Draft NSW Water Strategy submission form

The NSW Water Strategy will be the first 20-year water strategy for all of NSW. It will provide a blueprint to help us tackle the key challenges and opportunities for water management across the state.

For more information about the strategy or to download a copy of the strategy, please visit dpie.nsw.gov.au/nswwaterstrategy.

Your voice is important

We would like to hear your views on the draft strategy, including whether you think it identifies the right priorities, challenges, opportunities and actions.

Please provide your feedback in the submission form below and email your completed submission to nsw.waterstrategy@dpie.nsw.gov.au or post to NSW Water Strategy, Department of Planning, Industry and Environment, Locked Bag 5022, Parramatta NSW 2124 **by 28 March, 2021**.

The form will take approximately 15 minutes to complete and your response can remain anonymous if you wish (see question 1).

Questions marked with an asterisk (*) require an answer.

If you have any questions about making a submission, please email: nsw.waterstrategy@dpie.nsw.gov.au

Making your submission public

We collect information about you, which may include personal information, to assess submissions in response to the department's dealings and activities, and to perform other functions required to complete the project. This information must be supplied. If you choose not to provide the requested information we may not be able to assess your submission.

To promote transparency and open government, we intend to make all submissions publicly available on our website, or in reports. Your name or your organisation's name may appear in these reports with your feedback attributed, unless you have chosen to remain anonymous.

If you would like your submission and/or feedback to be kept confidential, please let us know when making your submission. You will be asked for your confidentiality preference at question 1.

If you request that your submission be kept confidential, it will not be published on our website or included in any relevant reports. However, it will still be subject to the *Government Information Public Access Act 2009*.

Your submission will be stored securely consistent with the department's Records Management Policy and you have the right to request access to, and correction of, your personal information held by the department.

Further details can be found in our privacy statement available on our website. industry.nsw.gov.au/privacy

Draft NSW Water Strategy

Submission form

1. Information on confidentiality and privacy*

I give permission for my submission to be made publicly available on the NSW Department of Planning, Industry and Environment website.

- (●) Yes
- ( ) No

I would like my personal details to be kept confidential.

- ( ) Yes
- (●) No

2. Your details

Name* Peter Rochlin

Contact phone number* +61414252535

Postcode* 2093

Email address* peterrochlin@optusnet.com.au

Do you identify as an Aboriginal person?

- ( ) Yes
- (●) No

Are you an individual or representing an organisation?*

- (●) Individual
- ( ) Organisation

3. Organisation or business details

Who do you represent?

- ( ) Government — Please specify
- ( ) Peak representative organisation — Please specify
- ( ) Local Water Utility
- (●) Other (please specify) — Author of a drought proofing scheme

4. Draft vision

The NSW Government has developed the draft NSW Water Strategy as part of a suite of long-term strategies to maintain the resilience of the state's water services and resources over the coming decades.

The proposed vision for the draft NSW Water Strategy is sustainable water resources for thriving people, places and ecosystems, both now and for future generations.

Which aspects of water management are most important to you and your local community?

Harvesting excessive rainfall

Do you support the proposed vision for the draft NSW Water Strategy?

- (●) Yes
- ( ) No

Please tell us more about your response:

Full submission titled Burdekin Murray Scheme, v29 dated 28th March 2021, is submitted under separate cover

5. Draft objectives

The draft NSW Water Strategy sets high level objectives and principles to guide water service delivery and resource management across NSW. We have identified six core objectives which underpin the draft strategy. These are based on the *Water Management Act 2000.* They are:

- protecting public health and safety
- liveable and vibrant towns and cities
- water sources, floodplains and ecosystems protected
- cultural values respected and protected
- orderly, fair and equitable sharing of water
- contribute to a strong economy.

Which objectives are most important to you?

Please rank the objectives from most important to least important (where 1 is most important and 6 is least important).

Protecting public health and safety

Liveable and vibrant towns and cities

Water sources, floodplains and ecosystems protected

Cultural values respected and protected

Orderly, fair and equitable sharing of water

Contribute to a strong economy

Do you have any comments on any of the proposed objectives?

6. Draft guiding principles

The draft strategy also proposes seven principles to guide the long-term strategic planning for water resource management in NSW. These principles work in tandem with the draft objectives to guide development and implementation of actions.

The guiding principles are:

- healthy environments sustain social and economic outcomes
- water is a limited (although recyclable) resource
- systems thinking to optimise outcomes
- data-enabled planning and decision-making
- transparency and accountability to engender community trust
- forward thinking to build preparedness and resilience
- giving effect to Aboriginal rights and access to water.

Which principles are most important to you?

Please rank the objectives from most important to least important (where 1 is most important and 7 is least important).

Healthy environments sustain social and economic outcomes

Water is a limited (although recyclable) resource

Systems thinking to optimise outcomes

Data-enabled planning and decision-making

Transparency and accountability to engender community trust

Forward thinking to build preparedness and resilience

Giving effect to Aboriginal rights and access to water

Do you have any comments on any of the guiding principles?

7. Opportunities, challenges and actions for improved state-wide water management

The draft NSW Water Strategy outlines seven strategic priorities for action, focused on meeting the core objectives based on the *NSW Water Management Act 2000.* These strategic priorities are:

1. Build community confidence and capacity through engagement, transparency and accountability
2. Recognise Aboriginal rights and values, and increase access to and ownership of water for cultural and economic purposes
3. Improve river, floodplain and aquifer ecosystem health, and system connectivity
4. Increase resilience to changes in water availability (variability and climate change)
5. Support economic growth and resilient industries within a capped system
6. Support resilient, prosperous and liveable cities and towns
7. Enable a future focused, capable and innovative water sector.

Under each priority the draft strategy identifies several opportunities and challenges, and a total of 41 proposed actions to improve water management across the state.

Do you have any comments on the seven strategic priorities identified?

Do you have any comments on any of the proposed actions identified?

Are there any additional opportunities, risks and challenges that should be considered in the draft strategy?

What actions should be prioritised for immediate implementation and how should they be implemented?

8. Other comments

Do you have any other comments on the draft NSW Water Strategy?

9. How did you hear about the opportunity to provide feedback on the draft NSW Water Strategy?

Please select all that apply from the list below:

- ☐ Newspaper
- ☐ Radio
- ☐ Department of Planning, Industry and Environment website
- ☐ Direct email
- ☐ Social media
- ☐ Have your say NSW website
- ☑ Word of mouth
- ☐ Other (please describe)

A Sustainable Water Security Solution with Environment Protection

Burdekin Murray Scheme

Water where we want it   *Jobs when we need them*

MEMORANDUM OF INFORMATION

Australian Infrastructure Solutions
March 2018,

Issue v29 updated 28th March 2021

Australian Infrastructure Solutions

SMEC   Cardno   SOLASTOR

The Burdekin Murray Scheme

A Sustainable Water Security Solution with Environment Protection

- *Redirects surplus water, currently lost to the ocean, to the worst drought affected regions in eastern Australia*
- *The Burdekin Murray Scheme will balance the needs of water delivery and environmental protection.*
- *Delivers 5 million MLpa of additional water (10 Sydney Harbours) or, about 90% of the average, annual water use in the Murray Darling Basin;*
  2006 to 2018, 5.6 million MLpa.
- *Eliminates fish kills in all major rivers west of the Great Dividing Range.*
- *Delivers water for half of the Ramsar wetlands on the Australian mainland.*
- *Provides 2,500 water holes and crossings for fauna along canal route.*
- *Significantly mitigates the intensity of major flooding of the Lower Burdekin River reducing serious flooding by 60% in the Lower Burdekin River.*
- *Reduces Great Barrier Reef pollutants and ensures a regular flow of fresh, clean water necessary for the reef and its ecosystems.*
- *Restores heritage, cultural and recreational river precincts for Aboriginal people.*
- *All energy required, 5,800 GWh pa, from Solar plus a new Hydro Power Station which can deliver 600 GWH pa, enough to power 120,000 homes.*
- *Avoids emissions of 4 million tonnes of greenhouse gases per year by utilizing:*
  - *i) Solar and Hydro Energy; for all water pumping*
  - *ii) Gravity; for water flow in all canals*
- *Facilitates decentralization and the creation of 180,000 full-time jobs.*
- *Requires no new dams. Additional land for the dam reservoir amplification already owned by Government.*

Contents

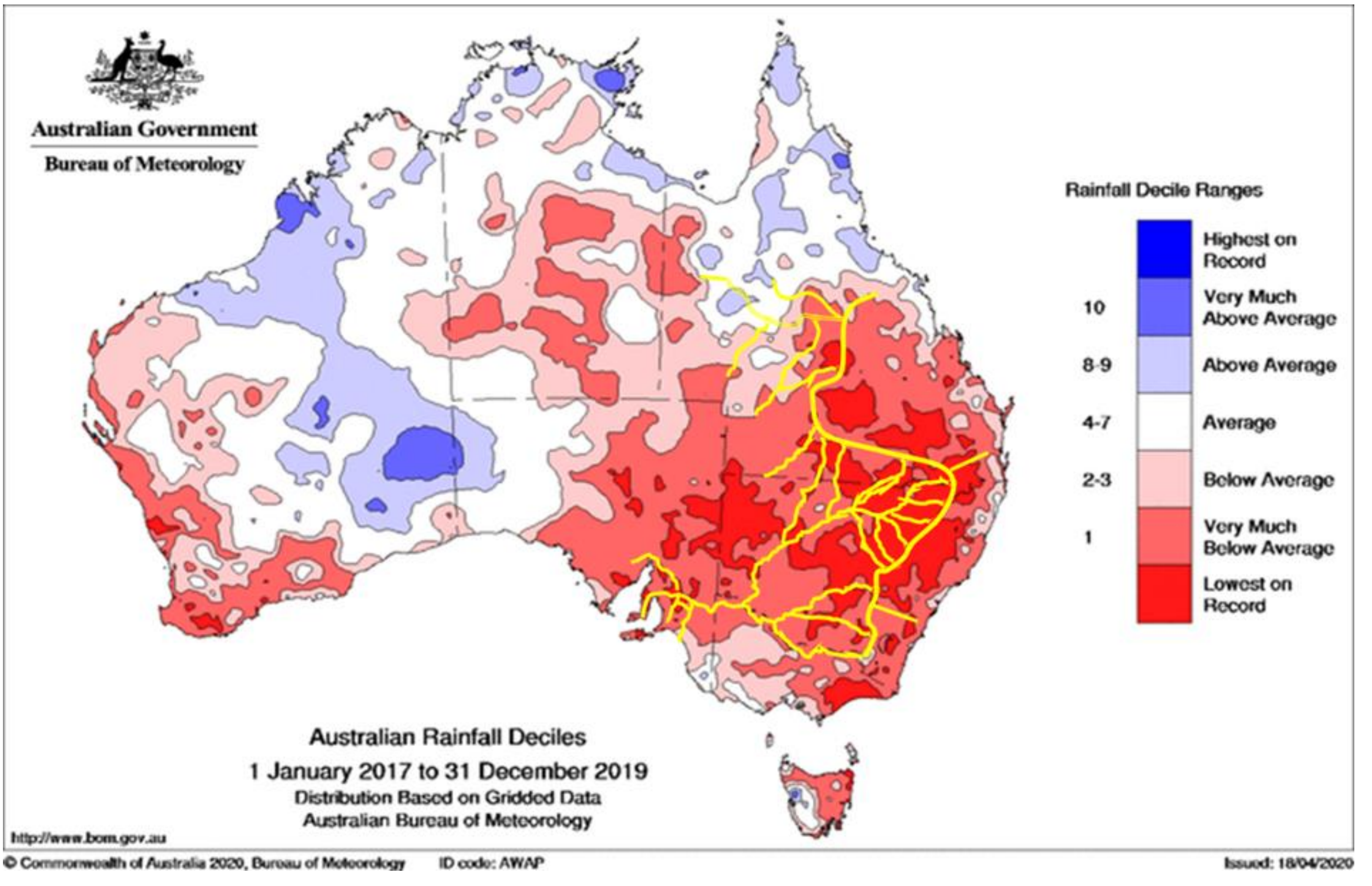
PART 1 — THE PROPOSAL

Executive summary

Introduction

The Burdekin Murray Scheme (shown in yellow) is a proposal to capture and distribute excess, unused runoff from North Queensland to the historically, worst affected, drought regions of South East Australia.

The scheme, which has been developed by a team of experienced engineers, is an innovative, cost effective solution for making these regions permanently drought resistant.
The Burdekin Murray Scheme (BMS) will balance the needs of water delivery and environmental protection.

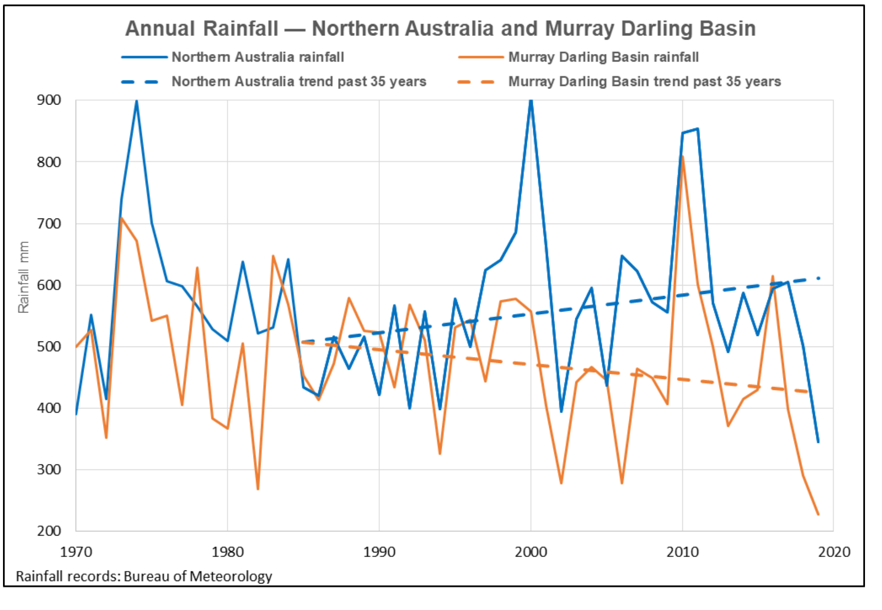


Need for the project

A. Changing weather patterns

Droughts across South East Australia are forecast to increase in frequency and severity accompanied by decreasing rainfall. Inflows are forecast to reduce from 20% to 40% over the next 50 years.

In spite of significant rainfalls during 2020/21, February 2021 NSW storage levels were 51% and 67% of Queensland was drought declared.



B. Economic stimulus

The BMS will create massive immediate and long-term employment and lift Australia's GDP by $14bn per annum.

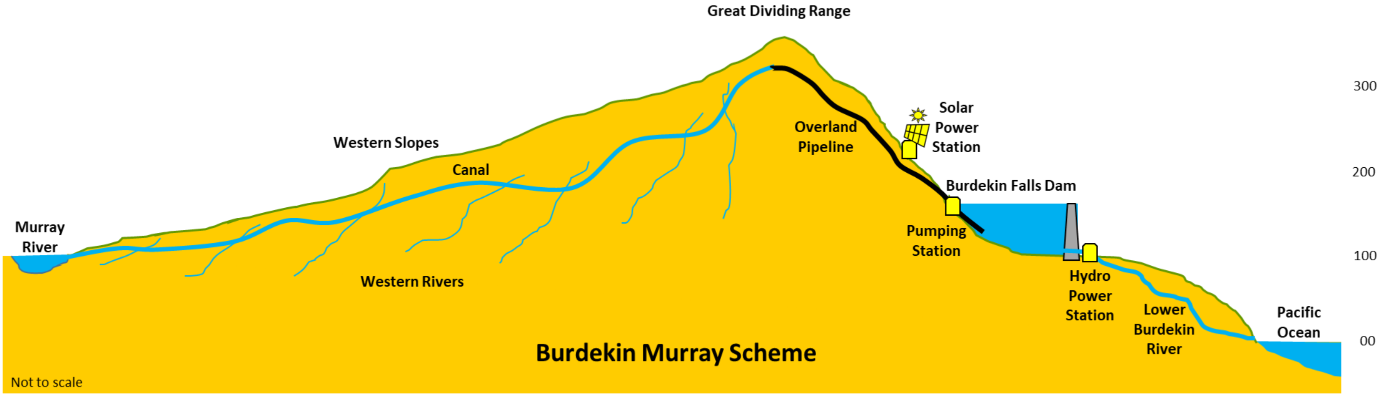
The Burdekin Catchment, the water source for the BMS

- This catchment is about twice the size of Tasmania and has an inflow from monsoonal rain runoff 3 times that of the Snowy Mountains catchment. Runoff is collected by the Burdekin Falls Dam, located at the centre of the catchment, on the Burdekin River.
- The Burdekin River has the highest peak discharge, by volume, of all Australian rivers.

The Burdekin Falls Dam

- The storage capacity of the Burdekin Falls Dam can be increased 5 times by raising the dam's 50 metre high spillway by 15 metres. Earthworks on most of the dam's perimeter were originally constructed to accommodate this new spillway height to allow for any future expansion of the dam.
- Additional land for the dam's expansion was also purchased by the State Government at the time of the dam's construction.
- The new storage capacity will enable the dam to capture 80% of the runoff which regularly flows over the dam's spillway and flows, unused, out to sea**.**

Project description



- Water will be pumped from the amplified dam 133 kms to the ridge of the Great Dividing Range using renewable energy: Hydroelectric energy plus Solar energy.
- From this high point water will be transferred to canals which will flow, by gravity, to Northern Queensland, Western Queensland, Central Queensland, NSW, Victoria and South Australia (via the Darling and Murray rivers). Canals will be lined with a heavy duty, heat sealed HDPE liner which has a 100 year service life.
- The delivery system includes the major rivers which flow west from the Great Dividing Range. Water is carried across rivers in aqueducts fitted with remote controlled diversion sluice gates. This will allow specific volumes of water to be distributed into any river while maintaining the balance between the needs of water delivery and environmental protection.
- The scheme includes complete offtake systems, (Solar Power stations, Pumping Plant and Pipelines), to augment the water supplies for the regions of Bundaberg, Townsville, South-East Queensland including Toowoomba, Warwick, Brisbane, Sydney and Adelaide.
- All evaporation losses from the dam and the distribution systems have been taken into account.

Outcomes and Benefits

Water availability

The BMS will deliver an additional 5,000 GL pa (5 million ML pa or 10 Sydney Harbours) plus the existing, average, annual, harvest of 500 GL pa. resulting in a total 5,500 GL each year. Water will be provided for Agriculture, Town water supplies and water supply systems for major cities and centres. Distribution will cover most of the rivers and towns west of the Great Dividing Range. Water will also be supplied for Mining and Industry.
The BMS will result in a more cohesive approach to the ongoing debate over MDB water sharing.

Agriculture

BMS will deliver an additional 5 million ML of water including water for agriculture or approximately 90% of the 5.6 million ML average water use in the Murray Darling Basin 2006-2018. The BMS will ensure the Government's goal for the 2030 Agriculture annual GDP of $100bn.p.a. will be met or exceeded. The BMS will provide water for new irrigation schemes including those in western Queensland such as the Hughenden Irrigation Project where the BMS will remove the need for a new dam in this region.

Economic activity, GDP

Economic benefits are forecast to exceed $14 billion per year. It is proposed that almost 100% of all materials and equipment will be manufactured in Australia with new manufacturing plants being built for the following industries: Large diameter pipe manufacture, Canal lining material manufacture and Graphite Thermal Battery manufacture. Several Australian companies have indicated a willingness to establish such plants. Australian made goods will in the order of $13bn.

Employment

During construction there will be 40,000 jobs created.
Following construction the project will create 185,000 full time agriculture, value-add and supply chain jobs.

Decentralisation

The additional water for the regional areas will be the catalyst for growing regional businesses which, in turn, will attract new business and migration to country areas providing an uplift to the economic prosperity of regional communities.

The Environment

The project provides many environmental benefits including those listed below:

a) Delivers continuous environmental river flows to all the major rivers west of the Great Dividing Range.
b) Eliminates fish kills.
c) Provides environmental flows to 50% of the Ramsar Wetlands located on the Australian mainland.
d) Significantly reduces the amount of pollutants flowing to the Great Barrier Reef.
e) Halves the frequency and intensity of the regular catastrophic floods in the Lower Burdekin region.
f) Eliminates zero flows in the majority of rivers west of the Great Dividing Range and ensures a continuous, year round flow securing water for agriculture, town water supplies and industry.
g) Avoids 4 million tonnes of greenhouse gases each year by the exclusive use of hydro and solar power generation.

Features of the Burdekin Murray Scheme

Project Delivery

a) The project can be funded with no impact on the Federal budget by the issue of infrastructure bonds.
b) The approval process will be expedited promptly because:

i) Dam expansion
The additional land around the existing dam required by the BMS was acquired by the Government in the 1980's prior to the construction of the dam to allow for future expansion of the dam. Most of the land tenure issues were dealt with at that time and the land rezoned for water storage.

iii) Canal route
It is proposed to offer free water, 40 ML/year/km of canal frontage, to landholders along the canal corridor. This has been unanimously supported by all of those canvassed to date.

iv) No new dams are required.

Value for money

- Project cost,

	Stage I	Queensland	$ 7 bn
	Stage II	NSW, Victoria, South Australia	$16 bn
			$23 bn

- Cost effective; utilises existing infrastructure, renewable energy and existing river systems.
- Economic Benefit / Cost ratio in excess of 2.4.
- Operational cost of delivering water $76/ML

Economic potential

A similar scheme, The Central Arizona Project, delivers 1,800 GL/year of water from the Colorado River across Arizona and currently generates economic benefits in excess of US$100 billion per year.

The Burdekin Murray Scheme will deliver 5,000 GL/year of additional water. A comparison of water volumes delivered indicates that the Burdekin Murray Scheme has the potential to increase Australia's future GDP in the order of $300 billion per year.

Funding

Initial financial modelling indicates a profit margin of 5.5%.

Dr Samuel Lackey, Former NSW Government Chief Economist and Director Investment Assurance Transport NSW, advises that "the project is eminently fundable and could be funded by a number of financing methods including 'off balance sheet' funding through the issue of long-term Infrastructure Bonds."

Introduction

The Burdekin Murray Scheme (BMS) is a proposal to redistribute unused runoff water from regular monsoonal rainfalls in Northern Queensland to most of the worst drought regions in Queensland, NSW, Victoria and South Australia. The proposal is the result of an investigation by a team of experienced engineers who have prepared a conceptual design.

Preliminary feasibility and economic studies have been carried out which demonstrate the scheme is viable showing a conservative Benefit Cost Ratio of 2.4.

The proposal was unanimously endorsed by the NSW National Party NSW at the June 2019 conference at Inverell and by the National Party 2019 Federal Council Canberra in August 2019.

In February 2020 the proposal was presented to a special meeting of the Federal Standing Committee on Agriculture and Water Resources at Parliament House, Canberra. The proposal was very well received with more information about the project being requested by the committee.

Infrastructure Australia

The proposal was formally submitted to Infrastructure Australia on the 27th August 2020.

The Burdekin Murray Scheme met the category criteria for the top two new initiatives on Infrastructure Australia's 2020 High Priority Initiatives list namely:

- **National water strategy**
  Strategic planning for water capture, use and management.

- **Town and city water security**
  Water supply and resilience for town and city populations.

The Burdekin Murray Scheme satisfies the basic requirements of Infrastructure Australia namely:

a) Results in a very favourable feasibility study.
b) Meet any business case study requirements.
c) Delivers a very favourable economic assessment resulting in an exceptional Benefit/Cost ratio, in excess of 2.4:1
d) Delivers many environmental flow-on benefits. (refer to 'Environmental benefits' section of this report)
e) Does not require the construction of a major new dam.

Australian Infrastructure Solutions understands that of all the major water transportation proposals which Infrastructure Australia has received, the Burdekin Murray Scheme is the only proposal whose development had been based on sound engineering principles.

Need for the project

Drought conditions will be the new normal — University of NSW

The Murray Darling Basin is under enormous stress following a number of phenomena of nature including; a prolonged drought, natural climate variability and emerging climate change.

The Water Research Centre, University of New South Wales recently completed a four year global research project and concluded:

"Drought conditions will be the new normal".

Accordingly, the UNSW supports the Burdekin Murray Scheme.

Research summary: "Drought conditions will be the new normal."

- Global water supplies are shrinking. Soils are drying out faster than before. Drought-like conditions will become the new normal especially in regions that are already dry.
- Even if rainfall remained the same the flows over the next 30 years will be lower than the last 30 years simply because of the drying soils.
- The large rivers are drying out due to quicker depletion of moisture in the soil. Even when a major storm dumps a lot of rain, the soils are so dry they absorb more water than before, and less reaches the rivers and reservoirs.
- **We're going to need re-engineering on a massive scale in some places if we are to continue living in them. But it's possible: places like Arizona and California receive barely 400mm of rain each year, but have engineered their water supply systems to make previously uninhabitable places liveable.**
- We need to adapt to this emerging reality. Any large-scale re-engineering project will require significant investment.
- The cost of inaction could be devastating.

