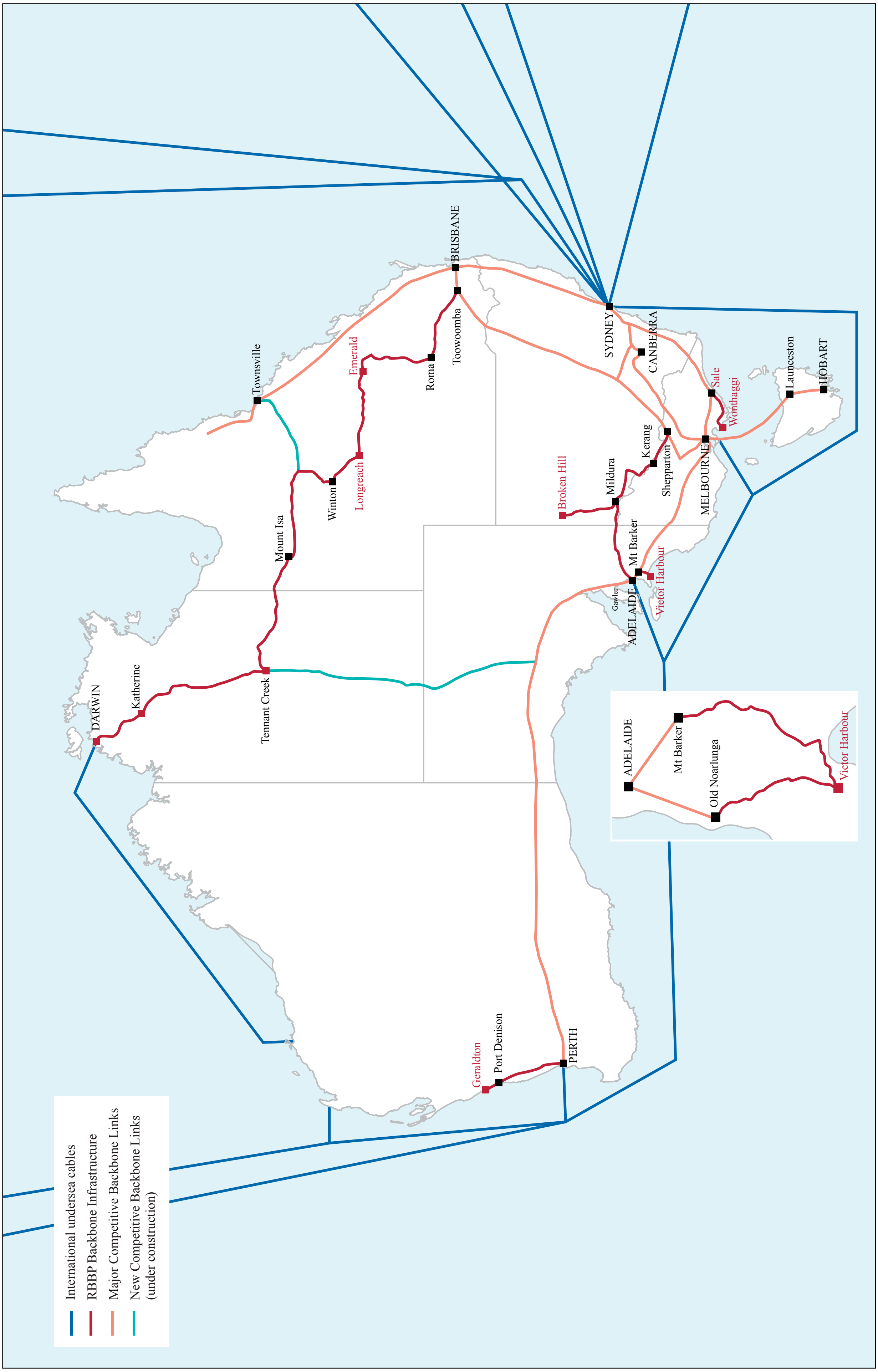


Map 24: Regional Backbone Blackspots Program investment