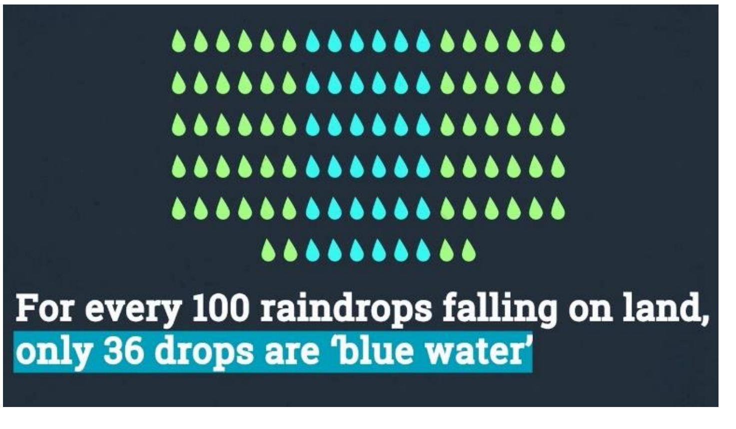
Read the article: www.hydrology.unsw.edu.au/the-long-dry-global-water-supplies-are-shrinking
Watch the video: https://youtu.be/UU_h9flAfC4 , Associate Professor Ashish Sharma, Hydrology/Hydro climatology/Water Resources and Professor Mark Hoffman, Dean of Civil Engineering UNSW

Extract from video:

'Blue water' vs 'green water'

For every 100 raindrops that fall on land, only 36 drops**,** are **'blue water', 36%**, the rainfall that enters lakes, rivers and aquifers – and therefore, all the water extracted for human needs.

The remaining two thirds of rainfall is mostly retained as soil moisture – known as 'green water' – and used by the landscape and the ecosystem.



As warming temperatures cause more water to evaporate from soils, those dry soils are absorbing more of the rainfall when it does occur – leaving less **'blue water', 13%,** for human use.'

The recent drought

The recent drought is one of the most severe droughts of the past century. It included Australia's driest year on record.

"Our records only go back 120 years but in terms of the rainfall records it is the most severe," Dr David Jones, manager of climate services at the weather bureau. For Australia's food bowl, the Murray-Darling Basin, rainfall has averaged a total of 887 millimetres over the 34 months to the end of October 2020. That's "clearly the lowest on record". Record heat has compounded the stress.

The basin's mean temperatures for those 34 months is running at 1.65 degrees above the bureau's 1961-90 baseline, easily beating previous record highs, says Dr Jones. In the basin alone, mean temperatures were the hottest on record for that period too, for the third year in a row."

Perhaps the most unusual feature of the recent drought, though, is the absence of cool season rainfall for three years running for much of the Murray-Darling Basin. "That's never happened in the instrumental record," says Michael Roderick, a climate researcher at the Australian National University.

"They've never really had two failed winters in a row. For the basin, just under 50 millimetres fell last winter, or less than half the 1961-90 average of 111 millimetres. For SE Australia the past 3 years have been the lowest rainfall on record.

Refer Fig.1. showing the proposed scheme overlaying a map of the Australian Rainfalls Deciles from 2017 to 2019 and Fig.2 a graph of rainfalls across the Murray Darling Basin from 1904 to 2019.

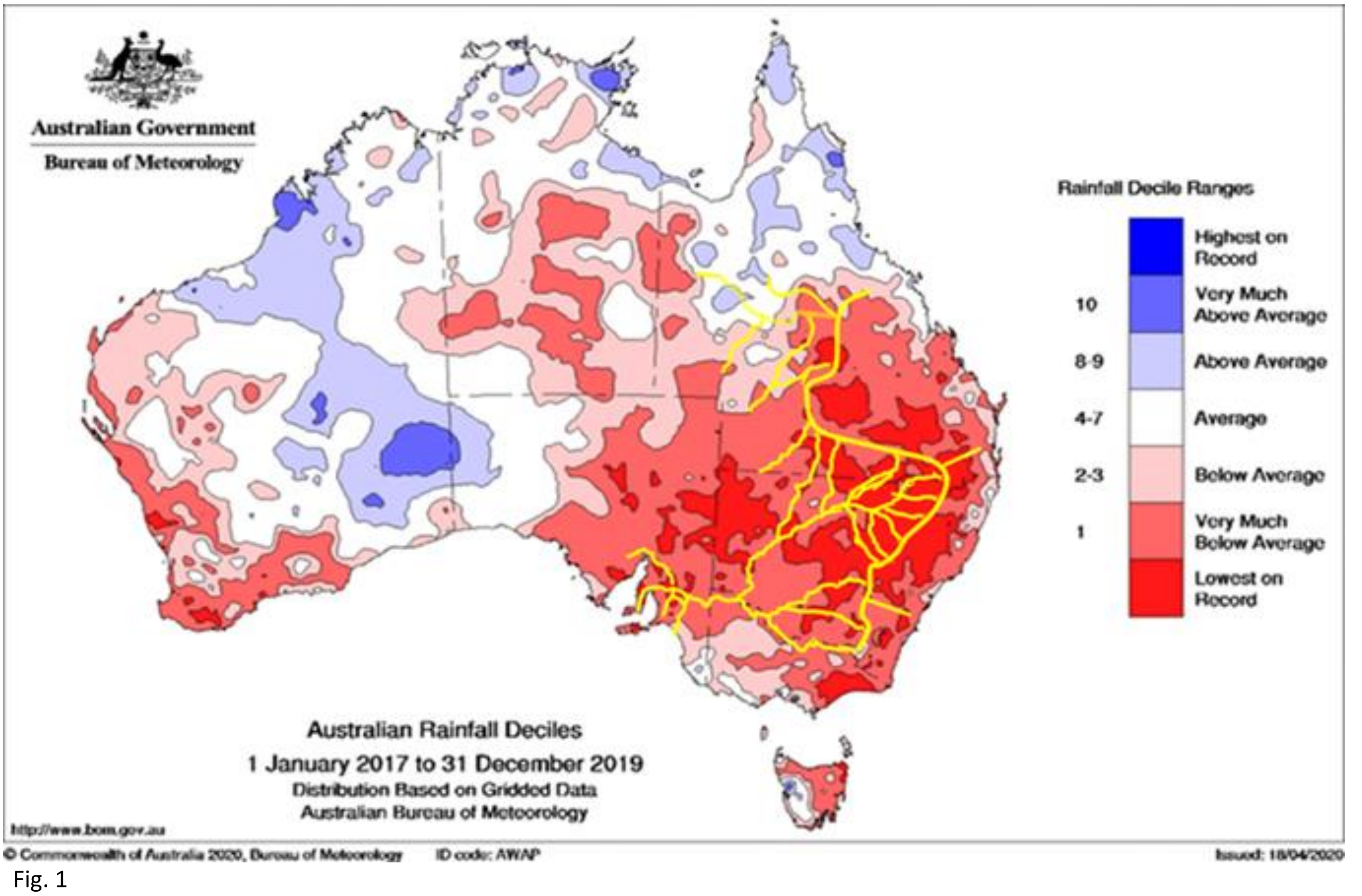
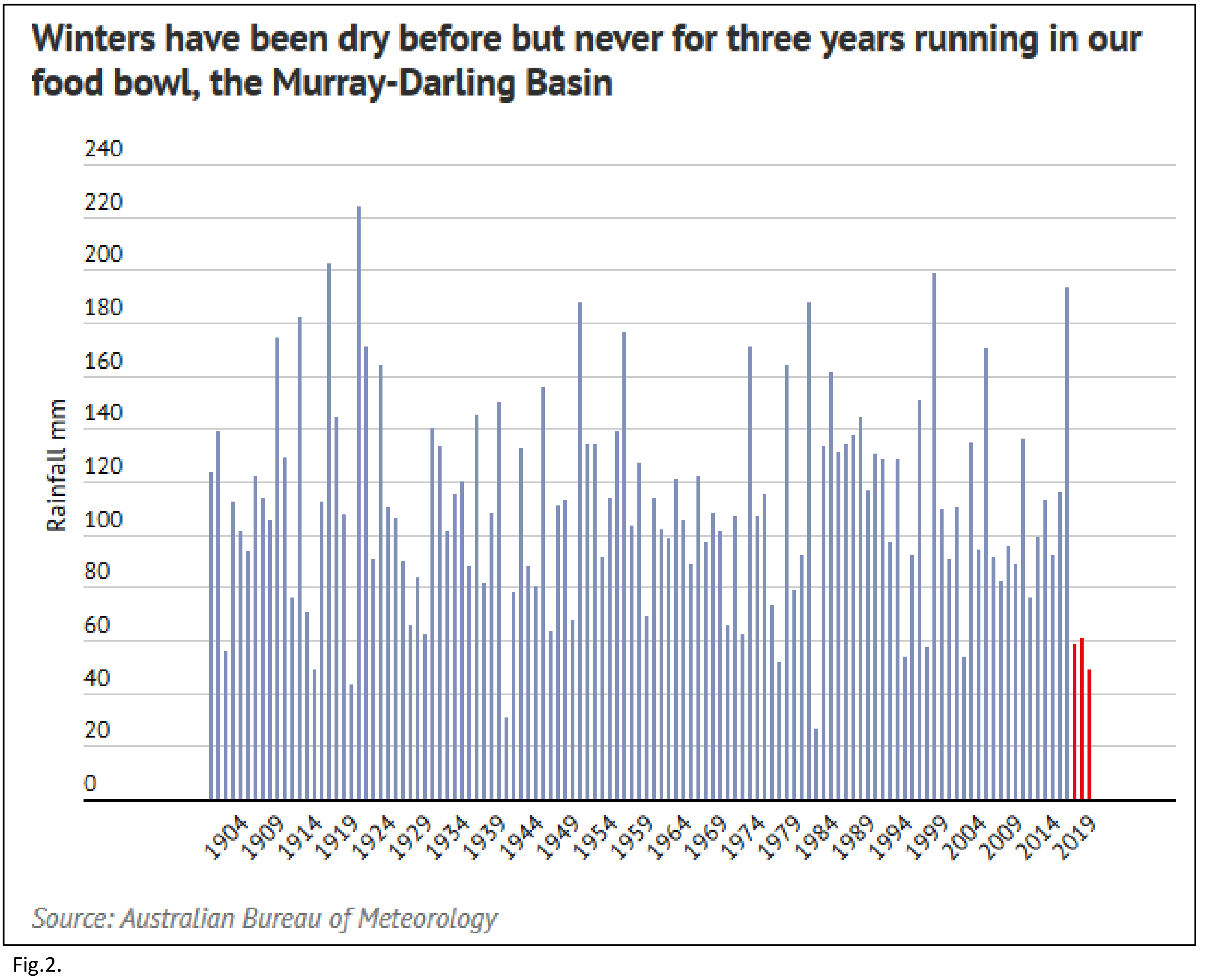


Fig. 1



Winters have been dry before but never for three years running in our food bowl, the Murray-Darling Basin
240
220
200
180
160
140
120
100
80
60
40
20
0
Rainfall mm
1904
1909
1914
1919
1924
1929
1934
1939
1944
1949
1954
1959
1964
1969
1974
1979
1984
1989
1994
1999
2004
2009
2014
2019
Source: Australian Bureau of Meteorology

Fig.2.

Economic and social effects of the drought

Economic loss

From the national perspective, prolonged drought had substantial impacts on national productivity. It was sufficient to force real GDP to more than 1.0% below base in 2018-19 and 2019-20. Modelling results indicate that NSW real GDP fell relative to forecast by 0.7% or $2.6 billion in 2017-18, and more than 1.3% or $5.5 billion in 2018-19 and 2019-20. These impacts reflect a severe diminution of farm output, given that agriculture accounts for around 1.6% and downstream processing for around 3.5% of NSW's income. The economic losses spread into regions not directly affected by drought such as Wollongong, Sydney and Newcastle, real GDP fell 0.6% below forecast and employment as much as 0.8% below forecast.*

*Glyn Witter, 2020. "Estimating the Regional Economic Impacts of the 2017 to 2019 Drought on NSW and the Rest of Australia," Centre of Policy Studies/IMPACT Centre Working Papers

The current drought in eastern Australia is forecast to cut the country's GDP growth in 2018-19 by up to 0.75 percent or $12.5 billion. The most significant decline forecast for New South Wales, where winter crop production may be 65 percent below the 20-year average. Despite strong population growth across every major city since 2012, many parts of the country lost thousands of people as the mining and agricultural sectors deteriorated.*

*Climate Council of Australia 2019

Employment

The marginal contribution of drought to national real wages growth was as much as minus 1%. NSW job losses due to drought were around 0.55% or 17,500 FTE jobs in 2017-18 and more than 1.0% or 34,000 jobs in 2018-19.

At the regional level, relatively farm-intensive parts of the state suffer proportionally greater drought-induced losses. All inland regions were affected severely by drought. The worst affected region was New England-North West, in which real GDP in both 2018-19 and 2019- 20 fell almost 15% below forecast, with an accompanying drop in employment of more than 5.0%. Other hard-hit regions include Far West-Orana, in which 2018-19 and 2019-20 real GDP fell 12% and employment fell 4.0% below forecast. Jobs in the coastal region which accounts for 78% of baseline state-wide employment fall by more than 21,000 FTE, with jobs in other regions falling by around 13,000 FTE in 2018-19 relative to base.*

*Glyn Witter, 2020. "Estimating the Regional Economic Impacts of the 2017 to 2019 Drought on NSW and the Rest of Australia," Centre of Policy Studies/IMPACT Centre Working Papers g-297, Victoria University, Centre of Policy Studies/IMPACT Centre.

Shrinking towns

Smaller farming communities across NSW are shrinking in the face of economic and social headwinds but those who remain fear the current drought is accelerating the decline.
The town of Hay is expected to shrink by 25 per cent over two decades.
Rural and remote parts of the country have shed up to a third of their population.*

*The Land, Feb 3, 2019

Government welfare

The drought diminishes national welfare. Lost productivity depresses income in drought. Even with NSW and national employment rising above forecast in recovery. Prior to the virus pandemic the real GDP remained slightly below base in recovery and does not compensate for drought-induced losses. The net present value of national welfare is $43 billion, equivalent to a loss in annualised terms of $1300 million at a 3% discount rate.

Economic stimulus delivered by the Burdekin Murray Scheme

Current Government debt

The Australian Government's coronavirus stimulus package totals about $200 billion so far, or about a third of total government debt before the pandemic. A major contributor to economic stimulus and reducing Government debt are large, productive, infrastructure projects such as the BMS.

The Burdekin Murray Scheme would generate revenue for Government from the following:

Government tax revenue

There will an increase in tax revenue from many areas including GST, payroll tax, company and personnel taxation.

Employment

During construction
 40,000 full time construction jobs.
On completion
 75,000 full time BMS and agriculture jobs plus,
 110,000 full time flow-on, supply chain and value-add jobs.

Manufacturing

A major feature of the project delivery process is the intention to produce all plant and materials in Australia. Accordingly, several industries have agreed to establish new manufacturing plants to produce items not currently manufactured in Australia. These industries which would produce goods initially for the BMS with a value of $15bn include the following:

- Large diameter steel piping for the rising mains from the dam to the ridge of the Great Dividing Range.
- High Density Polyethylene (HDPE) lining for the canals.
- Large scale Graphite-Thermal Batteries

Effect on GDP

The scheme will increase GDP by $14bn pa allowing the Government's goal for Agriculture GDP to reach $100bn. Refer Economic appraisal section.

Decentralisation

Regional centres will regain commercial activity and become attractive as centres for new business establishment and migration destinations.

Pandemic

The devastating effect of the pandemic on the economy has increased the need for the BMS as stimulus for the economy.

The drought isn't over — Water shortages in the Murray Darling Basin and Queensland

The drought isn't really over

Since January 2020, above-average rainfall has fallen on some parts of eastern Australia, particularly across some of the worst drought-affected areas of central and western New South Wales and southwest Queensland. Much of eastern NSW experienced heavy rain, while there were more widespread and consistent falls through many parts of south eastern Australia.

For many regions in eastern Australia, rainfall in 2020 has eased drought conditions by wetting soils and helping fill dams on farms. But most drought-affected areas still need sustained above average rainfall for streamflow and water storages to increase to at least average levels.

Summer rain is not so good for farmers

Rainfall and moisture sources for Australia and the Murray-Darling Basin are changing. In the past 35 years, the southeast of the country has been receiving less moisture in winter, and more in summer. This is likely due to increased easterly wind flows of moisture from the Tasman Sea in summer, and reduced westerly flows of moisture from the Southern Ocean in winter.

This has significant implications, particularly for agriculture and water resource management. For example, more rainfall in summer is a problem for horticultural farms, as it can create problems for getting access onto wet fields for harvesting, make crops more susceptible to fungal diseases, decreases the quality of wine grape crops and affects harvest scheduling.

Less winter rain also means less runoff into creeks and rivers — a vital process for mitigating drought risk. And this creates uncertainty for dam operators and water resource managers.

Bureau of Meteorology Study
Hydrologists, Dr Alison Oke and Daniel Burton, 19th May 2020
Study conclusions Refer Fig.3

1. It will take 2 years of average rainfall to return storages to 50% capacity
2. It will take 4 years of average rainfall to return storages to 80% capacity

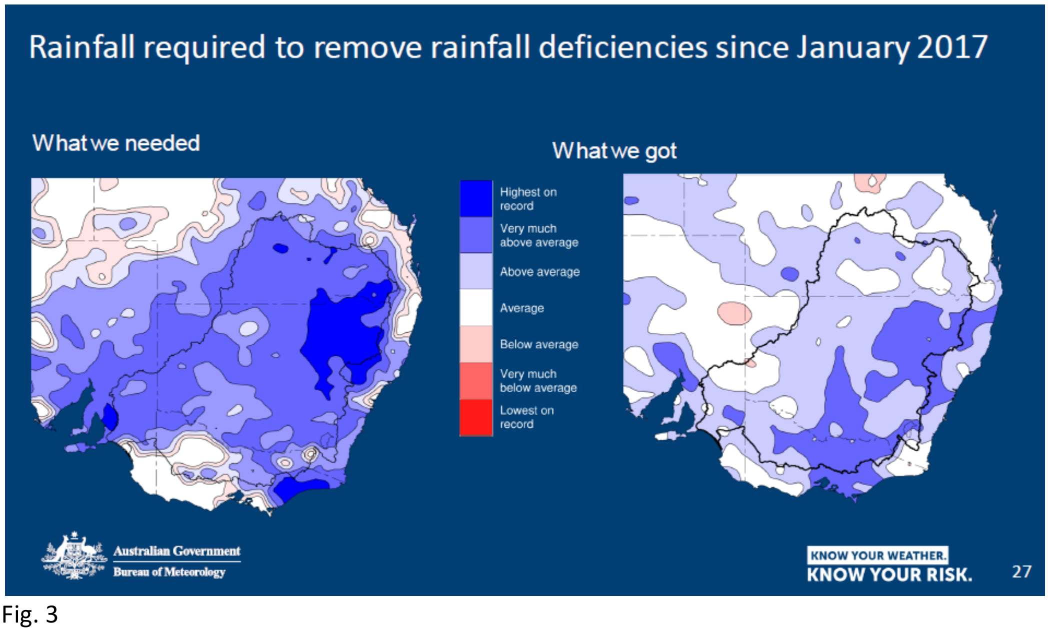


Fig. 3

Murray Darling Basin Water Shortages

Even after significant rainfalls during 2020 as at 17th February 2021 the average storage level of all the storages in the Murray Darling Basin was 51%. Refer Fig. 4

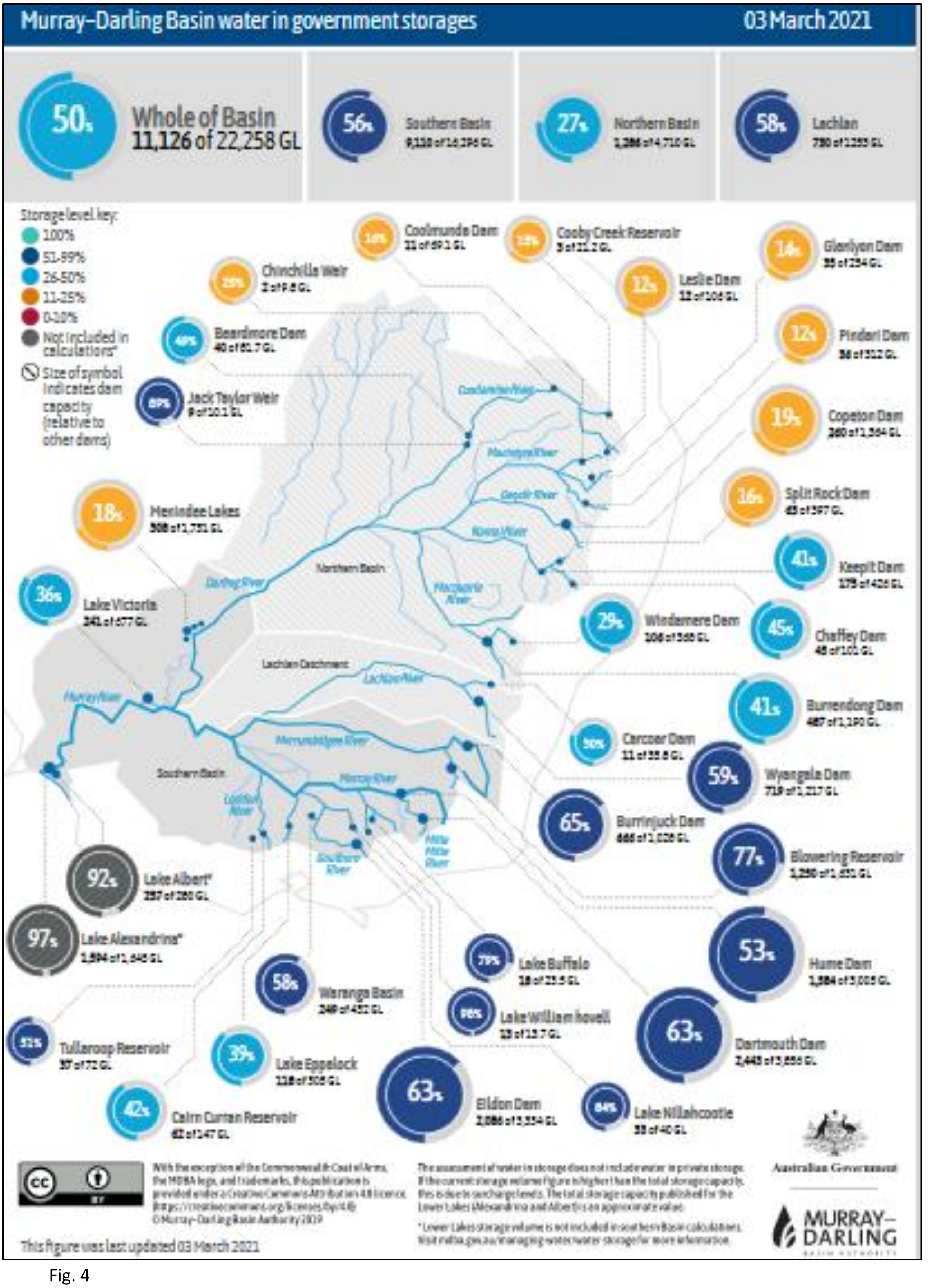
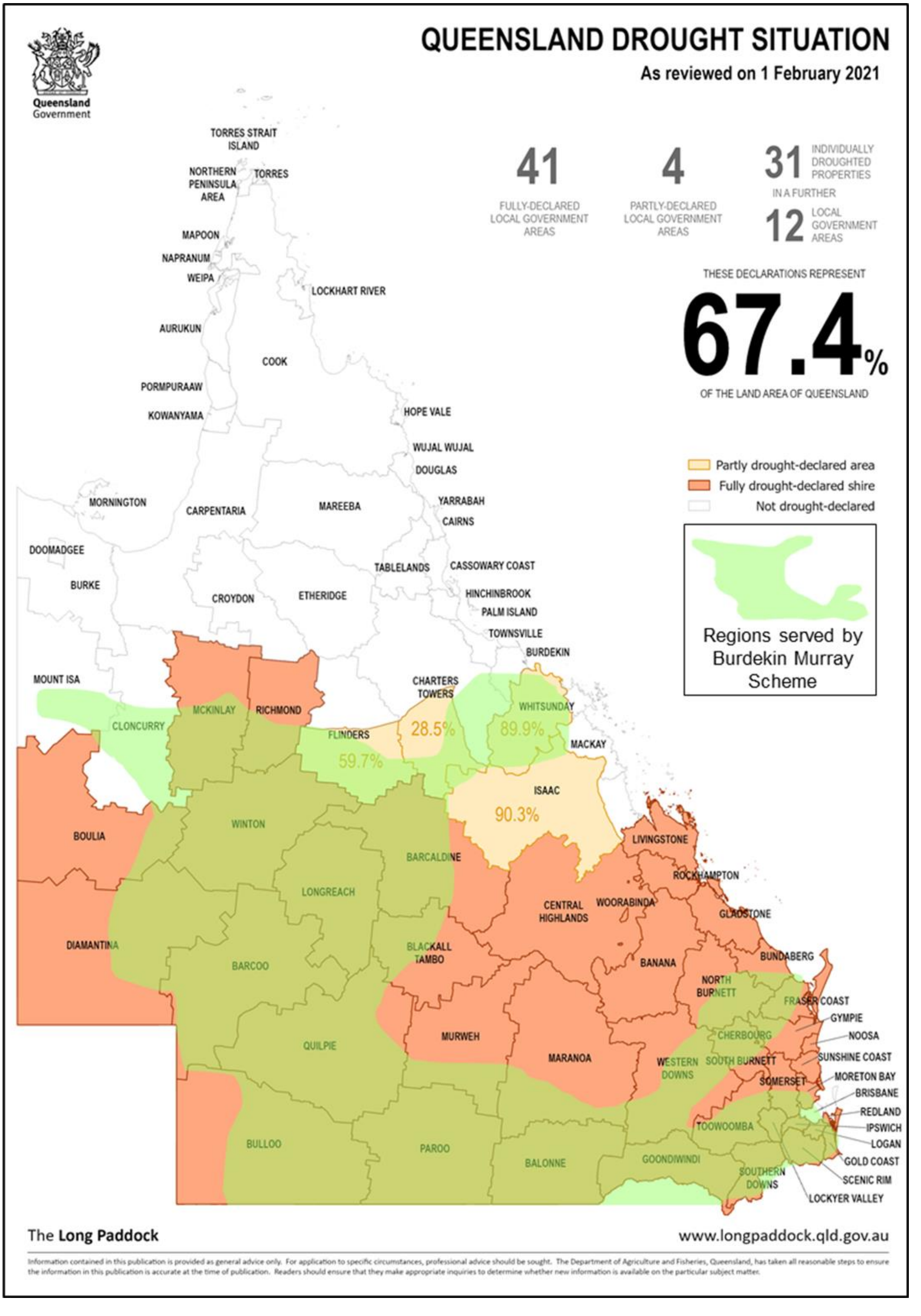