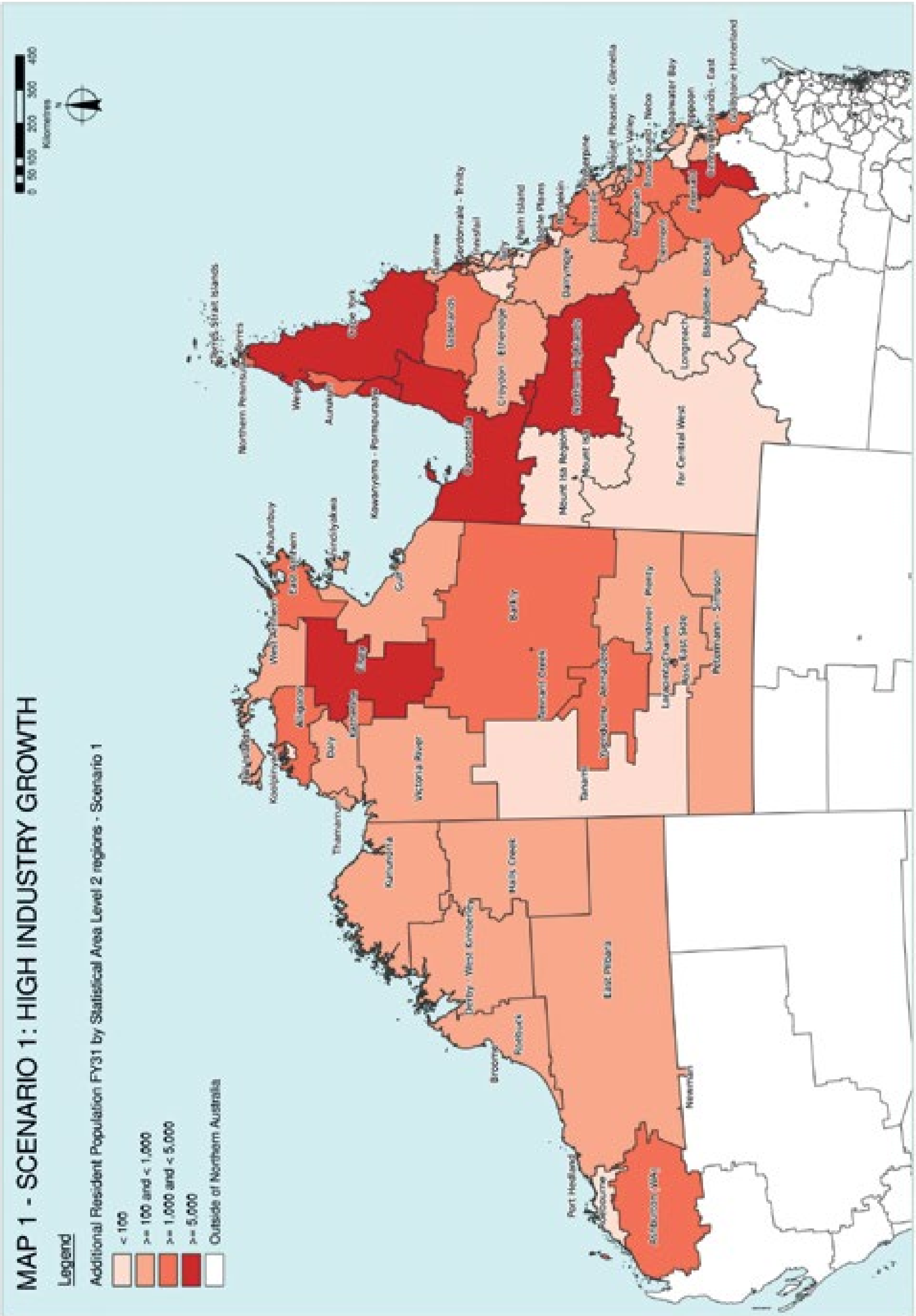


Source: Adapted from Australian National Audit Office (2013)