Fig. 4

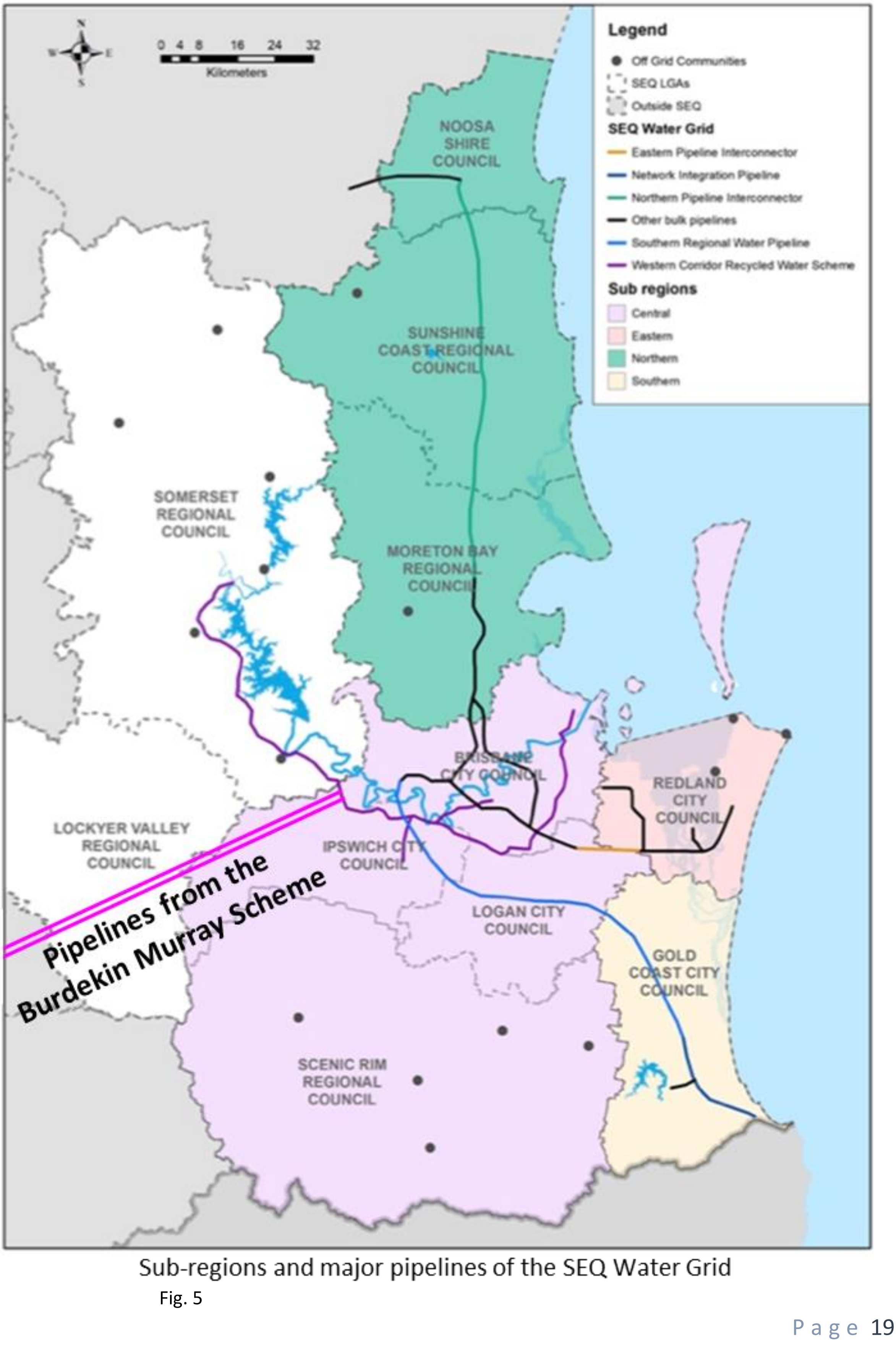
Queensland Water Shortages



South East Queensland Water Shortages

Pipelines from the Burdekin Murray Scheme main canal

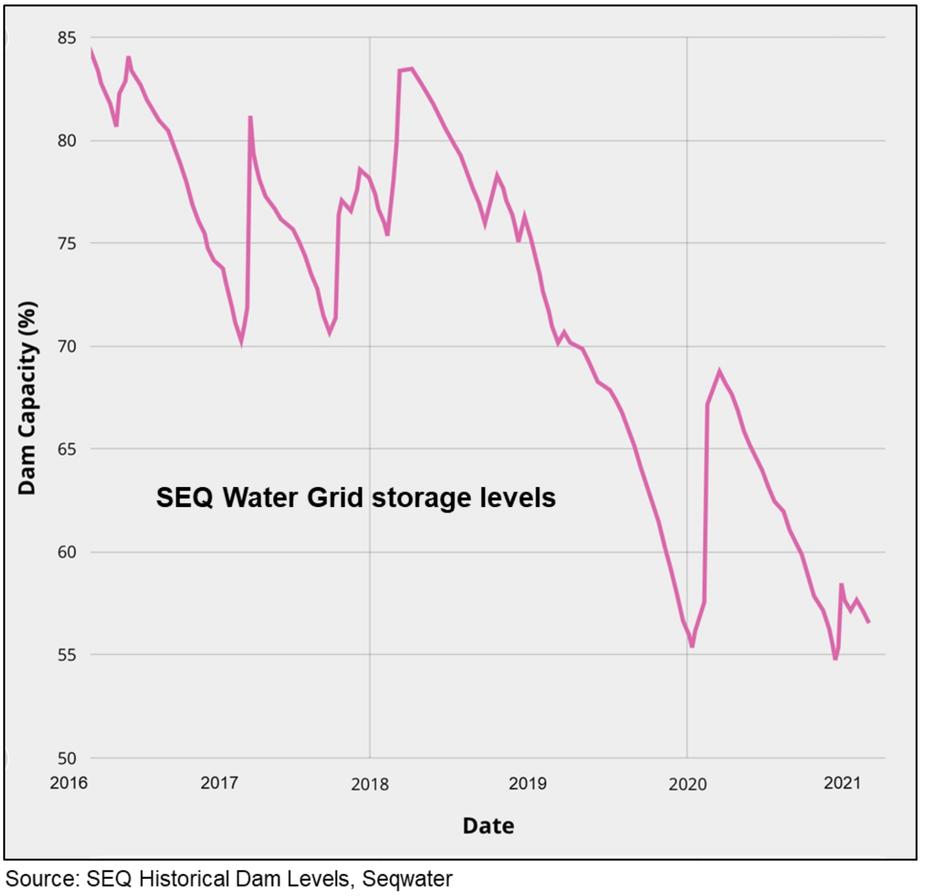
Stage I of the Burdekin Murray Scheme (Queensland) will provide drinking water for South East Queensland via pipelines from the main BMS canal near Goondiwindi.. Refer Fig. 5



Sub-regions and major pipelines of the SEQ Water Grid

Fig. 5

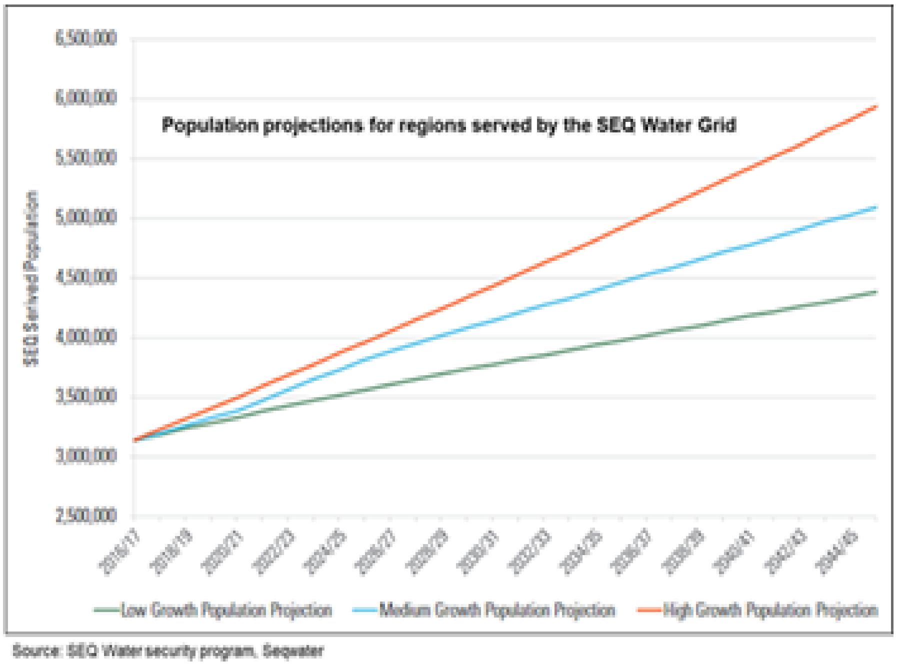
South East Queensland Water Storage Levels
South East Queensland's water grid storages have declined from 85% to 55% over the past 5 years.
Ref Fig 6



Source: SEQ Historical Dam Levels, Seqwater

Fig. 6

South East Queensland Population Projections
South East Queensland is one of the fastest growing regions in Australia. Population is forecast to increase by approximately 50% to 5 million over the next 25 years. Refer Fig. 7

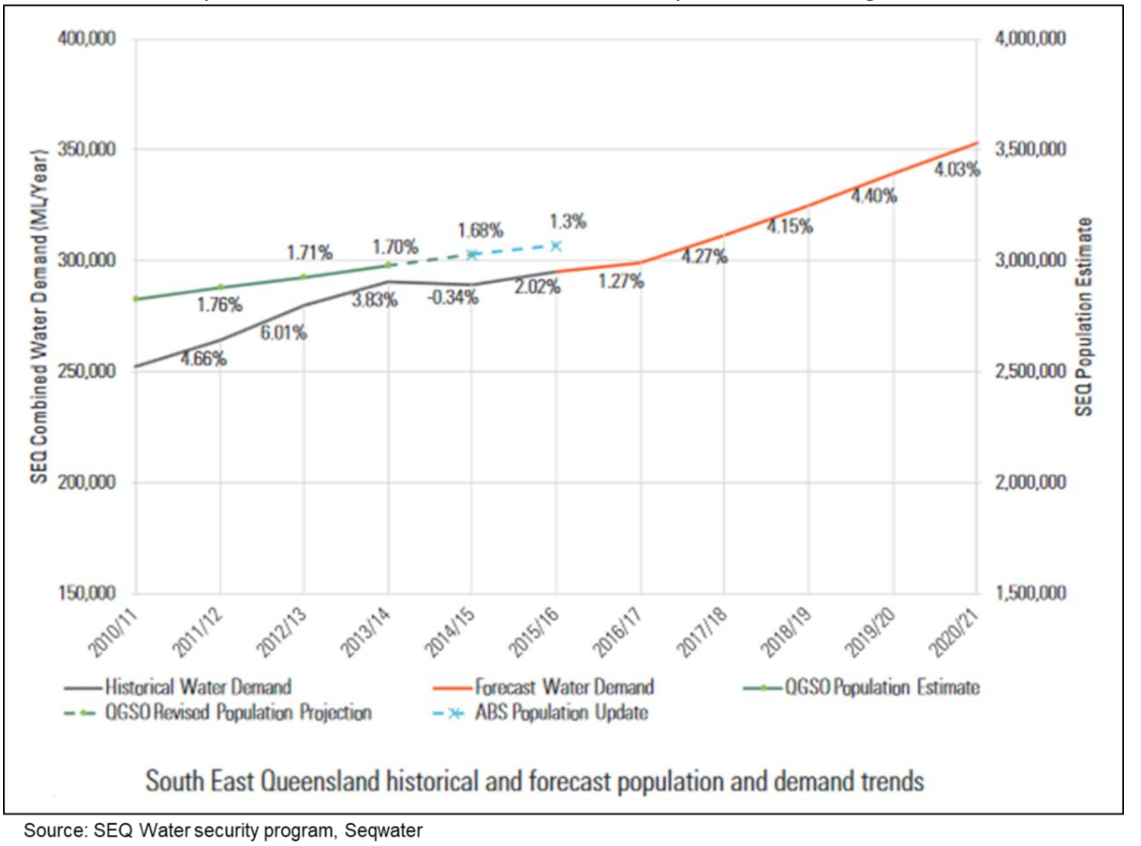


Source: SEQ Water security program, Seqwater

Fig. 7

South East Queensland Water Demand

For the past 5 years the water demand for SE Queensland has been increasing by approximately 4% pa. Refer Fig. 8. At this rate over the next 25 years the demand will have increased by 270%. Refer Fig 9.



Source: SEQ Water security program, Seqwater

Fig. 8

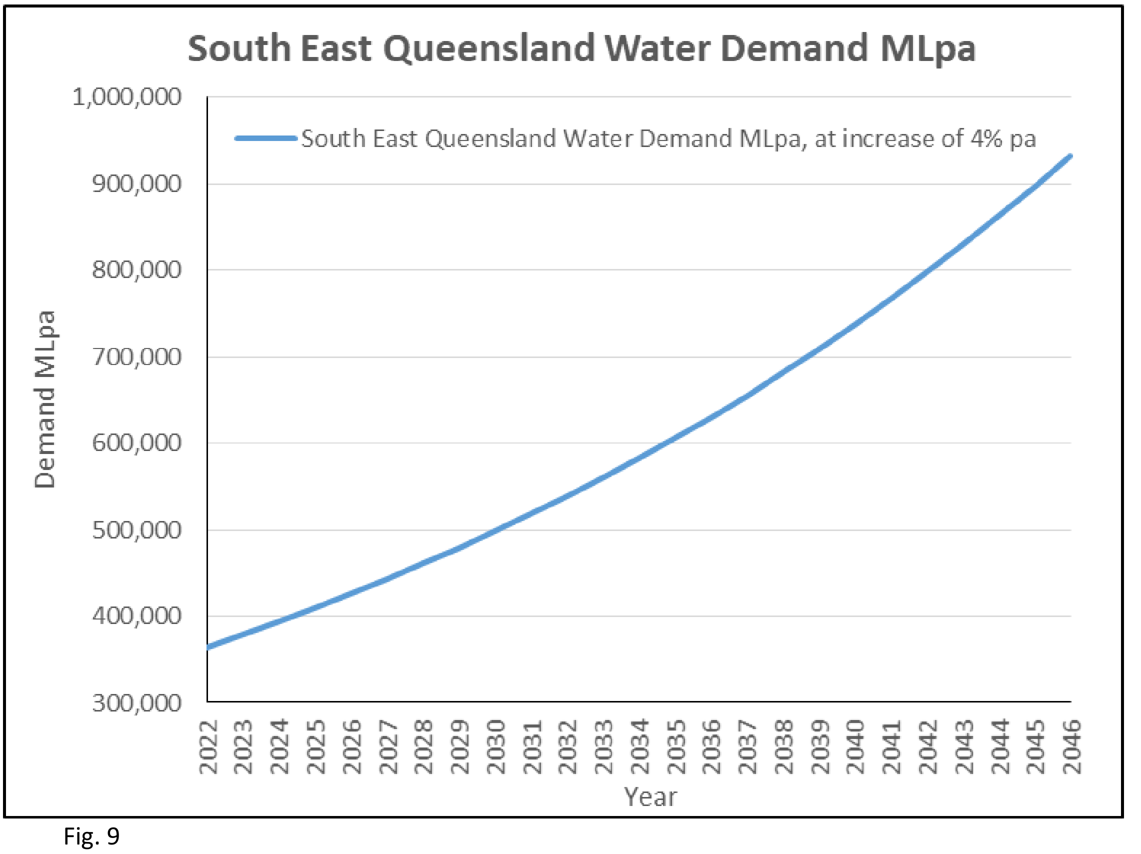


Fig. 9

Changing weather patterns for Australia

Weather patterns are changing around the world. Australia is considered a leader in climate study. Some of the research carried out by Australian institutions is summarised below:

BOM and CSIRO

The Bureau of Meteorology and the CSIRO are very confident that rainfall during the so-called cool season from April to October is trending lower for both the south-west and south-east of Australia, as noted in last year's State of the Climate report. Farmers rely on that rain to grow the winter crops that make up the bulk of the nation's output. Where winter rain is on the rise – in parts of the north and interior – the extra moisture is typically on top of a low base and in sparsely populated regions.

The 2008 CSIRO study on Sustainable Yields in the Murray Darling Basin projected the average volume of available surface water could decline by up to 40% by 2030.*
*Source; www.csiro.au/en/Research/LWF/Areas/Water-resources/Assessing-water-resources/Sustainable-yields

In the southeast Australia, rainfall has declined by around 11 percent over the past 35 years. Refer Figs. 10 and 11. accompanied by a general increase in aridity of the Australian mainland. Refer Fig. 12

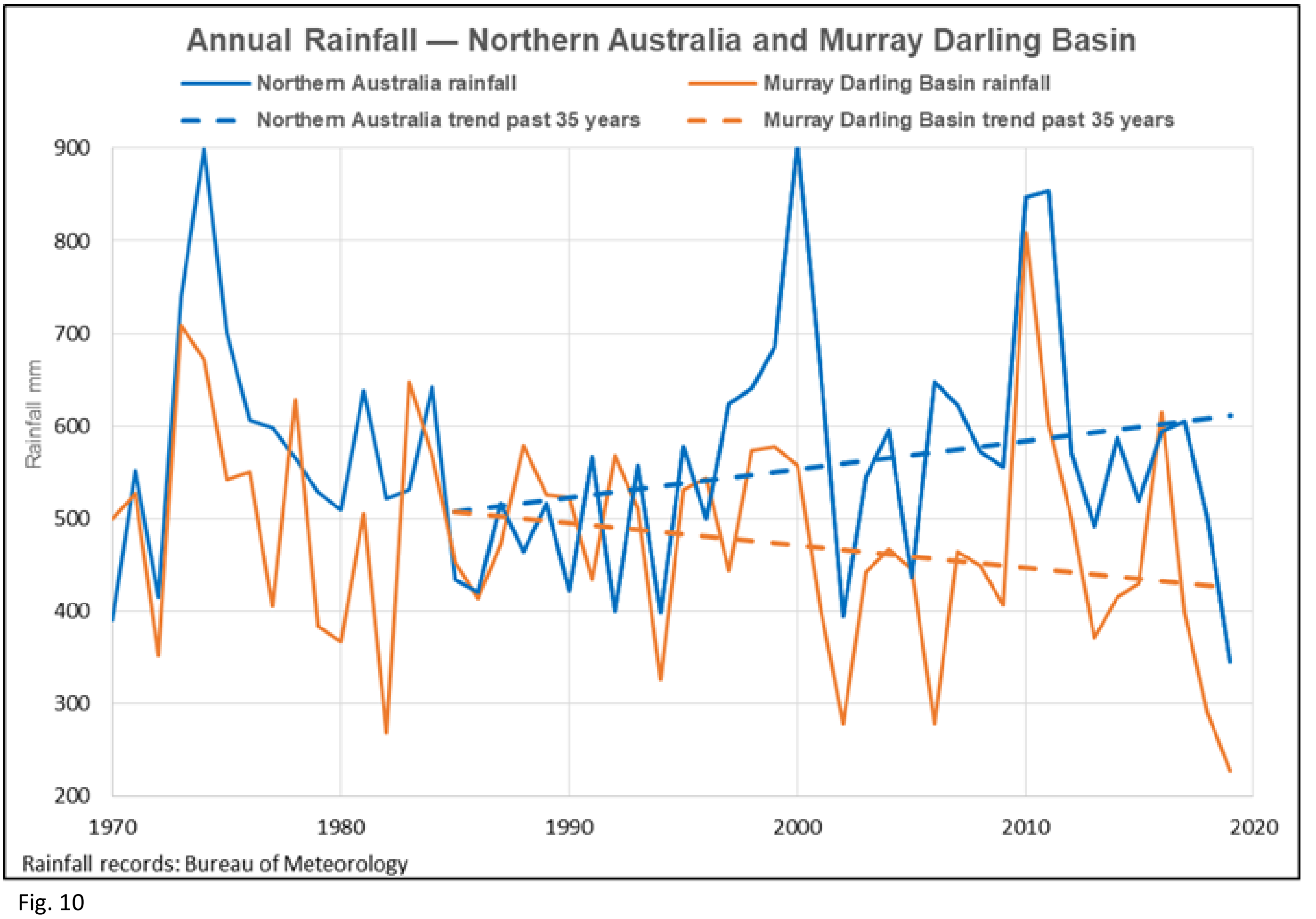


Fig. 10

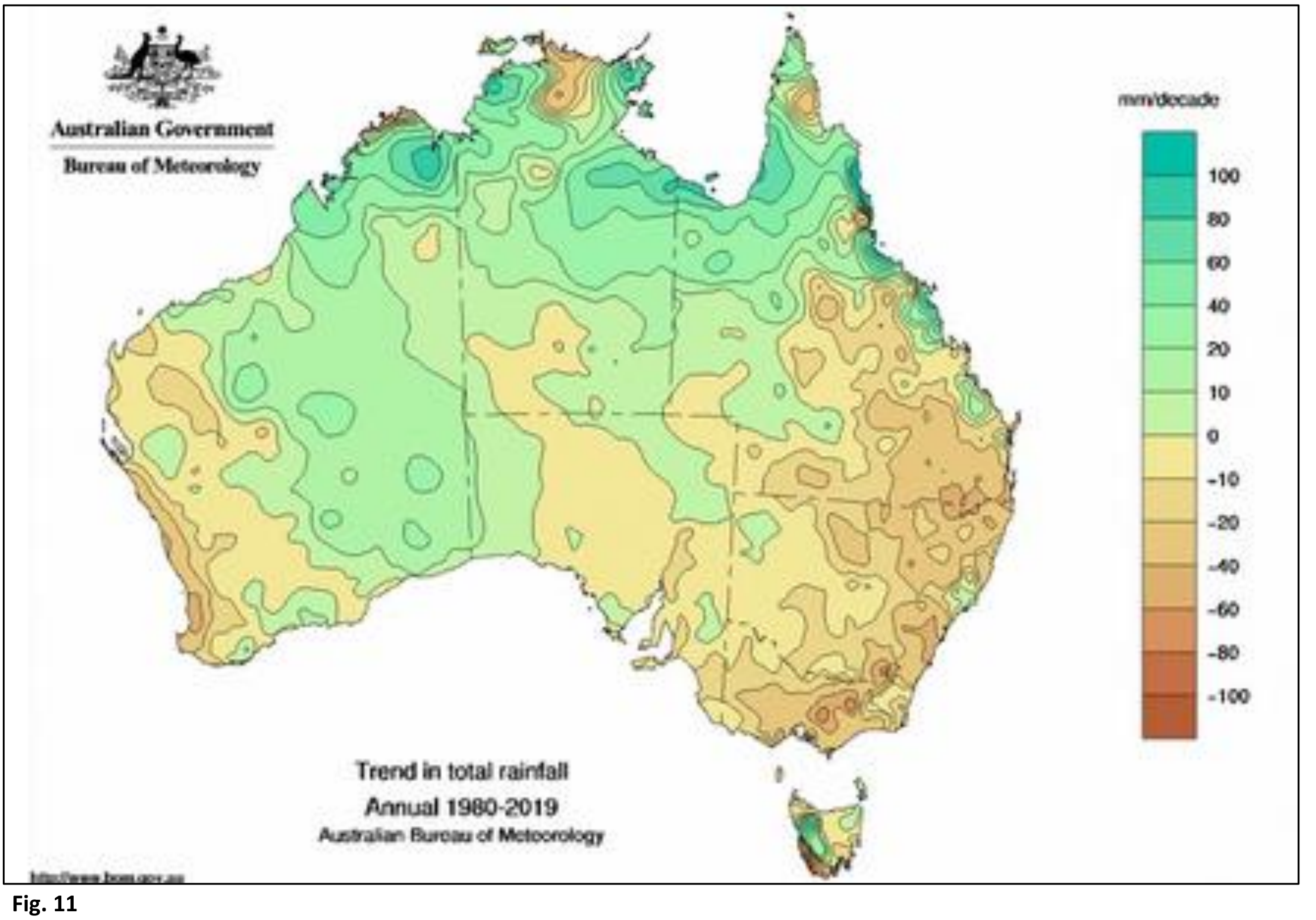
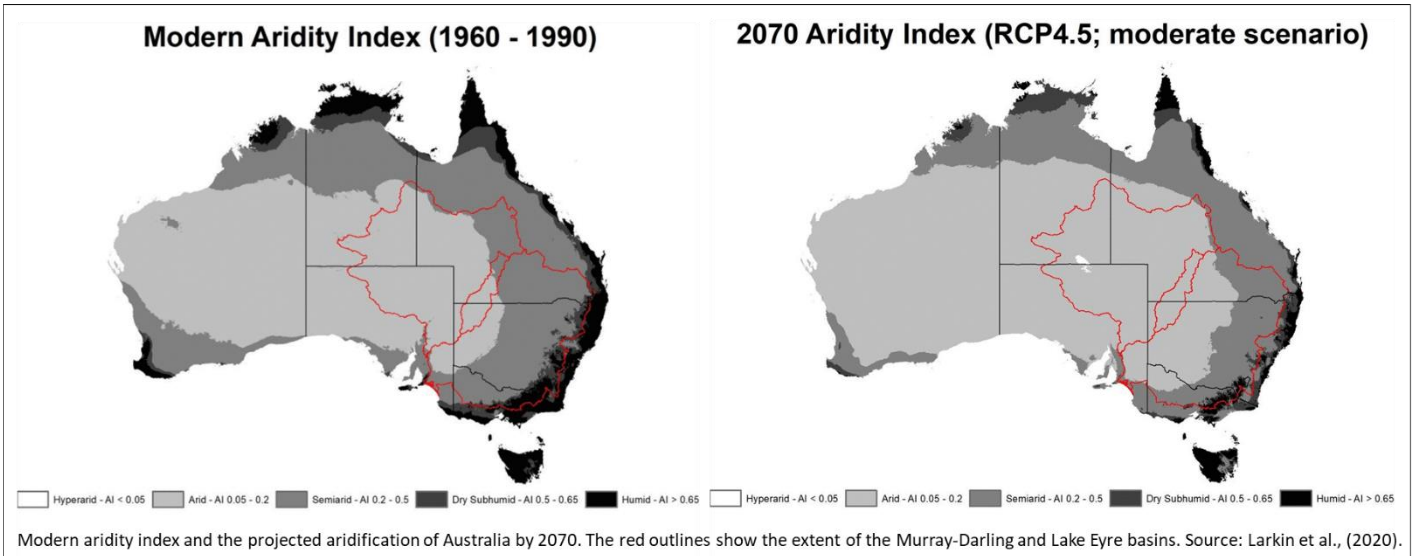


Fig. 11



Modern aridity index and the projected aridification of Australia by 2070. The red outlines show the extent of the Murray-Darling and Lake Eyre basins. Source: Larkin et al., (2020).

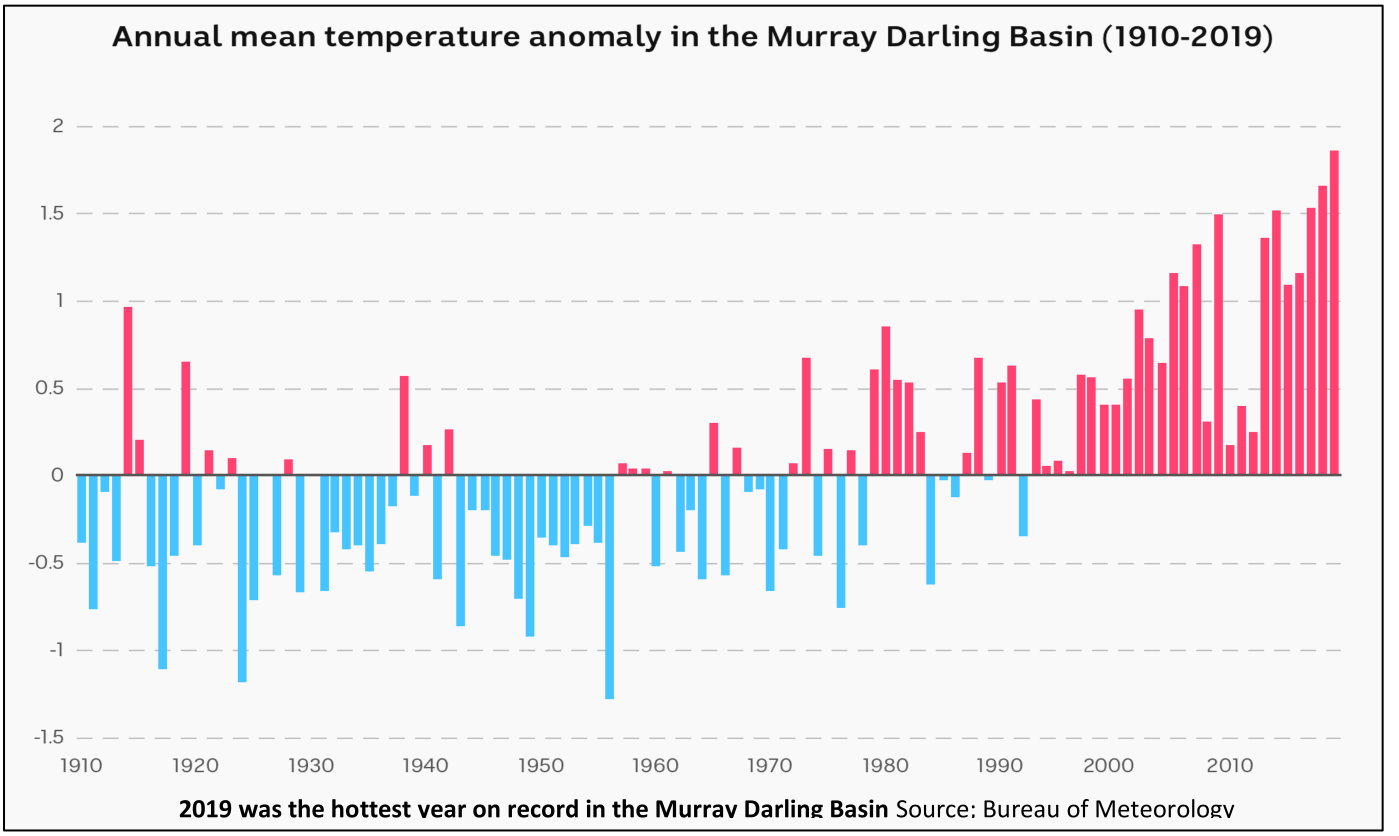
Fig. 12

Australian National University

Latest research* by the Australian National University shows trend towards “increasing, unusually dry and hot weather in south-eastern Australia. That pattern typically means spring rainfall shifts westwards, increasing the odds of unusually dry and hot weather in south-eastern Australia. Refer. Fig.13.

*Research summary

"Historically, strong events like the one we saw in 2019 have been very rare, over the reconstruction beginning in the year 1240, we see only 10 of these events, but four of those have occurred in just the last 60 years. <u>In the future, climate change will be producing more frequent and huge positive IODs. It spells big impacts on places such as Australia.”</u>



2019 was the hottest year on record in the Murray Darling Basin Source: Bureau of Meteorology

Fig. 13

Melbourne University

“800 years of seasonal rainfall patterns across the Australian continent show that parts of Northern Australia are wetter than ever before, and the major droughts of the late 20th and early 21st centuries in southern Australia are without precedent over the past 400 years.”*

*Sources; Multi-century cool- and warm-season rainfall reconstructions for Australia's major climatic regions, Melbourne University

Rationale behind the Burdekin Murray Scheme — water capture and harvest

The Burdekin catchment

- The Burdekin Falls Dam is the collection point for the Upper Burdekin catchment. It has an area of 114,000 km2, about the size of England (130,000 km2) or twice the size of Tasmania. The Upper Burdekin catchment makes up most of the total Burdekin catchment area of 130,000 km2. Refer Fig.14.

- The catchment captures runoff from the regular monsoonal rains. Annual rainfall varies from 600 mm in the south of the catchment to 1,600 mm in the north east of the catchment.

- The long-term forecast rainfall forecast across the catchment is for steady to increasing rainfall.

- The resulting average inflow to the Burdekin Falls Dam is 8,000 GL pa* which is about 3 times the average annual inflow (2,800 GL) of the Snowy Mountains catchment. Refer Fig.14.
  *Source; Flood generation in the Burdekin and Haughton rivers north Queensland, CSIRO 1991.

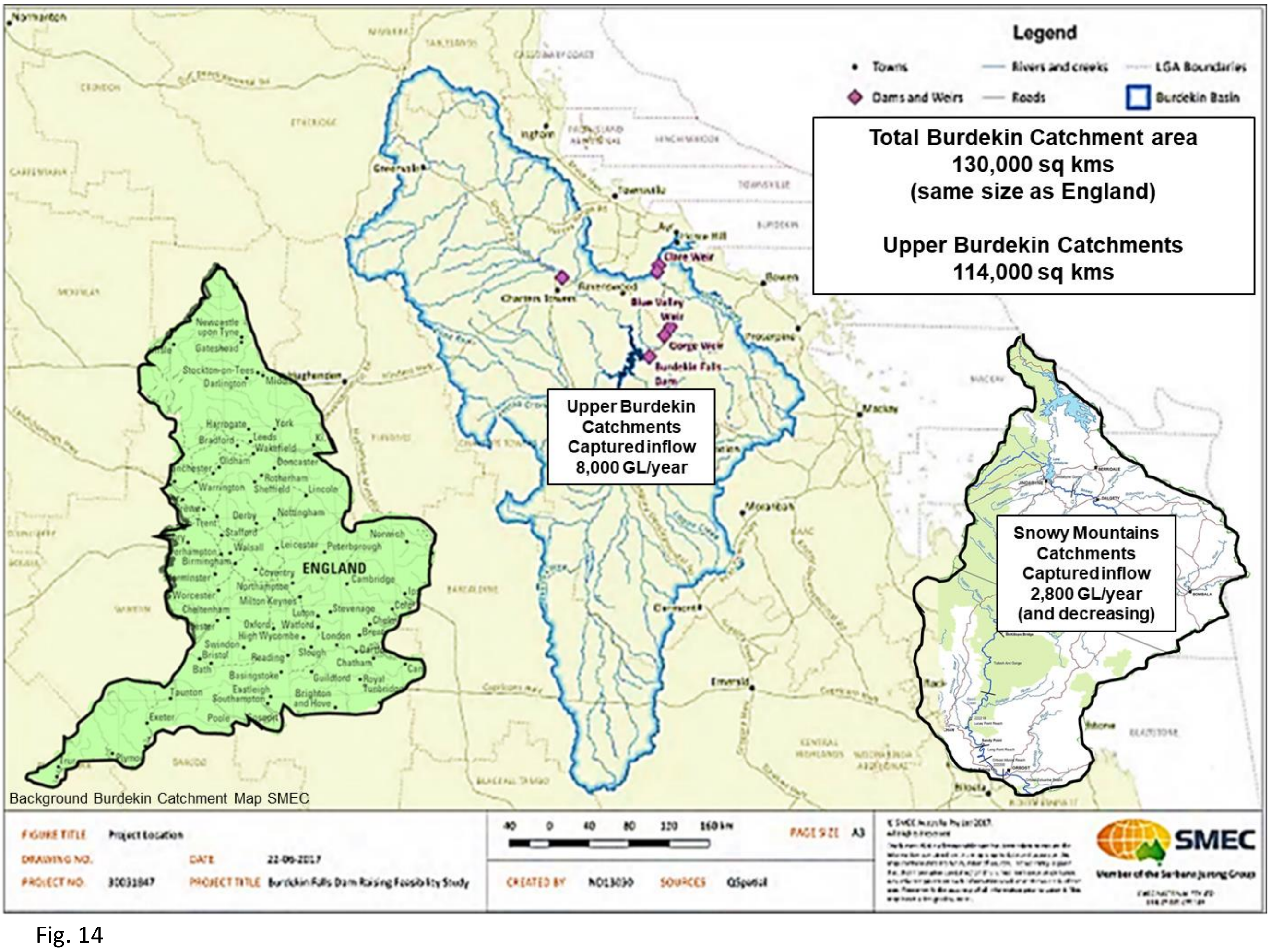


Fig. 14

The Burdekin Falls Dam

The Burdekin Falls Dam is the collection point for the catchment runoff. The dam is located on the Burdekin River has the greatest average annual peak discharge of all Australian rivers. Accordingly, the dam has the longest spillway (504 m) of all Australian dams. On average 82% of the annual inflow to the dam overtops the spillway and flows, unused, to the ocean.

Flows over the dam spillway

Since the dam was completed in 1988, flows have overtopped the spillway 30 out of 32 years*. Refer Fig.15.

*Runoff in the catchment is very reliable and flows have overtopped the spillway every year, except one, since it was built. The volume of inflow into the dam during a flood event is considerable, and water spills from the dam for an average of three months each year. ANCOLD (Australian National Committee on Large Dams) 2009

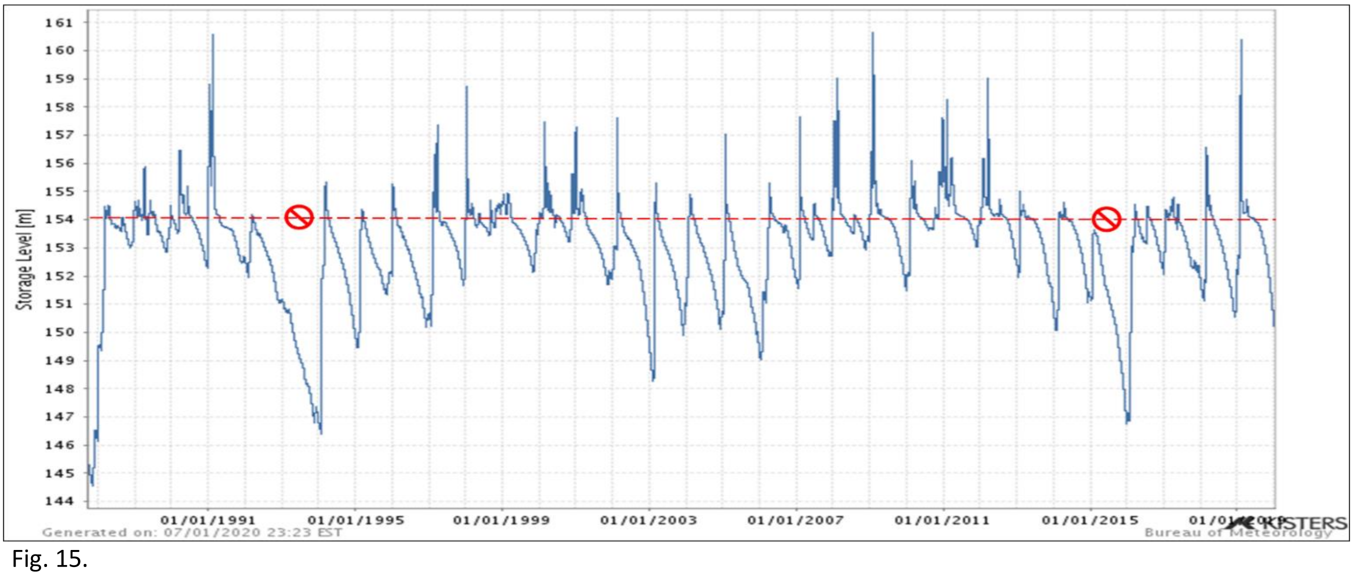


Fig. 15.

Spillway flow during the 2019 floods

During the 2019 floods water flowed 6.46 metres above the spillway at a rate of 1,504 GL/day (3 Sydney harbours per day) Refer Fig. 16 and Fig. 17.

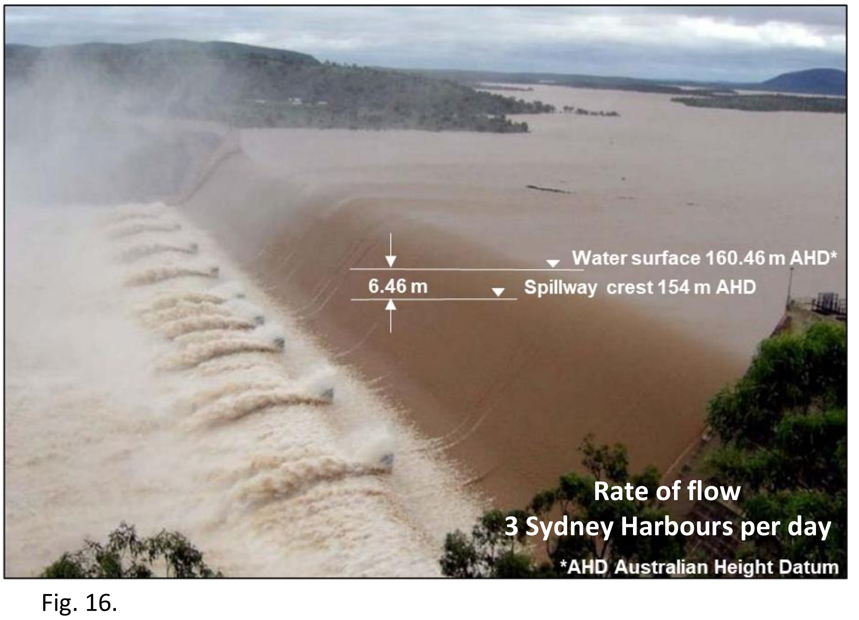


Fig. 16.

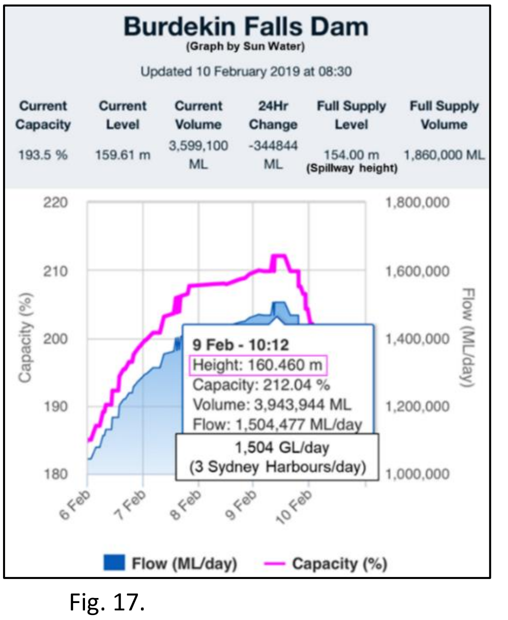


Fig. 17.

Burdekin Falls Dam — Spillway height vs Storage capacity

Raising the spillway has been considered ever since the dam was built. The saddle bank embankments on the northern side of the lake were constructed to accommodate future raising of the spillway by 15 metres which is the height proposed by the BMS. Refer Fig.18.

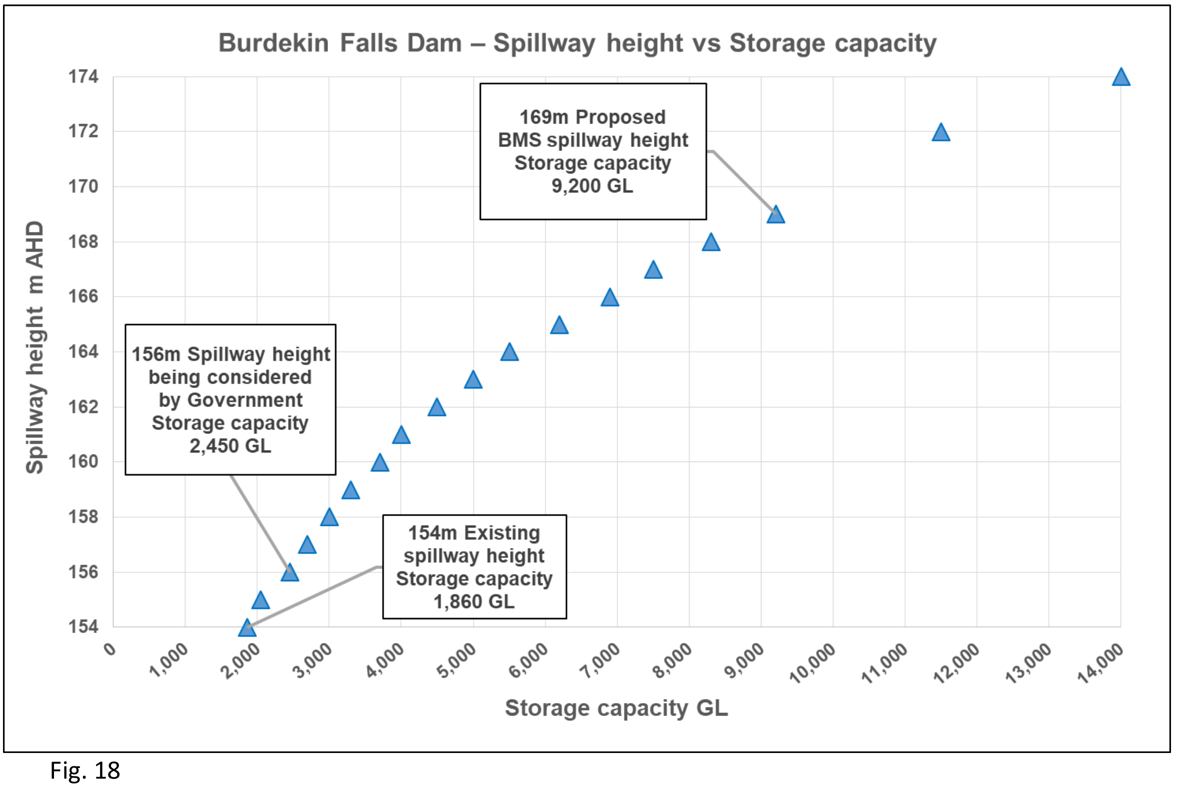


Fig. 18

Burdekin Falls Dam — Spillway height vs Water capture

The BMS will allow the capture and harvest of 5,500 GL pa of runoff water. The volume of excess runoff that is currently lost to the ocean will be reduced from 82% to 25% of the annual inflow of 8,000 GL pa. Refer Fig.19.

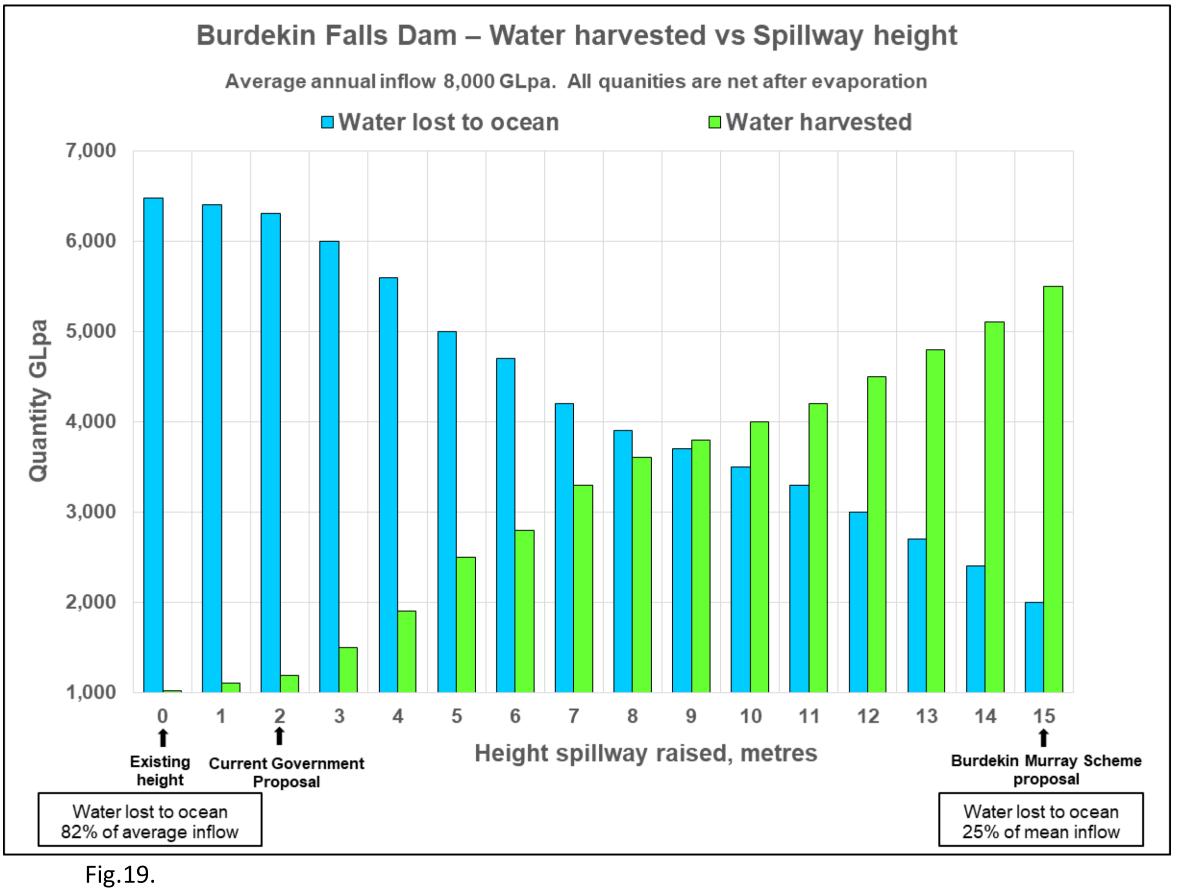


Fig.19.

Burdekin Falls Dam — Proposed dam amplification to enable increased water harvest

Raising the spillway 15m (to its original reservoir design height) will increase the storage capacity by almost 5 times. Refer Fig.20.