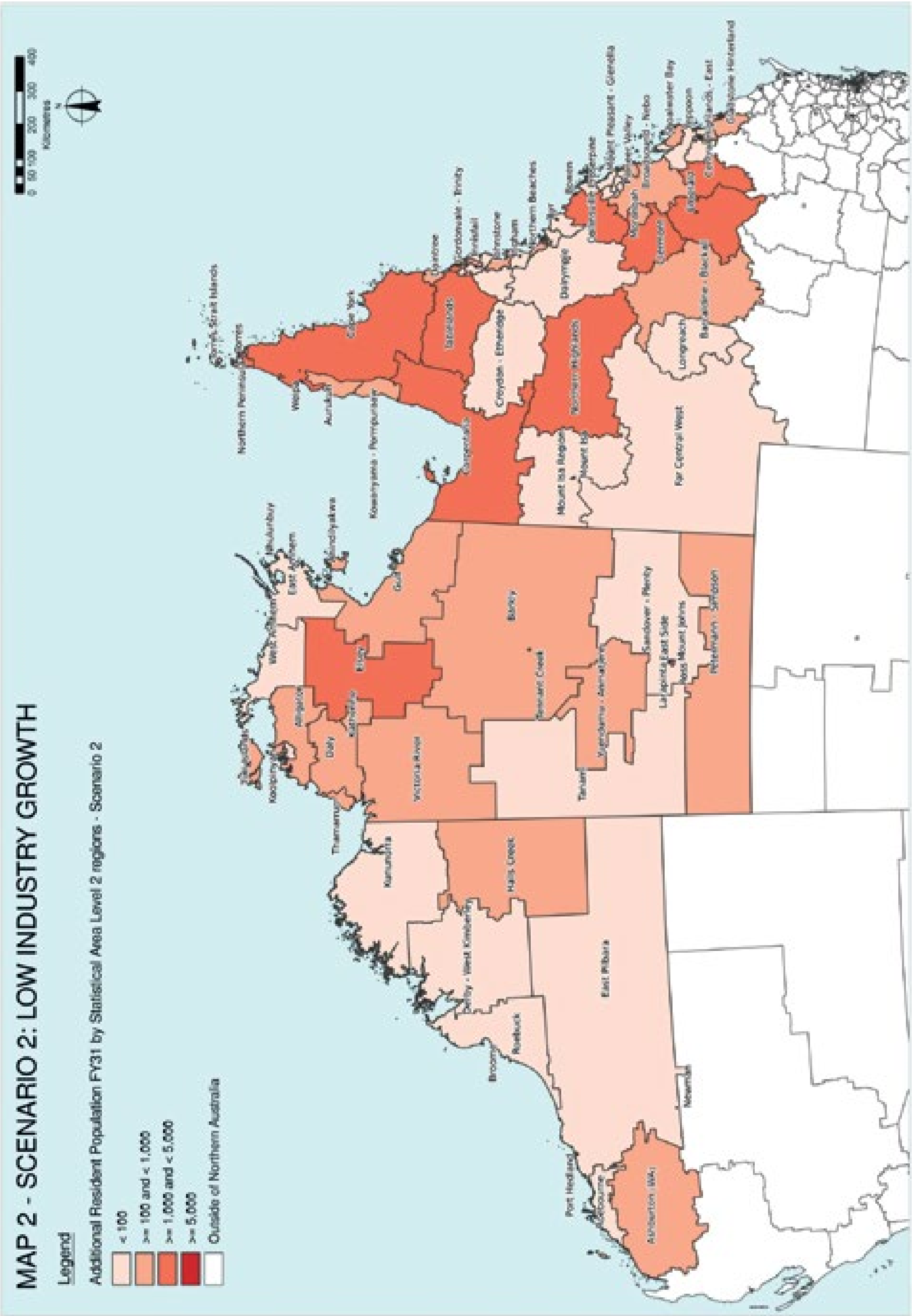
Map 25: Existing and proposed international undersea cables, Australia