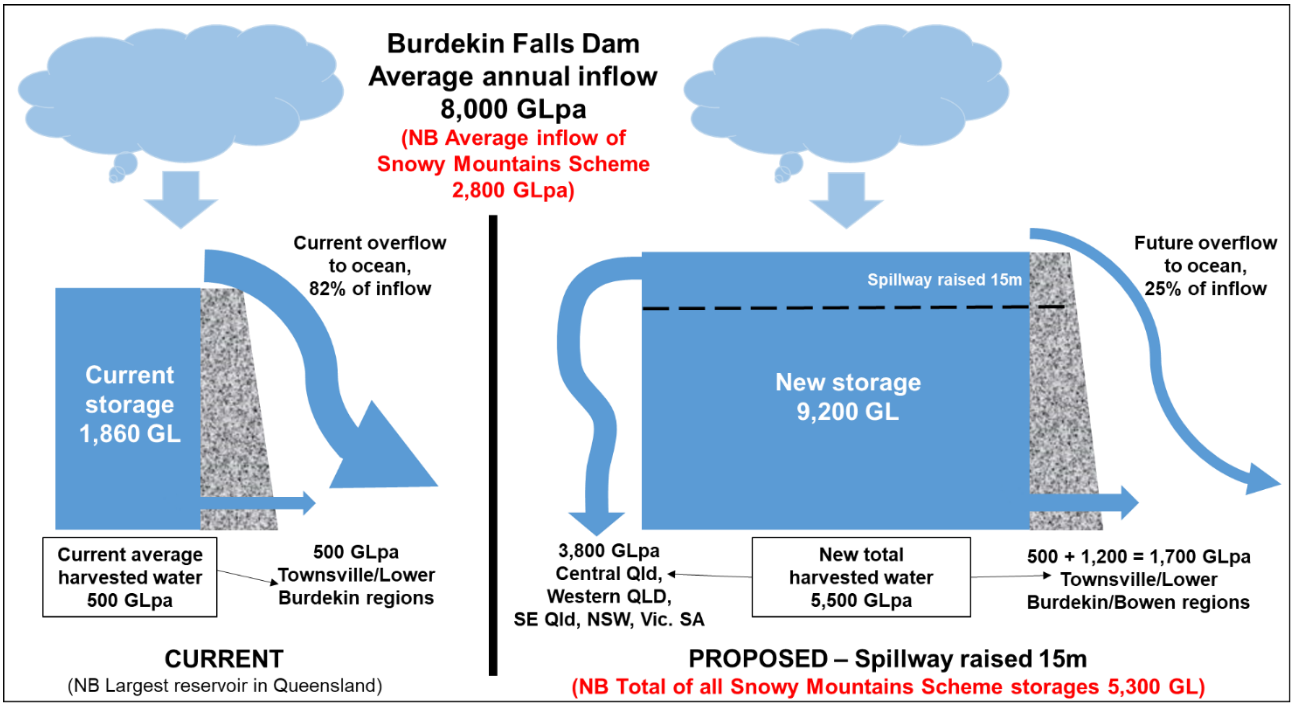


Fig.20.

Reliability of harvesting 5,500 GL pa

The probability of harvesting 100% of the 5,500 GLpa net harvest is 78%.* Refer Fig.21

*Hydrological data sources

1.. Event-based community water quality monitoring in the Burdekin Dry Tropics Region, Australian Centre for Tropical Freshwater Research James Cook University Townsville. 2007, CSIRO Land and Water Davies Laboratory Townsville, Department of Natural Resources and Water Townsville.

2. Flood generation in the Burdekin and Haughton rivers north Queensland CSIRO 1991.

3. BOM Streamflow records

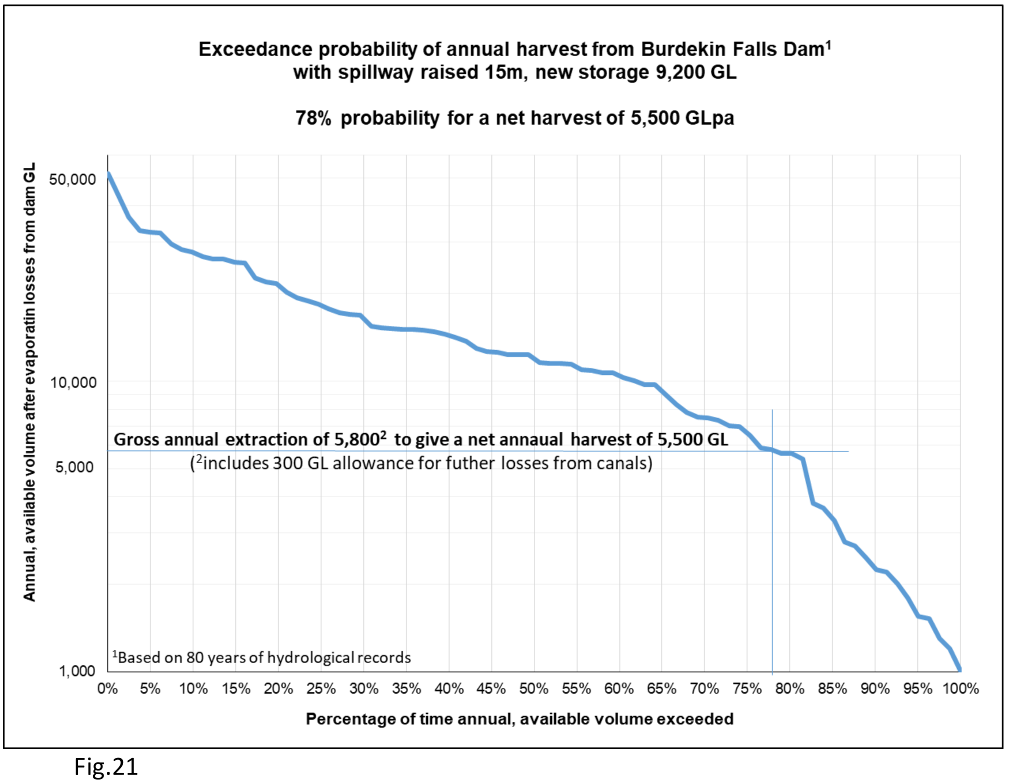
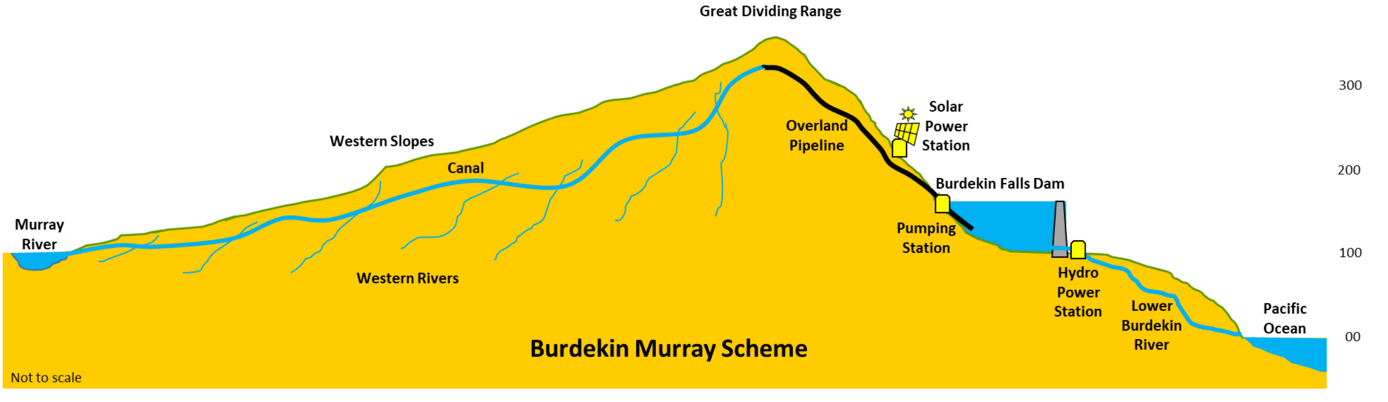


Fig.21

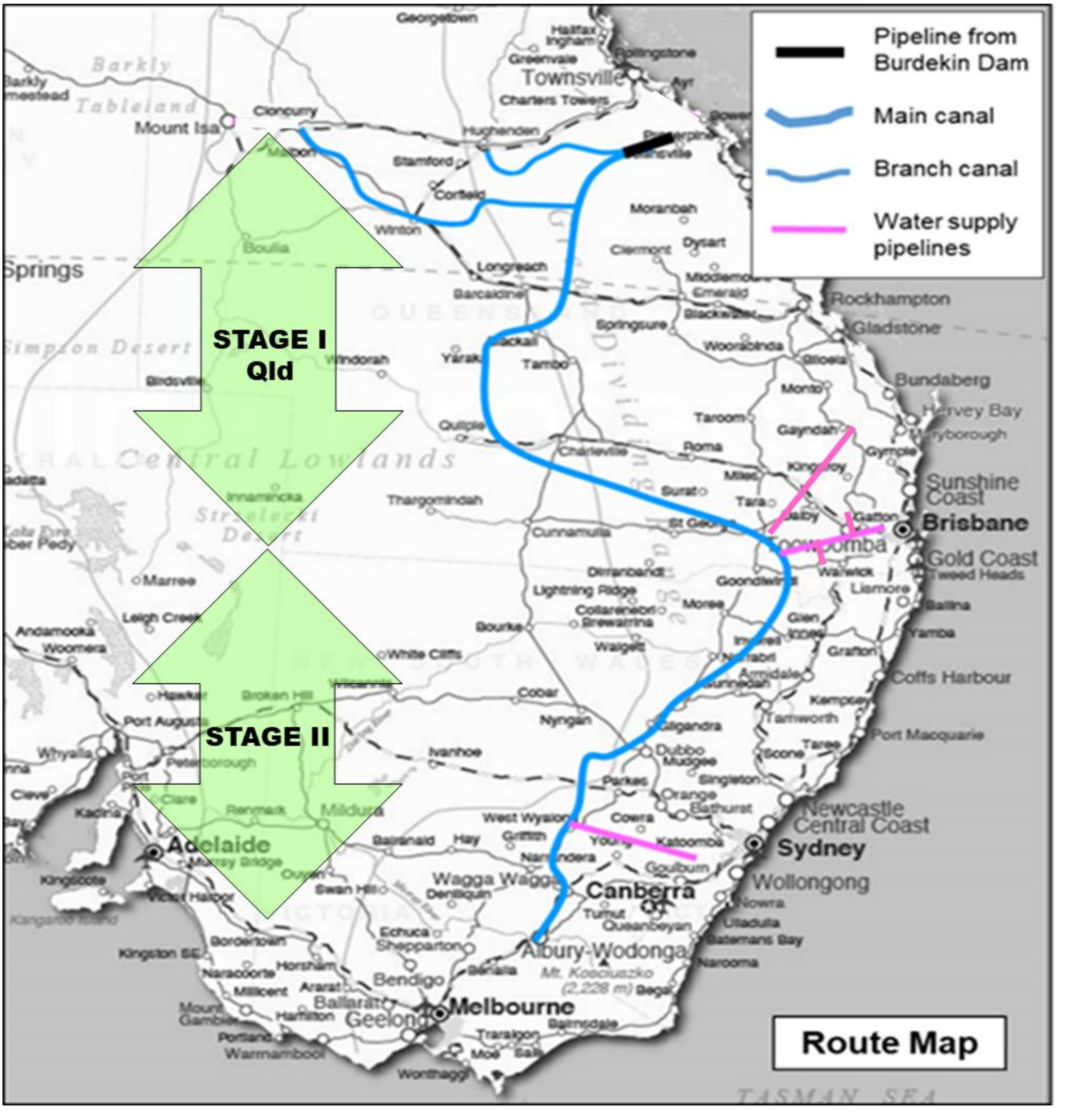
The Proposal



Project Description

- Water will be pumped from the amplified dam 133 kms to the ridge of the Great Dividing Range using renewable energy; Hydroelectric Energy and Solar Energy.
- From this high point water will be transferred to canals which will flow, by gravity, to Northern Queensland, Western Queensland, Central Queensland, NSW, Victoria and South Australia (via the Darling and Murray rivers). Canals will be lined with a heavy duty, heat sealed HDPE liner which has a 100 year service life.
- The delivery system includes the major rivers which flow west from the Great Dividing Range. Water is carried across rivers in aqueducts fitted with remote controlled diversion sluice gates. This will allow specific volumes of water to be distributed into any river as required.
- The scheme includes complete offtake systems, (Solar Power stations, Pumping Plant and Pipelines), to augment the water supplies for regions of Bundaberg, Townsville, Toowoomba, Warwick, SE Queensland, including Brisbane, Sydney and Adelaide.
- All evaporation losses from the dam and the distribution system have been taken into account.
- The scheme can be built in two stages; Stage I Queensland, Stage II NSW, Victoria and South Australia.

Canal Route and Project Staging



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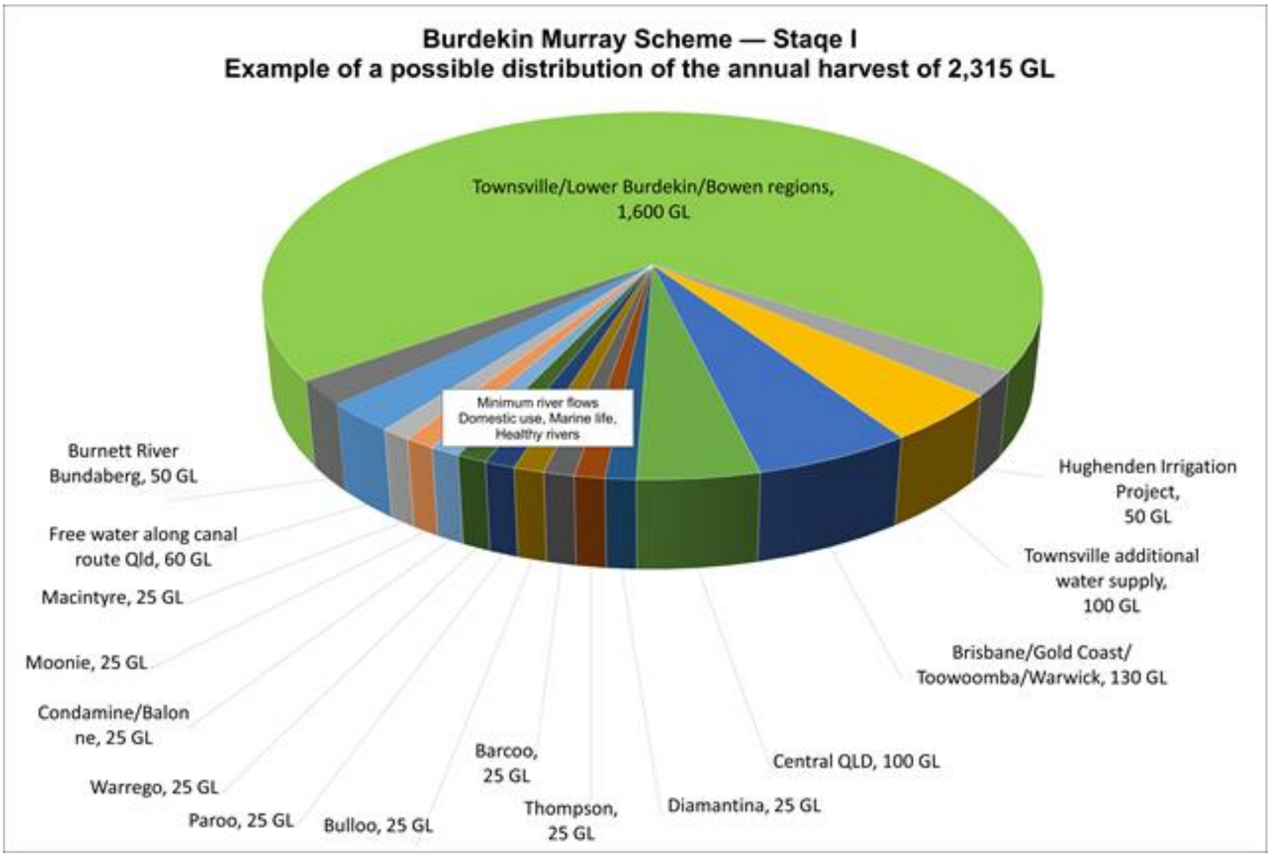
An example of an expected general distribution is shown in the Staging Summary below.

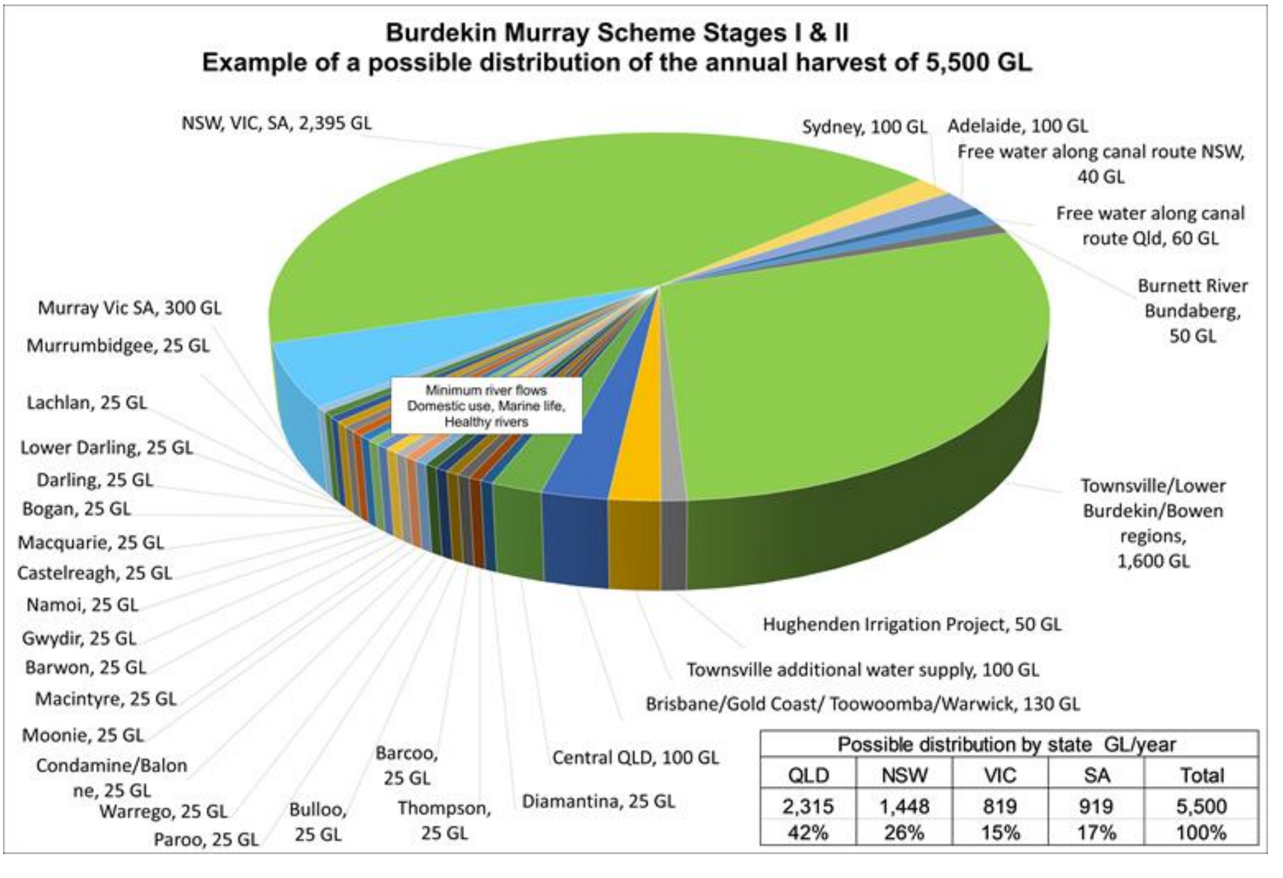
STAGING SUMMARY			
Feature	**Stage I**	**Stage II**	**Stages I & II**
States served	**Qld**	**NSW, Vic, SA**	**Qld, NSW, Vic, SA**
CAPEX	**$7 bn**	**$16 bn**	**$23 bn**
% dam amplification works, final capacity	**100%, 9,200 GL**	**9,200 GL**	**9,200 GL**
Canal length	**1,500 km**	**1,000 km**	**2,500 km**
Water harvest distribution **Lower Burdekin, adjacent regions (via dam gates)** **Western Qld, Central Qld, SE Qld (via canal)** **NSW, Vic, SA (via canal)**	 **1,700 GLpa** **615 GLpa** **2,315 GLpa**	 **3,185 GLpa**	 **5,500 GLpa**

Water distribution

Stage I



Stages I & II



Water delivery system

The BMS deliver system will consist of the main canal plus the 22 major rivers which flow west from the Great Dividing Range (GDR).

The length of the main canal, from the GDR ridge in Queensland to the Murray River is approximately 2,500 km. Minor canals will supply water as far as the Flinders and Cloncurry regions of Northern Queensland. Refer Fig. 24

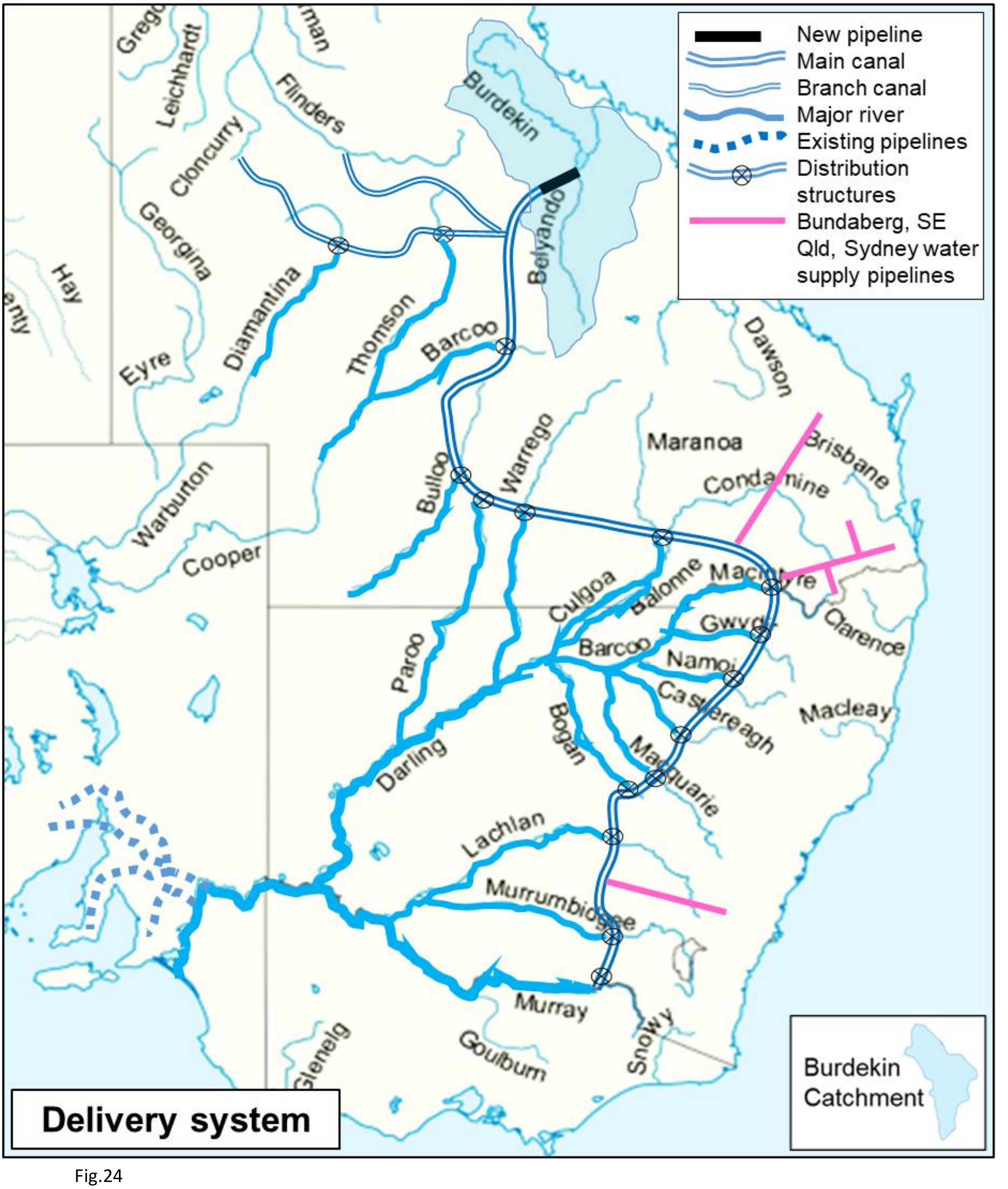
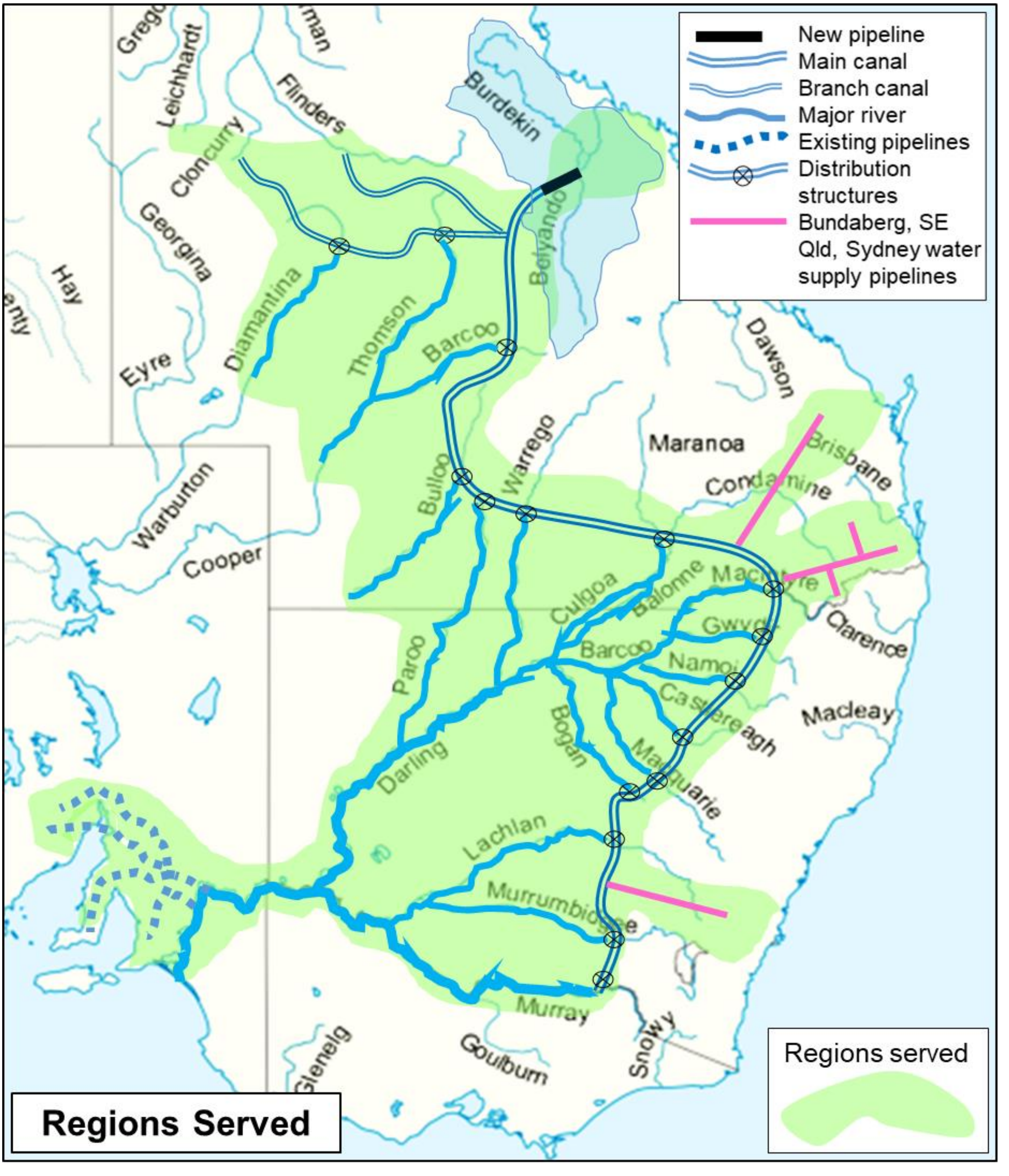


Fig.24

Regions Served



Water quality, Biosecurity, Canal flow data, Delivery system operation, Why open lined canals

Water Quality
Water is sourced from the Burdekin Falls Dam. As the dam is the source for Townsville drinking water it is subject to rigorous quality control and monitoring. Refer APPENDIX A, Water Quality Management Plan.

Biosecurity
Screening ponds adjacent to the Burdekin Falls Dam pumping station will be monitored for any invasive species of fauna or flora. The arrangement will be similar to that used for the Central Arizona Project (CAP) pumping station as shown in APPENDIX A. Biosecurity.
To date the Burdekin Falls Dam has been relatively free of any harmful species. Further, runoff from the catchments immediately to the north and west of the Burdekin catchment eventually drains into the Darling River when there are heavy rains. In wet years, the lower Paroo receives flows from the Warrego River system via Cuttaburra Creek. In very wet years the waters of the Paroo will flow to reach the Darling River, between Louth and Wilcannia. To date, this has not caused a biosecurity.

To ensure overall water quality is maintained monitoring stations located along the canal route will carry out continuous water sampling.

Canal flow data

- Main canal length 2,500 km
- Fall 200m (excluding 20m fall through aqueducts). General canal fall rate 1:12,500
- The maximum flow quantity is 120 m3/sec.
- The average flow velocity of is 1.6 m/sec.
- The travel time from the ridge at the Burdekin catchment to the Murray River is 18 days.
- Average evaporation loss for water flowing the full length of the canal will be 5%. Losses for average length of flows will be approximately 3%.
- The canal is designed for an average additional flow of 8% to cover average canal and average, subsequent river conveyancing losses.

Delivery system operation
At each location where a canal crosses a major river remote controlled diversion structures in the canal will divert water to any river in any quantity as required. Depending on the topography, the diversion structure may be located in the aqueduct as it crosses a river. Refer Fig.28.
Route design and catchment modelling
Development of the route from preliminary design to final route determination will be facilitated by the use of LiDAR (Light Detection and Ranging). All adjacent sub-catchments along the route will be digitally 3D modelled using data collected by LiDAR. <u>Canal cross drainage will be designed to ensure existing overland flows either side of the canal corridor remain unaltered following canal construction.</u>

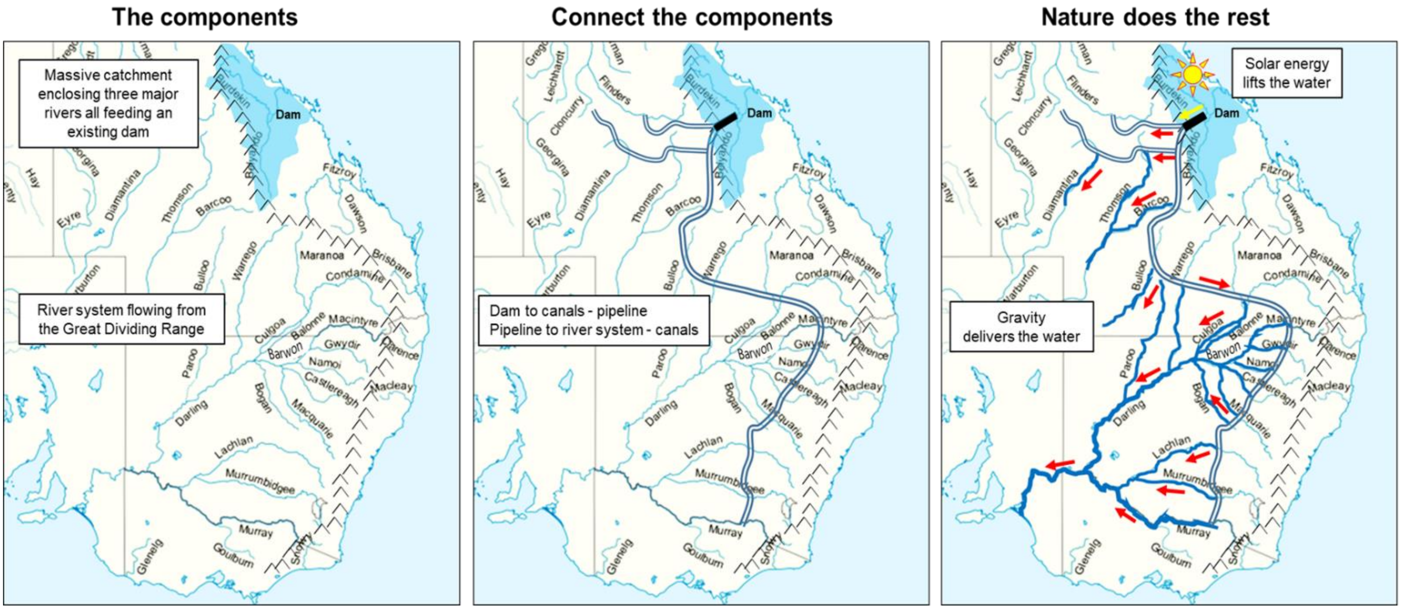
Why open, lined canals

Open, lined canals vs Covered canals or Pipelines

Covered canals The cost of covering a canal with a roof to limit evaporation losses can increase the cost of the canal by 100% even after providing slightly larger canals to cover the relatively minor evaporation losses associated with an open canal.

Pipeline The cost of a pipeline is about 50 to 70 times the cost of a canal per km, for transporting the same water volume. Further, operating cost are much less as water in canals will flow by gravity alone whereas water in pipelines will require pumping; a) wherever the pipeline has to climb terrain and b) continually, to overcome friction losses associated with pipeline flow.

Most of the scheme is already in place.



Project approval

The project can be shovel ready and built relatively quickly as many of the approvals can be fast tracked for the following reasons:

i) No new dams are required

ii) Amplification of the existing dam storage capacity

The dam was constructed in the 1980's with a maximum storage level of RL 154m. Prior to the dam's construction the Queensland Government purchased all the land up to a projected 'high water' level contour of RL 169m (white freehold area) to allow for future expansion of the dam.

The level of 169m is the full storage proposed by the Burdekin Murray Scheme. Accordingly, most of the land tenure and environmental issues have already been addressed. Refer Fig.26. and extract below from; Burdekin Falls Dam Raising Feasibility Report, SMEC 2018

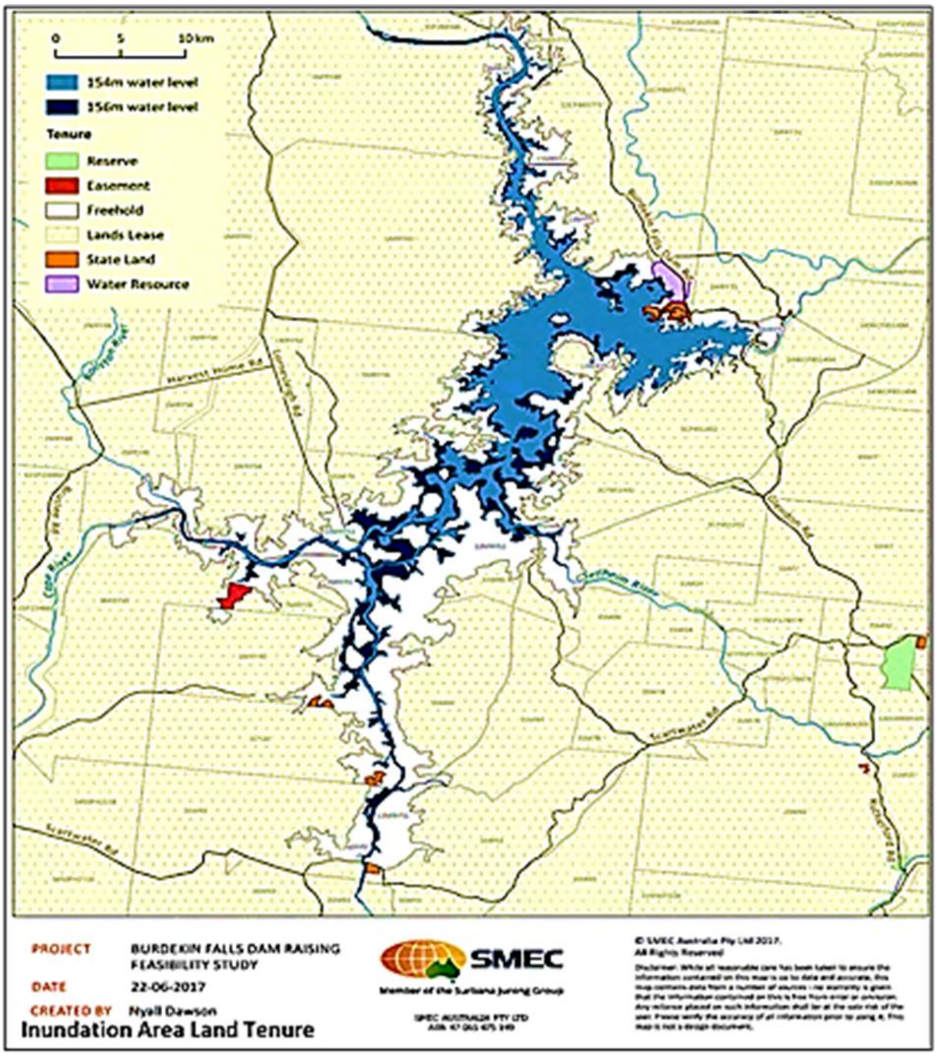


Fig.26

“Most of the land required for the raising of the dam and resulting increased inundation area is freehold land owned by SunWater (Lot 13 MRY51). When the dam was constructed in the 1980s, the land to 169 m AHD (FSL plus 15 m) was acquired by the Queensland Government, with exception of the land in the upstream reaches of the Burdekin River and tributaries. The land in these areas was considered unlikely to be impacted by flood beyond that which it already experienced, hence the land was not acquired. The adopted flood margin of 1 in 100 Annual Exceedance Probability (AEP) for the raising is located within the 169 m AHD contour except in the upstream reaches of the Burdekin River and Suttor River. This means that no additional land will need to be acquired, except for the areas in the upper reaches of the Burdekin and Suttor Rivers where further investigation into acquisition (or taking of a lease for the flood margin) will be required.”

.

iii) Canal route

It is proposed to offer landholders whose property is located on the canal route a total of 100GL of free water annually, for stock and domestic purposes. This represents 2% of the total annual harvest (5,000 GL) and would be distributed at 40ML/km for every kilometre of canal length which crosses the landholder’s property.

This proposal has been unanimously supported by all the farmers canvassed along the proposed route corridor. Accordingly, no major problems are anticipated regarding approval for the route of the canals.

Construction details

Modifications to dam

It is proposed to raise the height of the spillway by 15 metres to its maximum design height of RL 169 metres. Refer Fig.27.

The additional land required to extend the banks of the reservoir up to an RL of 169 metres has already been acquired by the Government, Refer Project Approval Fig.26.

There will be some relatively minor works required such as modifications to the dam's abutments and the saddle banks on the northern side of the reservoir. The northern embankments were originally constructed to RL 171m, which is the height required for the BMS. Refer Fig. 28. Other works required will be similar to those relating to raising the dam wall by up to 6 metres, as presently being considered by the Queensland Government. Refer APPENDIX E, Specific works related to raising the dam wall up to 6 metres, Queensland Government June 2020.

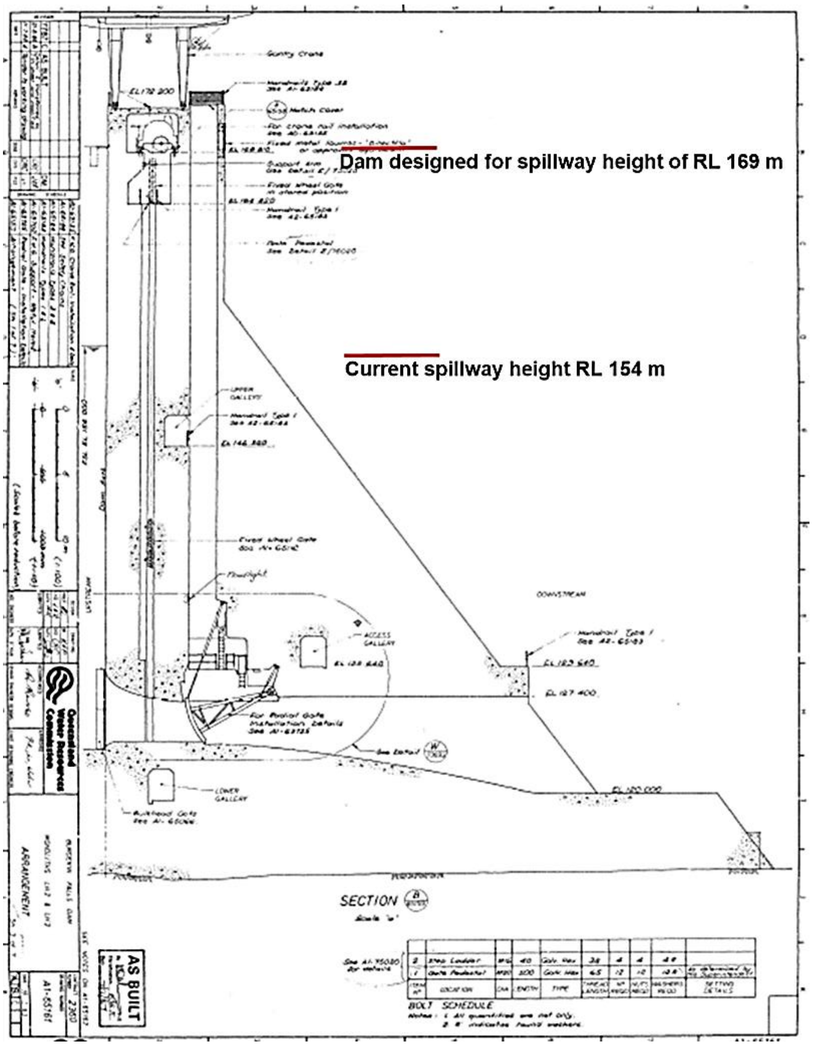


Fig.27

Fig.28.

Hydro Power Station

The scheme includes a Hydro Power Station to be located below the Burdekin Falls Dam. An indicative arrangement of the power station components is shown in Fig. 24.

The outlet works of Burdekin Falls Dam is consist of two mild steel lined conduits each regulated by 2m wide x 3m high pressure radial gate. Refer Figs. 29, 30, 31. A third outlet was built-in during the dam's construction in 1987 to cater for a future Hydro Electricity power station.

The Queensland Government recently announced that it will build a new Hydro power station in this location when the wall of the existing dam is raised 2 metres. The announcement further stated that the proposed hydro power station would generate 150 GWH of electricity providing enough electricity to power 30,000 homes.

The power station proposed by the Burdekin Murray Scheme, in the same location, with the dam wall raised 15 metres and the storage capacity of the dam increased fivefold, will generate up to 600 GWH of electricity and provide enough power for 120,000 homes. The hydro power will be used to assist with pumping water from the dam.

The regions of Townsville and Central Queensland each have approximately 100,000 dwellings.

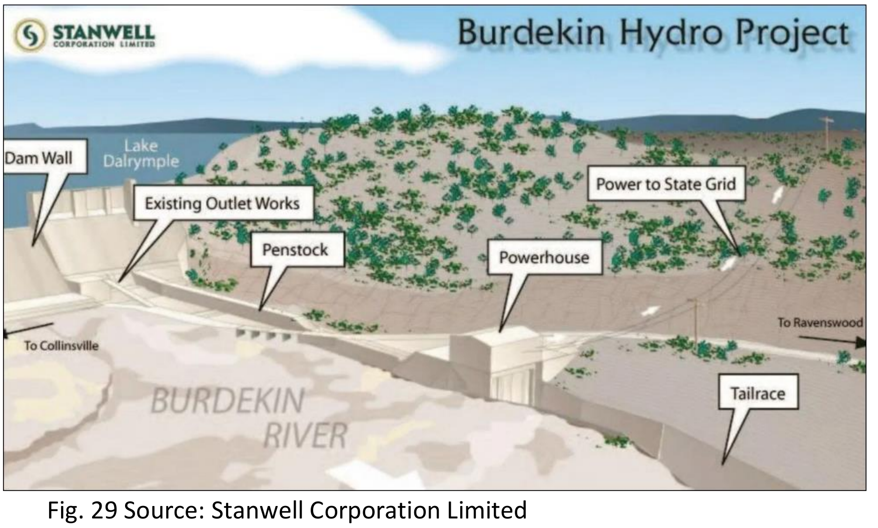


Fig. 29 Source: Stanwell Corporation Limited

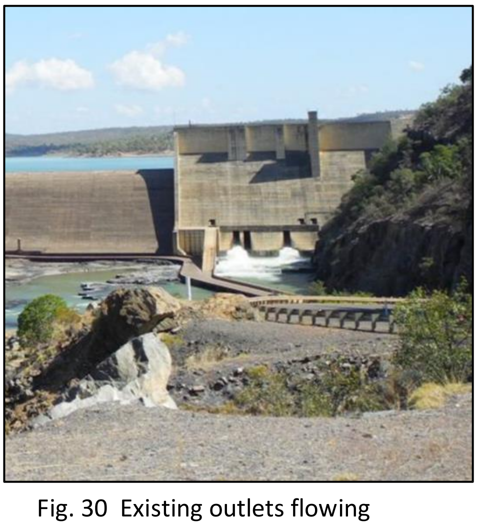


Fig. 30 Existing outlets flowing

Fig. 31 Existing outlets flowing

Pumping system, Graphite Thermal Batteries

Pumping power of 500 MW will be provided solar energy with Graphite Thermal batteries. Refer Fig.32

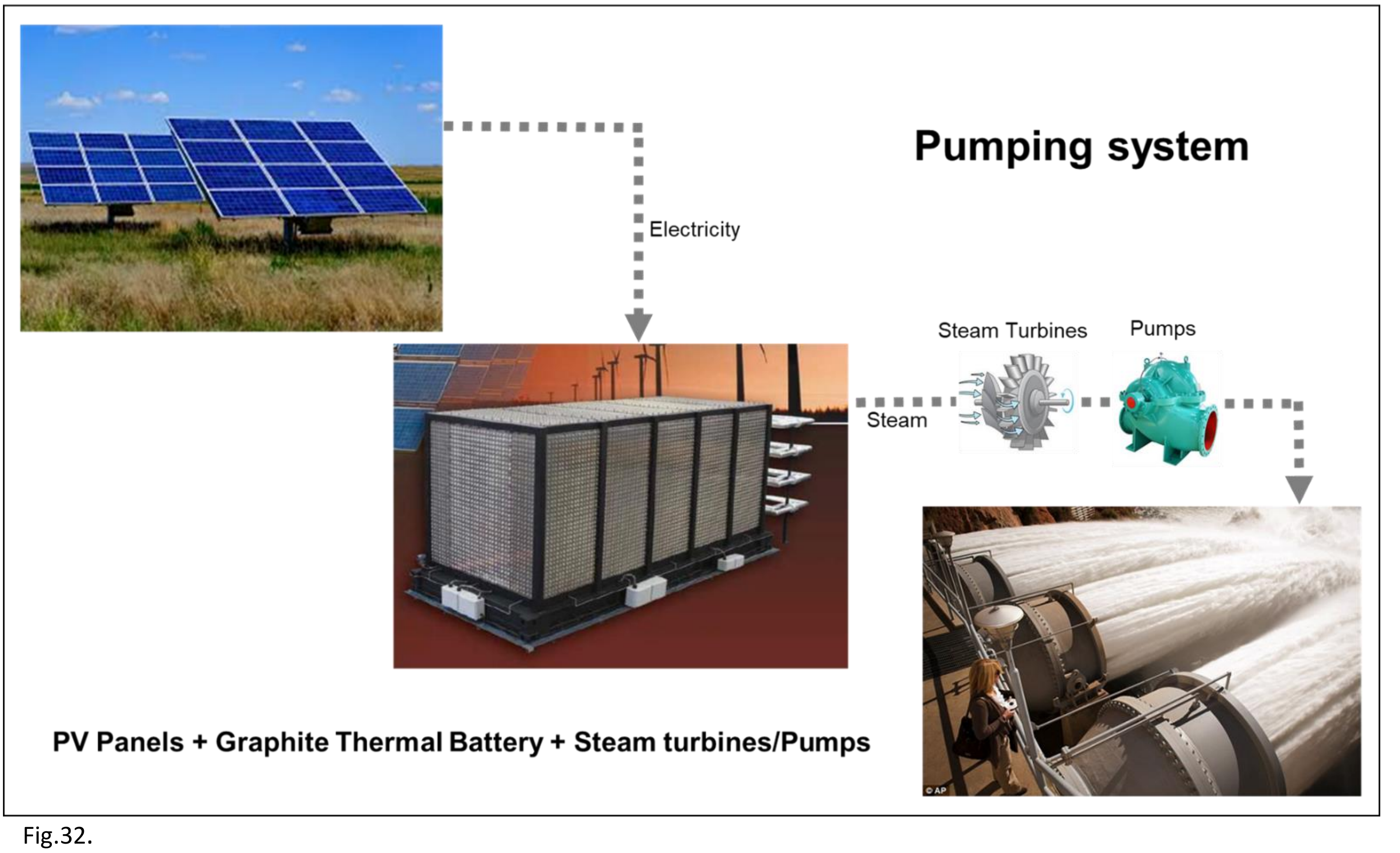


Fig.32.

Graphite Thermal Batteries

Background

- Australian invention developed over the past 20 years.
- Original battery prototype built and tested in Snowy Mountains Scheme workshops, Cooma Australia.
- Approved for use in 30 countries.
- Demonstration plants have been built in Australia and China.
- Currently being rolled out in the following countries:
  - Cyprus; 50 MW solar power station.
  - Egypt; 1,000 MW solar power station to supply power, via subterranean cable, to Europe.

Operational features

- Practically unlimited service life.
- Able to operate under 100% charge/discharge regimes without any effect on operational life. (Unlike Lithium ion batteries)

Cost savings

- Half the capital cost of all other large scale batteries.
- Minimal O & M costs.
- Plant generates 430 MW. Saves electricity purchase costs of approximately $500 mpa.

Environment

- Avoids greenhouse emissions of 4 million tonnes pa.*
  *Department of Environment and Energy, Purchased electricity emission factors Queensland

Canal and Aqueduct details

Main canal Refer. Fig.33.