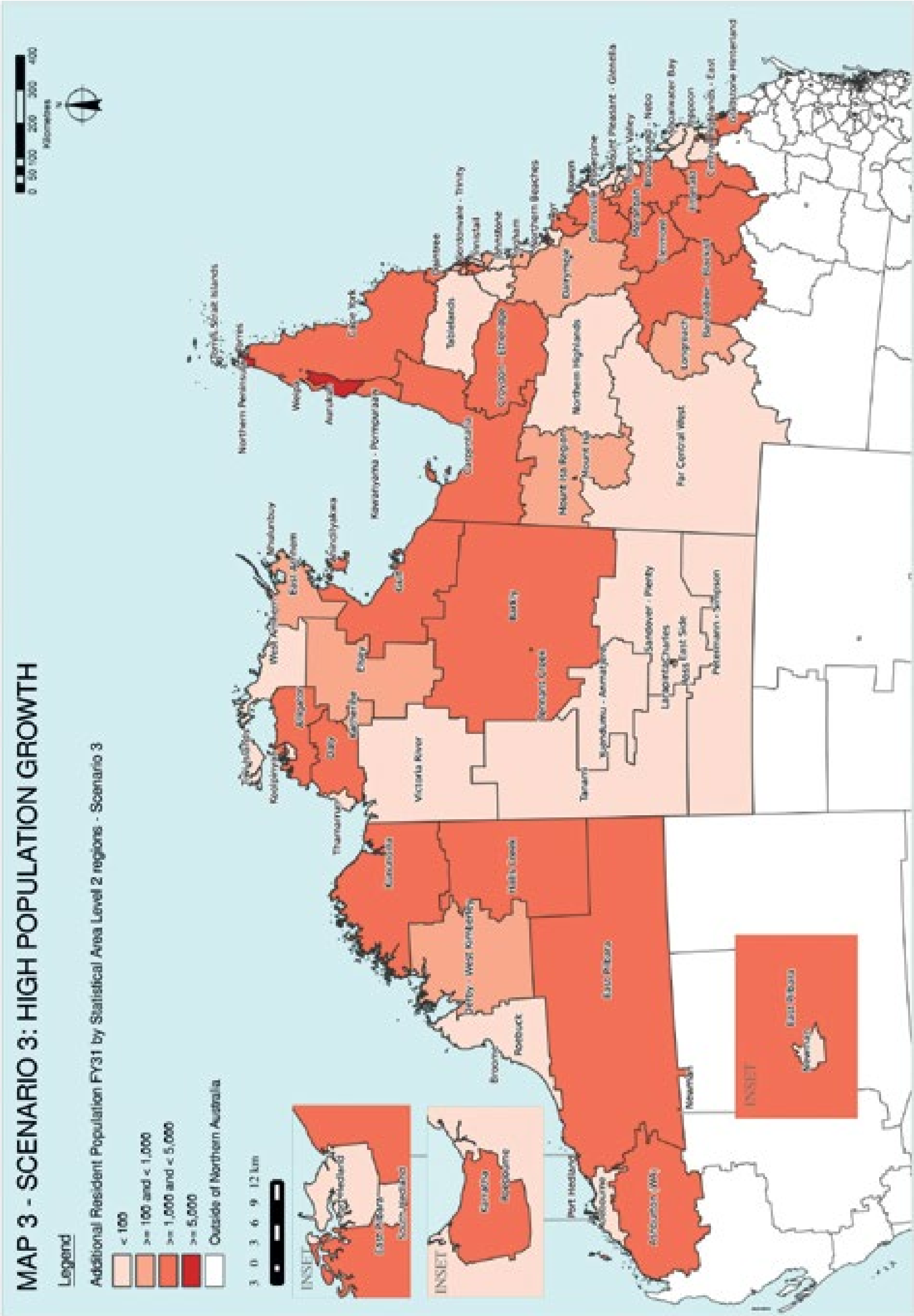
Source: Adapted from Australian National Audit Office (2013) and www.submarinecablemap.com information.