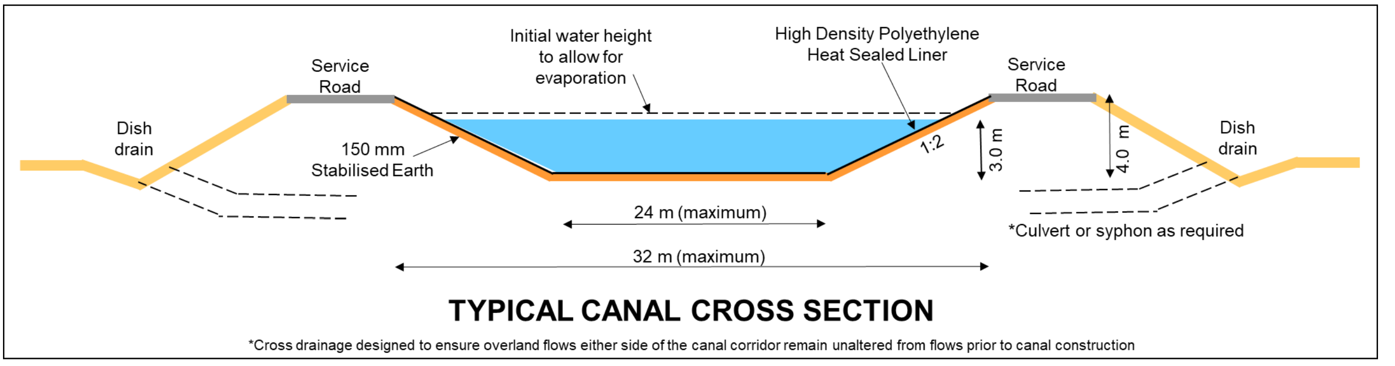


Fig.33.

Lined canal under construction
Refer Fig.34

- Liner High Density Polyethylene (HDPE).
- 100 year service life.
- Field seams hot fusion welded.
- Seepage losses virtually eliminated
- Heavy duty UV and generally puncture proof

Fig.34.

Typical canal arrangements
Refer Fig. 35

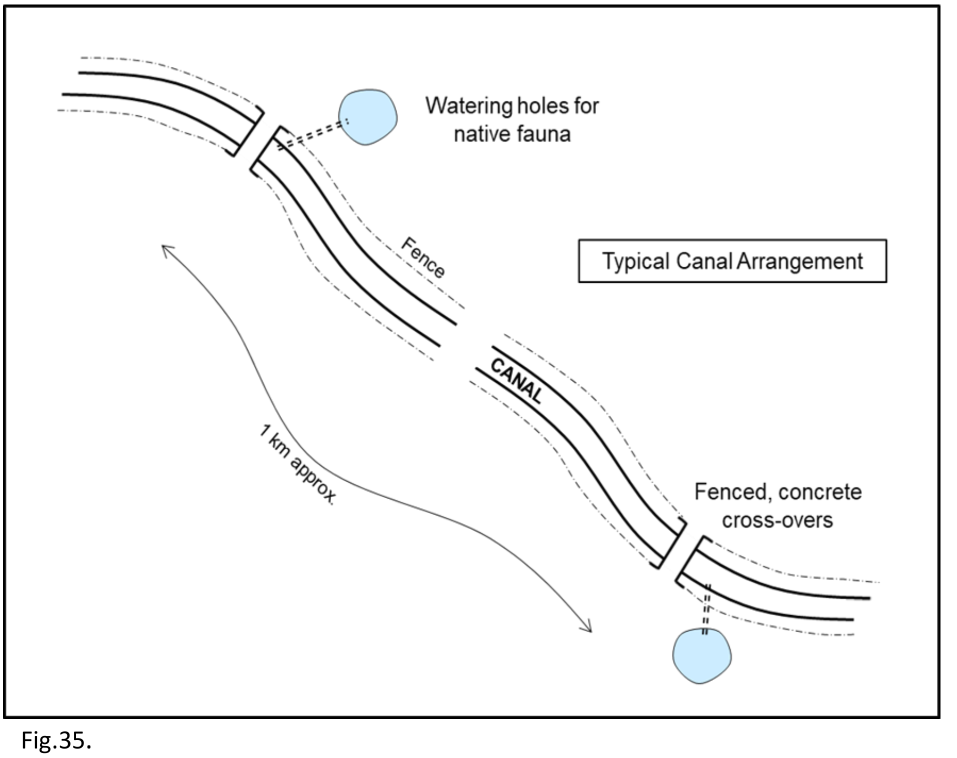


Fig.35.

Aqueduct details

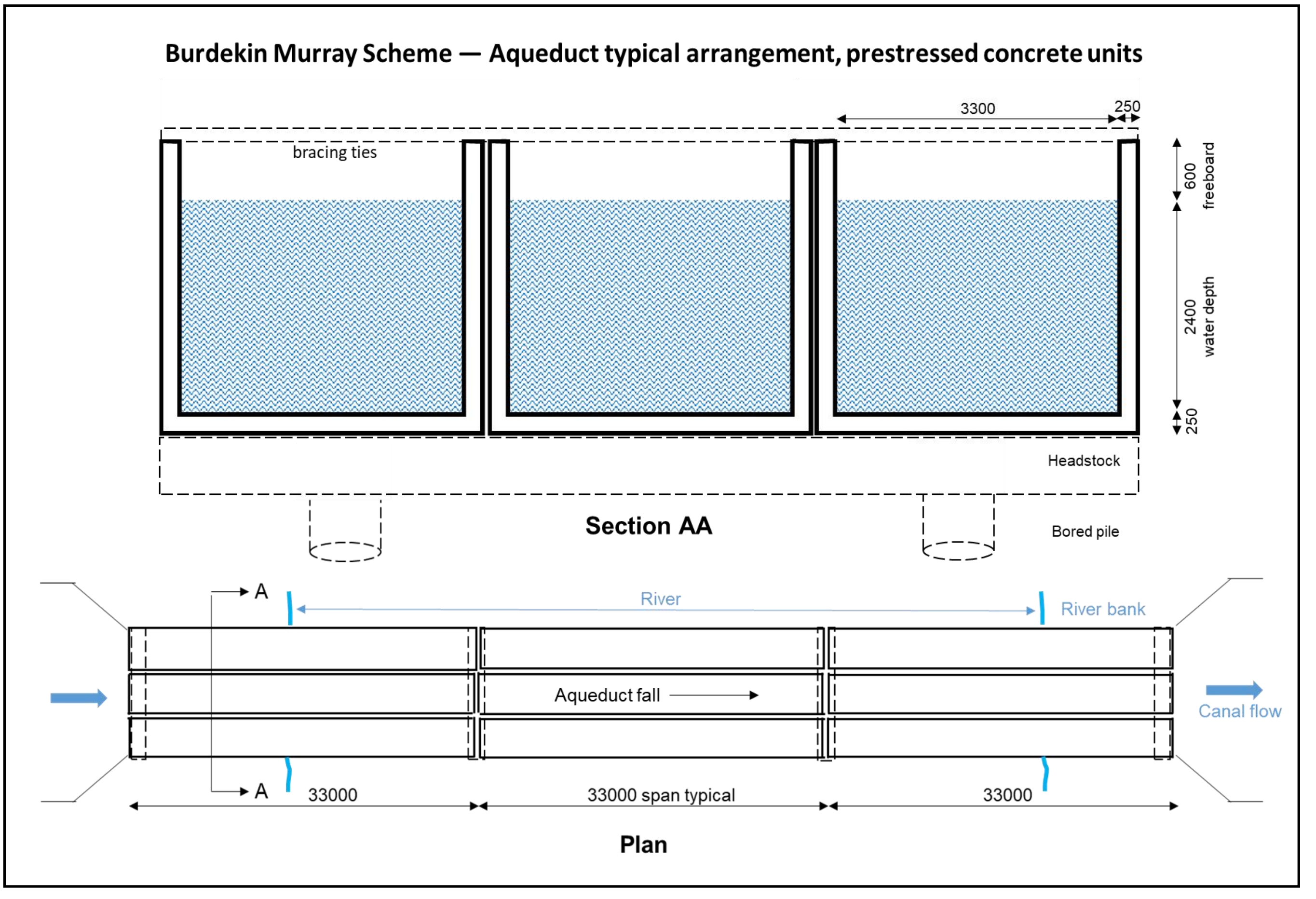


Fig. 36

- Aqueducts shall consist of modified, precast concrete ‘U’ sections
- Aqueducts shall generally be configured in 2, 3 and 4 precast unit arrangements. Refer Fig.36

Example of a typical regional road bridge construction using precast concrete ‘T’ or inverted ‘U’ sections. The BMS proposal will use modified, precast concrete ‘U’ sections for aqueducts along the canal route where the canal is required to cross a river, gorge, roadway, rail line etc.

Aqueduct data

Aqueducts shall generally consist of 2, 3 or 4 precast concrete units. Each unit is approximately 33m long. Typical arrangement; 3 units side by side. Estimated total number of aqueducts, in the order of 125, based on an average length of 75 metres.

Hydraulic data for a single precast concrete unit			
Data	**Value**	**Units**	**Remarks**
Average length of one precast unit	33	m	Average aqueduct 75m long, will vary to suit site
Slope along unit	0.00213	m/m	Fall along aqueduct, (average length of 75m) 160mm
Water area	7.92	m2	3.3m W x 2.4m H
Wetted perimeter	8.1	m	
Manning number	0.0115		Smooth concrete
Flow rate	31.34	m3/s	
Velocity	3.96	m/s	
Froude number	0.82		Subcritical flow
Velocity head	0.8	m	
Specific energy	3.2	m	
Critical slope	0.003	m/m	

Construction program

Following approval, detailed programming has demonstrated the scheme can be constructed as follows:

In a single stage; 3 years. Refer Fig.37.
or
b) In 2 stages, 3 years each stage; 6 years

Program can be achieved by commencing canal construction simultaneously on multiple sections of the canal.

NB The existing dam was built in 2½ years.

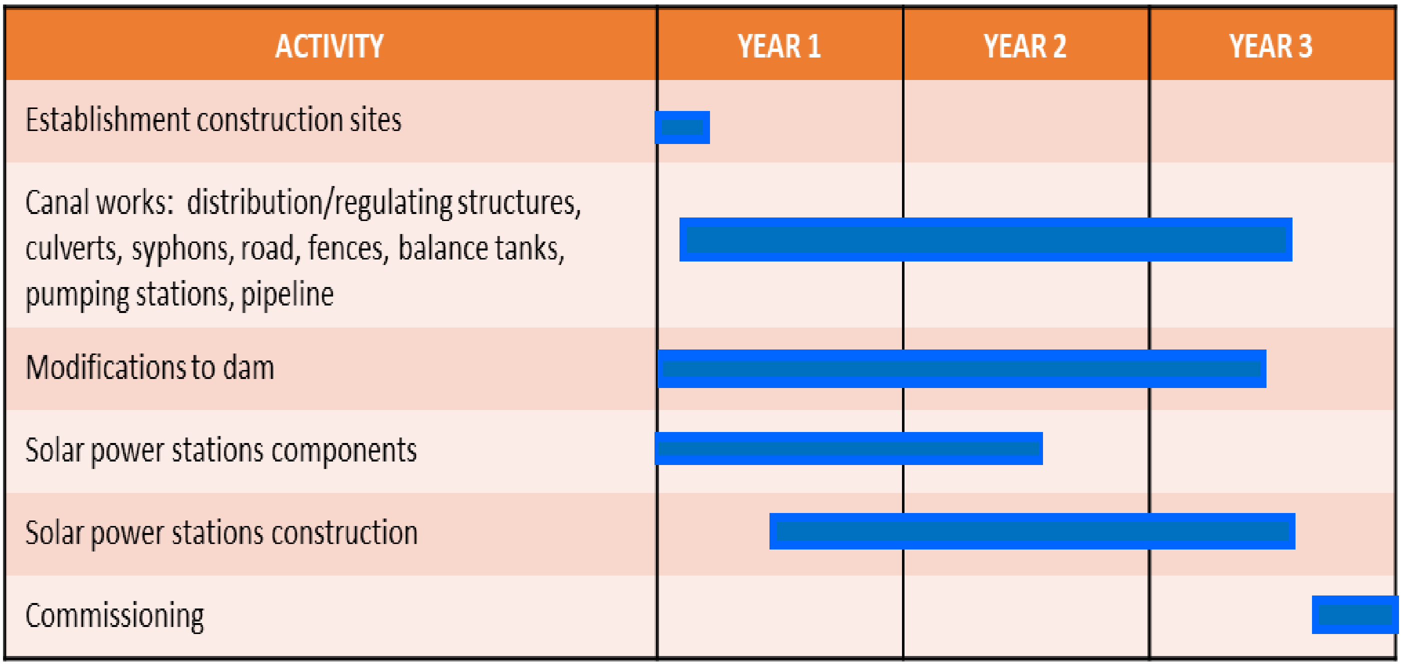


Fig.37.

Burdekin Murray Scheme — Irrigation structures

The Burdekin Murray Scheme will use remote controlled structures similar to those which have been used for many years throughout Australia.

Main canal regulating gates

Offtake canal regulating gates

Remote control of offtake structures in the Goulburn-Murray Irrigation District

Aqueducts and syphons along the Torrumbarry No 2 Channel in the Goulburn Murray Water Irrigation district, Victoria.

Diversion aqueduct, Northern Districts Irrigation Area, Victoria

PART 2 — SUPPLEMENTARY INFORMATION

Financial Summary and Economic Appraisal

Financial summary

Project cost

Stage I Queensland		$ 7 bn
Stage II NSW, Victoria, South Australia		$ 16 bn
	Total	$ 23 bn[1]

[1]Cost includes:

- Contingency (20%), Complete off take systems (Solar Power station, Pumps & Pipelines) for pumping augmentation water from canal to Bundaberg, South-East Queensland (incl. Brisbane) and Sydney water supply systems.
- Hydroelectric power station including headrace, penstock and tailrace.
- Stage I includes full cost of dam amplification works and canal, constructed for St I & II capacity, to the NSW border.

O & M $380 mpa

Total volume of additional water supplied 5,000,000 MLpa

Net operating cost of providing water $380m/5,000,000 **$76/ML**

NB Average price of high priority Murray Darling Basin water allocations for past 12 years is $140/ML Refer Fig.38.

Fig.38.

Project funding

Dr Samuel Lackey, Former NSW Government Chief Economist and Director Investment Assurance Transport NSW, advises that "the project is eminently fundable and could be funded by a number of financing methods including 'off balance sheet' funding through the issue of long-term Infrastructure Bonds."

Economic appraisal

Indicative economic assessment[1]

Economic benefits	$65 bn
Economic costs	$27 bn

[1]ABS methodology, Includes NPV Gross Value of Irrigated Agricultural Production, O&M and Amortisation costs.

Benefit/Cost ratio	$65bn/$27bn	**2.4**

Employment

Jobs created:

During construction:

Construction jobs	40,000

Following construction:

Full time jobs	75,000
Flow-on full time jobs	110,000

Agricultural supports the jobs of 1.6 million Australians in farming and related industries, accounting for 17.2% of the national workforce.*

*National Farmers Federation

Agriculture GDP

The Burdekin Murray Scheme will increase the GVAP by $14 bn pa.*

***ABS Australian Environmental-Economic Accounts 2016, GVIAP ($) per ML of irrigated water used in agricultural production.

Government goal for Agriculture GDP

The scheme will enable Government to achieve its goal of an Agriculture GDP of $100 bn* by 2030. Refer Fig.39.

*Forecast criteria: BMS introduced progressively over 6 years plus GDP with growth of 5% pa.

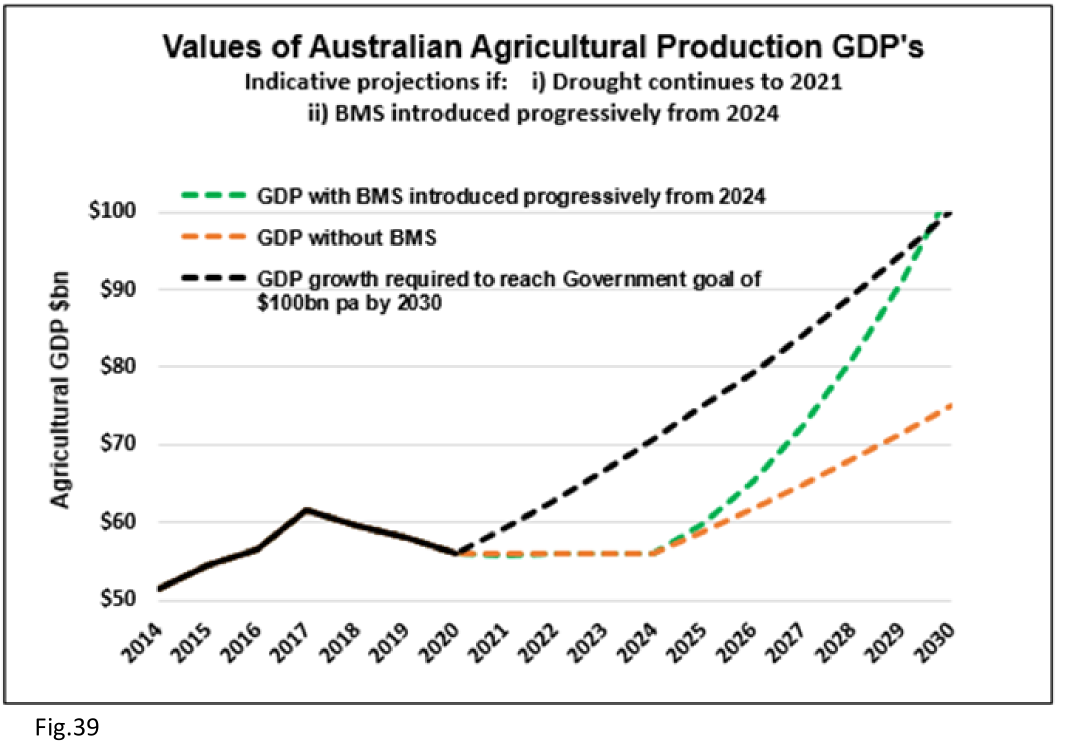


Fig.39

The scheme has the potential to increase the Australian GDP by an amount in the order of $300 bn pa.*

*Refer Section: BMS could increase Australia's GDP by $300bn ipa.

Features of the scheme

Benefiting regions

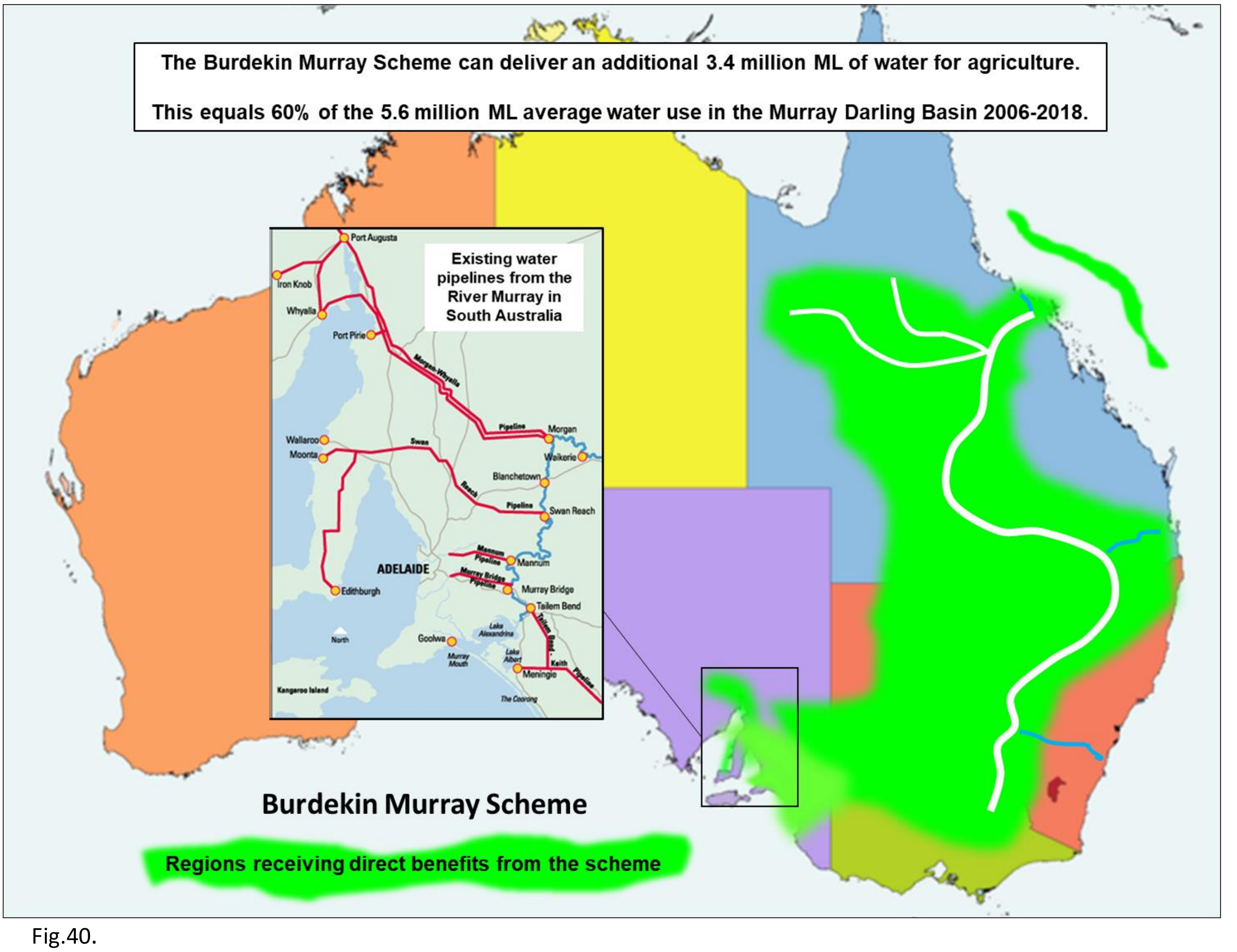


Fig.40.

Benefiting regions — 1.2 million sq.km (16% of Australian mainland)
Benefiting 25 million Australians, 13 million Australians directly

Water security

- Ensures clean town water for most western towns in Queensland and SE Australia. Refer Fig. 40.
- Provides augmentation water to Townsville, Toowoomba/Warwick/Brisbane/Gold Coast, Sydney and Adelaide to each city. Defers construction of new desalination plants for at approximately 20 years.
- Secures Townsville's existing and future water supply. New allocation from the BMS will be 100% reliable and clean. Refer APPENDIX A.
- Provides a year-round, continuous water flow in the Lower Burdekin River, the Flinders River at Hughenden and the Cloncurry River. Eliminates zero flows in these rivers.

Water availability

- BMS can deliver an additional 5 million ML of water for agriculture. This equals 90% of the 5.6 million ML average water use in the Murray Darling Basin 2006-2018. Source, Dept. Agriculture, Water and Environment, Gross Average Water Use MDB 2006-2018.
- Allows size of Hughenden Irrigation Project to be doubled in size from 8,000 Ha to 16,000 Ha.

Indigenous people

Within the Basin, alone, there are over 40 Aboriginal Nations. Rivers are important for indigenous people because they have significant cultural and heritage values. In addition, they provide centres for fishing and recreational activities.
The BMS will ensure that these are preserved as healthy rivers for future generations of Indigenous communities.

Economic stimulus

- Provides an economic stimulus of $14bn pa. by providing reliable water to various sectors. Refer Fig.41.
- Australian Agriculture GDP increased to $100 bn pa by 2030
- Full time jobs created

  During construction:
  40,000 Construction jobs

  Following construction:
  75,000 Agriculture jobs plus
  110,000 supply chain and services roles
  185,000 Total new jobs

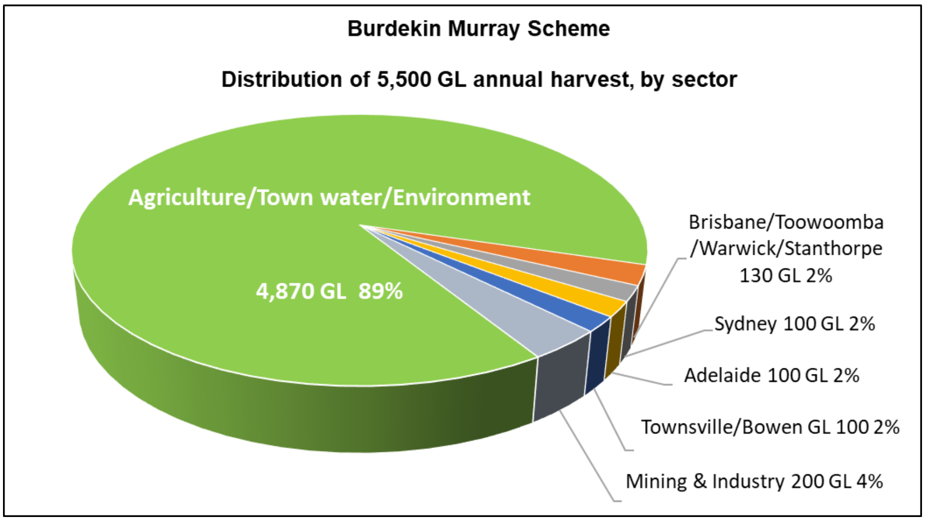


Fig.41

Benefits for the Burdekin, Townsville and Bowen regions from just raising the dam wall

The Queensland Government's is considering a project to raise the wall either 2 metres or up to 6 metres.
The accompanying Initial Advice Statement (IAS) provides Project information includes the following:

"All benefits relate to provision of a secure water supply which is sufficient to support urban, industrial and agricultural growth which will in turn support a buoyant regional economy with continuing employment and suitable provision of services. Benefits sought by the Project include:

- secure reliable water supply attracts industry and supports population, quality of life in Townsville
- increased agricultural production (with regional economic benefits)
- economic development near Bowen
- industrial development in the Bowen and Galilee Basin
- more secure and environmentally friendly diversified power supply to NQ, generated locally
- enhanced access to goods and services due to injection of wealth into local economies
- generation of employment opportunities
- improved ability to access health services and recreational activities.
- increased availability of water for future generations.

Employment and expenditure will accrue at the location of water use (Townsville, Bowen, mines, Burdekin agriculture)."

Scheme will be a catalyst for increasing decentralisation.