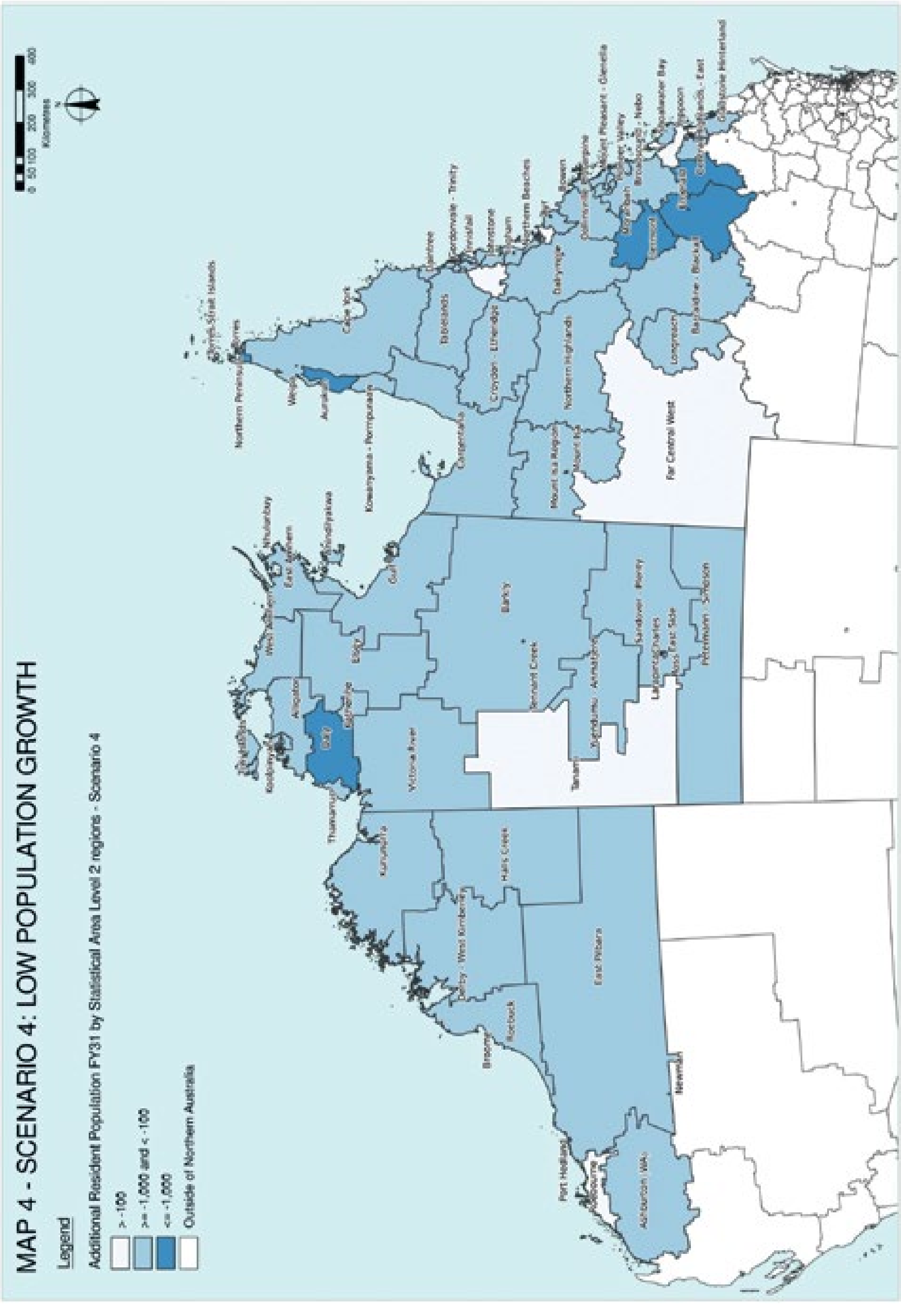
Map 26: Map of absolute population growth in Scenario 1



Map 27: Map of absolute population growth in Scenario 2



Map 28: Map of absolute population growth in Scenario 3



Map 29: Map of absolute population decline in Scenario 4

January 2015

Northern Australia Audit Report

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