Requirement for new infrastructure minimised

- No new dams or tunnels required.
- The dam's saddle bank embankments on the northern shoreline of the reservoir were constructed to a height to for the spillway to be raised by 15 metres if it was decided to increase the capacity of the dam in the future. This is the spillway height proposed by the Burdekin Murray Scheme.
- The additional land required for the dam expansion was acquired by Government prior to the dam's construction. Refer Fig.35.
- The water delivered to South Australia via the Murray River can be delivered to Adelaide and the gulf regions via the 3 existing pumping stations on The Murray River and the network of existing pipelines. Refer Fig.32.

Flexibility of the scheme

One of the main attributes of the scheme is its ability to direct a specific quantity of water to any region as required.

Environmental benefits

BMS can provide environmental flows to all major rivers west of the Great Dividing Range simultaneously

Refer Fig.42.

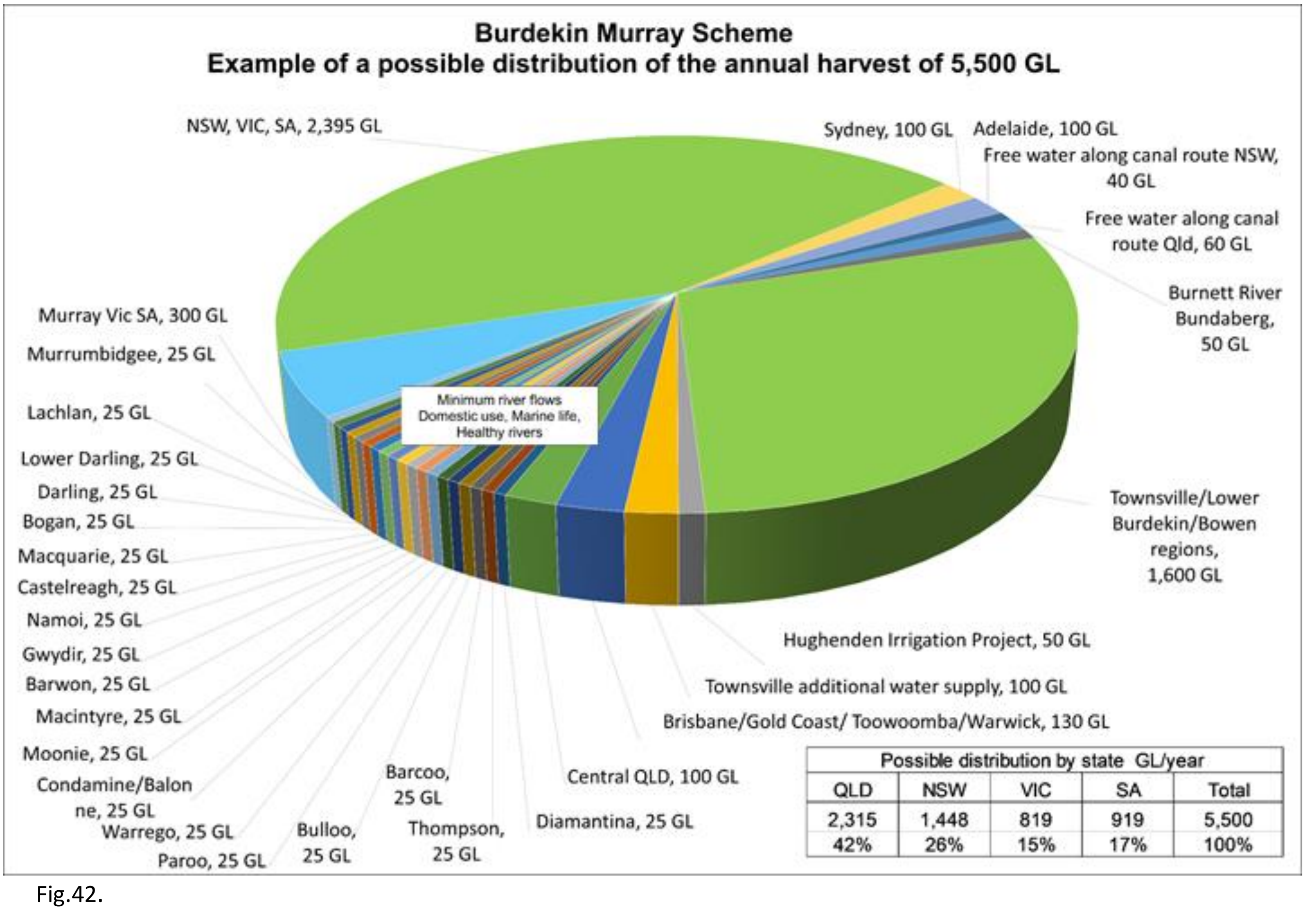


Fig.42.

Reduces Great Barrier Reef pollution

The Burdekin Region is one of the most important GBR catchments because of its size, 33% of the whole GBR catchments. The region is one of the largest contributors of freshwater, sediments and nutrients to the GBR lagoon. Studies have highlighted that the Burdekin region is a high risk to reef ecosystems due to runoff of herbicides, dissolved inorganic nitrogen and fine sediment from agriculture lands.

The Burdekin River alone contributes around 80% of the total annual Burdekin Region discharge.

Major spillway overflows of the Burdekin Falls Dam result in ‘first flush events’ of the Lower Burdekin River. These ‘first flush events’ carry the majority of damaging pollutants out to the Great Barrier Reef. Raising the spillway of the Burdekin Falls Dam by 15m, as proposed by the BMS, will halve the frequency and intensity of major spillway overflows.

However, the BMS will ensure that the Lower Burdekin River provides a regular flow of clean, fresh water necessary for the Reef’s ecosystem. Refer APPENDIX B The Burdekin Murray Scheme and the Great Barrier Reef and APPENDIX D, Elimination of zero flows.

“Rivers act as corridors for many important species to move between freshwater, estuarine and marine environments.” Source, Reef 2050 Water Quality Improvement Plan.

BMS revives river systems across 80% of south east Australia, eliminating fish kills.

Reduced stream flows usually results in reduced dissolved oxygen (DO) levels particularly in streams with dense aquatic plants (typically weeds), which can lead to fish kills. Dense aquatic vegetation can reduce DO levels in waterways by several mechanisms including creating a physical barrier to gas exchange, breakdown of dead plant material and overnight respiration.

Flood mitigation reduction in catastrophic flooding, Improvement water quality; Lower Burdekin.

The BMS will halve the intensity of major flooding in the Lower Burdekin River by reducing overflows of the spillway from 94% of the time to 52% or, 30 overflow years out of 32 years of overflows would be reduced to 17 years out of 32 years. Refer APPENDIX C, Flood Mitigation in the Lower Burdekin River and APPENDIX D, Elimination of zero flows.

The current Burdekin Falls dam traps up to 65 per cent of coarse sediments that would otherwise pass through to the coastal floodplain and the Great Barrier Reef (GBR) lagoon, however fine particulates (clay colloids) rarely settle and turbidity is an ongoing challenge for the receiving environment. The near-constant release and reticulation of water that is more turbid than under 'natural' conditions (i.e. pre-dam non-flood) has transformed a natural short-term ecological 'stress' (i.e. turbid flood flows) into a long-term ecological 'strain' (i.e. turbid base flows).

The BMS will provide a constant year round flow in the Lower Burdekin River. This will reduce the amount of reticulated used which will result in a more natural water quality with a lower base turbidity.

Restoration of land erosion regions adjacent to the mouth of the Lower Burdekin River

The BMS will include measures to replenish areas which have been subject to erosion over the last half century; particularly the Bowling Green Bay peninsula.

Zero Flow events eliminated in western flowing rivers

Examples of zero flows being replaced by continuous, year-round flows are show for the Lower Burdekin, Flinders, Cloncurry and Thomson Rivers in north Queensland. For flow details Refer APPENDIX D. The BMS will also eliminate the need for a new dam for the Hughenden Irrigation Project.

Water for Lake Alexandrina, South Australia

The BMS will provide environmental water for Lake Alexandrina via the Murray River.

The Burdekin Murray Scheme provides water for the Ramsar Wetlands

Australian Ramsar wetlands cover more than 8.3 million hectares. Ramsar wetlands are those that are representative, rare or unique wetlands, or are important for conserving biological diversity.

BMS provides water for approximatelyt half the Ramsar wetlands on the Australian mainland. Refer Fig. 43

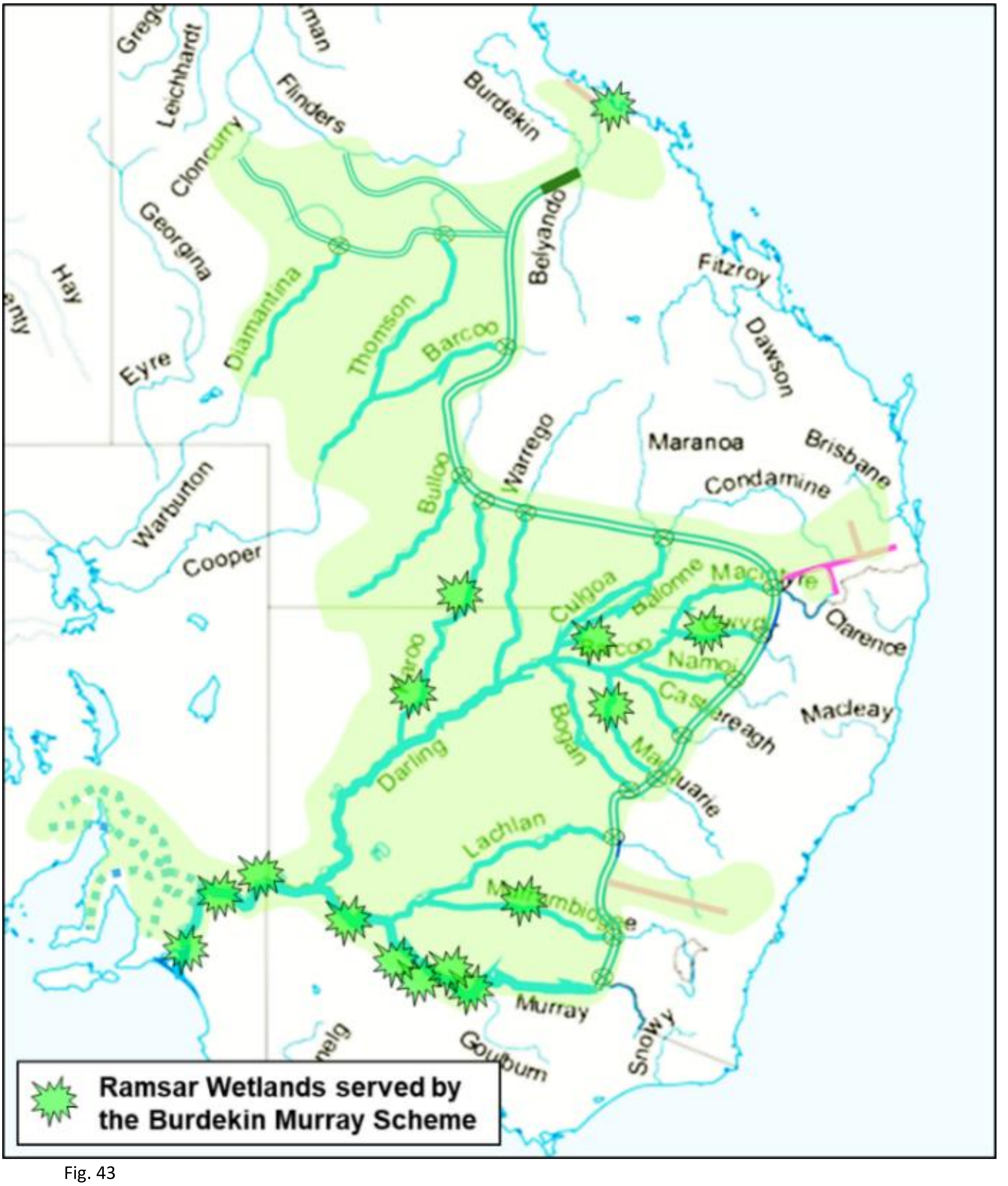


Fig. 43

Renewable Energy – BMS avoids the emission of 4 million tonnes of greenhouse gases per annum

Pumping all water

Solar energy plus hydroelectric energy:

Pumping water from the Burdekin Falls Dam to the ridge of the Great Dividing Range

Solar energy

Pumping water from the BMS canal for Bundaberg region, SE Queensland and the greater Sydney region

Greenhouse emissions avoided

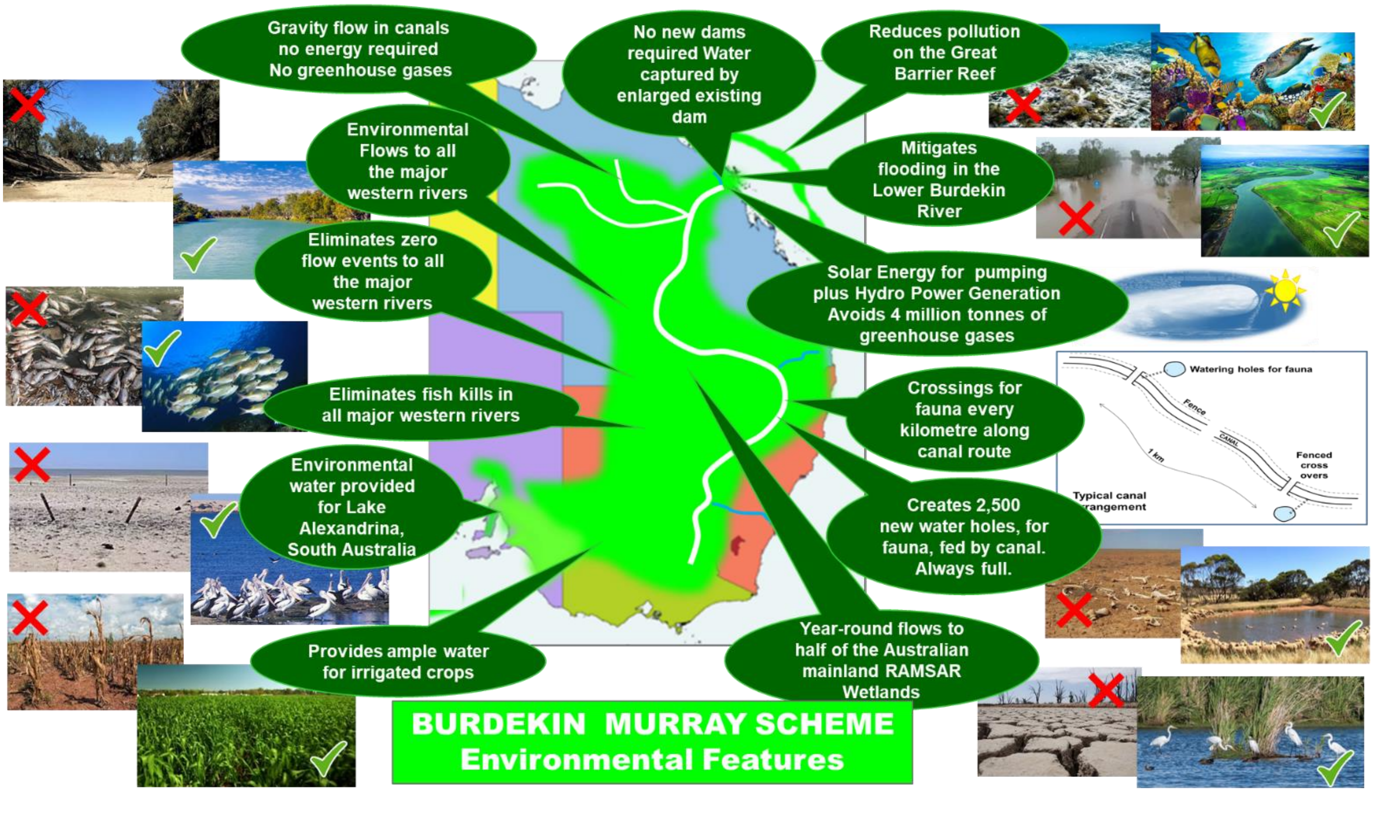
Solar	4.0 million tonnes pa.
Hydroelectric power	**0.5 million tonnes pa.**

The Burdekin Murray Scheme will produce 62% of the total renewable energy generated in Queensland in 20219 (9,321 GWh)

Renewable energy outputs: Snowy Mountains Scheme, Snowy 2.0, Burdekin Murray Scheme

COMPARISON OF RENEWABLE ENERGY OUTPUTS GWH per year		
Snowy Mountains Scheme	Snowy 2.0	Burdekin Murray Scheme
4,500	350	5,800

Summary of Environmental Benefits of the Burdekin Murray Scheme



It has been done before

There are similar projects in Australia and all over the world

Murrumbidgee Irrigation Area, Australia

California Water Project

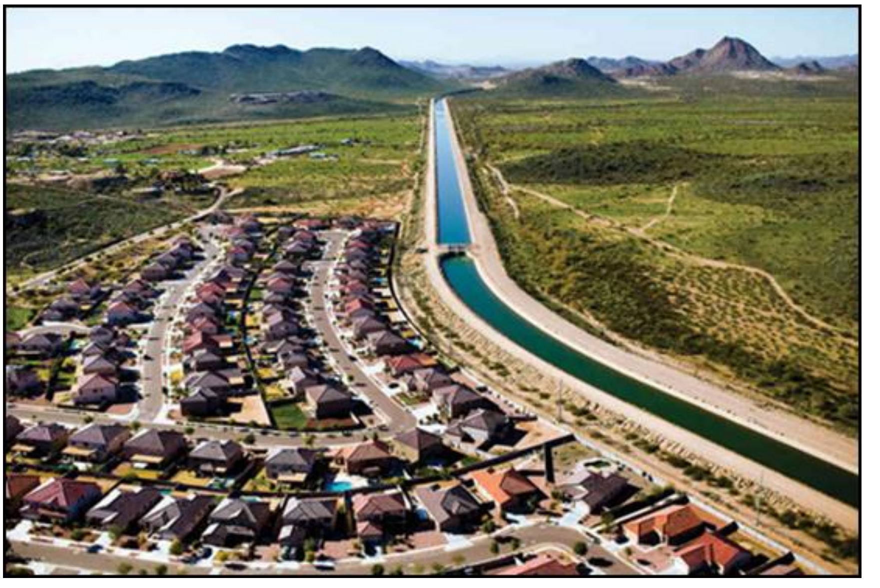
The Delta–Mendota Canal (left) and the California Aqueduct (right) near Tracy, California

The Colorado River Aqueduct

Colorado River Aqueduct
Similar terrain to western slopes of the Great Dividing Range

The Central Arizona Project (CAP)

Passes through similar terrain to that of the western slopes of the Great Dividing Range, Australia.



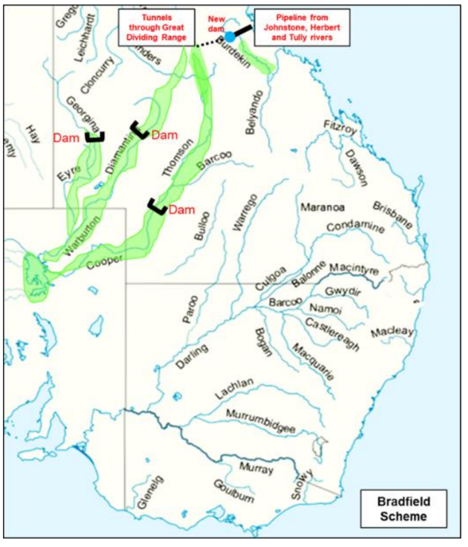
The CAP is a canal and pipeline scheme which delivers water from the Colorado River across Arizona.

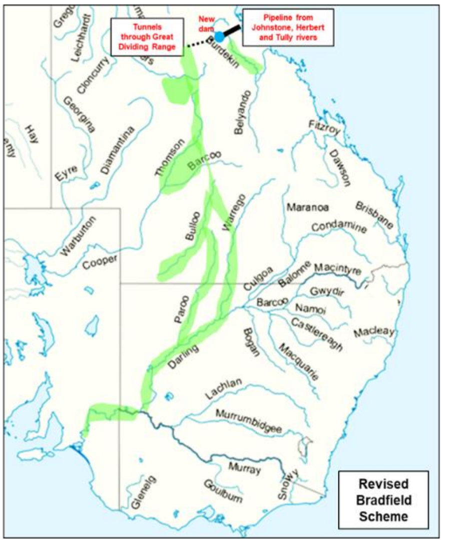
The scheme was completed in 1985 and delivers 1,800 GL/year.

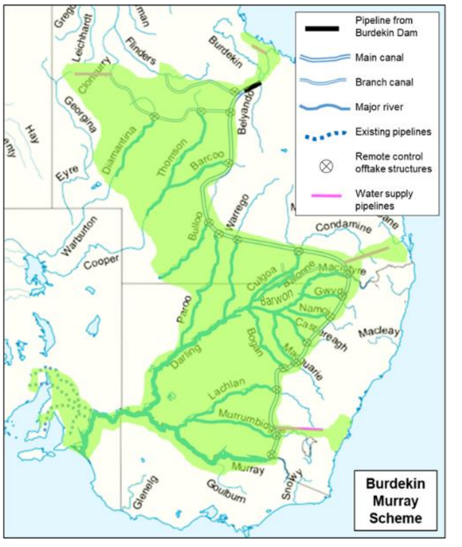
- **Since completion CAP's delivery of Colorado River water has generated $2 trillion ($2,000,000,000,000) which is 30% of Arizona's Gross State Product.***
- **CAP currently generates an economic benefit of $100 billion per year*, accounting for more than one-third, of the entire Arizona Gross State Product.**
- **In 2010 CAP's supply of water generated annual employment of more than 1.6 million jobs.**

*Source: The Economic Impact of the Central Arizona Project to the State of Arizona, School of Business, Arizona State University, 2010.

Comparison with other proposed schemes







NB The Burdekin Murray Scheme is the only large scale water transportation scheme completely based on sound hydrological data and engineering principles.

Scheme features	Bradfield	Revised Bradfield	Burdekin Murray Scheme
Project cost	> $20bn[1]	>$30bn* *120m high wall Hells Gate Dam	$23bn
O & M costs	>$1,000mpa[1]	>$1,000mpa[1]	$340mpa
Water delivered	<1,000 GL/year[2]	<1,000 GL/year[2]	5,000 GL/year
River systems serviced	4	7	22
New dams required	yes	yes	no
New tunnels required	yes	yes	no
Services Queensland	partly	partly	North & South Qld
Services NSW	no	Darling River only	All regions west of range
Services Victoria	no	no	Murray River region
Services South Australia	no	no	Adelaide & Gulf regions
Augments water supply for Brisbane/Gold Coast	no	no	yes
Augments water supply for Sydney/Illawarra	no	no	yes
Augments water supply for Adelaide	no	no	yes
Secures water supply for Townville & Bowen regions	no	no	yes

[1]Estimates base on available information [2]Maximum possible volume calculations based on BOM records

BMS could increase Australia's GDP by $300bn pa

The Central Arizona Project (CAP) is a similar system to the BMS as both schemes pump water from a source up to a point where the water is able to flow by gravity in a canal overland for a long distance,. The purpose of both schemes is to deliver drinking water and water for agriculture.

The CAP has been operating since 1985 which has allowed the benefits of the scheme to be properly assessed. In 2010 the Arizona State University Business School carried out a comprehensive assessment of the economic benefits arising from the CAP.

A guide as to the order of the potential Economic benefits which could result from the BMS has been made by comparing the benefits from the CAP based on the volumes of water delivered by each scheme.

COMPARISON CENTRAL ARIZONA PROJECT AND THE BURDEKIN MURRAY SCHEME		
Feature	**Central Arizona Project**	**Burdekin Murray Scheme**
Completed	1985	Could be completed by 2026
Volume of water delivered	1,800 GL pa	5,000 GL pa
Economic benefits generated	$100 bn pa (2010) More than one-third of the Arizona State Gross Domestic Product	$300 bn pa (2051) Comparison basis; delivered volumes (5,000/1,800 x $100 bn pa = $278 bn pa)
Jobs created	1.6 million jobs From 1985 to 2010	4.4 million jobs by 2051 Comparison basis; delivered volumes
Contribution to Annual GDP	$2,000,000,000,000* From 1985 to 2010 CAP contributed $2 trillion to the Arizona State economy	$5.6 trillion by 2051 Comparison basis; delivered volumes

*Source: The Economic Impact of the Central Arizona Project to the State of Arizona, School of Business, Arizona State University, 2010

Next steps

In order to move the scheme forward a full feasibility study of the scheme should be carried out. The feasibility study would include, as a minimum, the following:

- An updated hydrological study of the Burdekin catchment
- Burdekin Falls Dam storage study.
- Investigation to determine optimum canal route.
- A final cost estimate and business case. Approximate cost $20m.
- Economic analysis to confirm project value for money, Cost Benefit Ratio.
- Investigation of funding options.

The opportunity

The current pandemic and associated recession has created an environment where:

1. Government requires large, productive infrastructure for stimulating the economy.
2. Australia needs to be more self-sufficient in producing food for home consumption as well as export.
3. There is increasing demand for our 'clean' agricultural products particularly from our immediate Asian neighbours.
4. The cost of capital has never been so cheap.

Governments are becoming aware that:

- Water is rapidly becoming the most valuable commodity on earth.
- The cost of inaction or delays in launching large productive projects such as the Burdekin Murray Scheme will be many times the cost of the project.

Research acknowledgements, Copyright, Disclaimer

Research acknowledgements

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APPENDIX A Water quality and Biosecurity

Water Quality used for supplementing Townsville's water Supply

SUNWATER: Drinking Quality Water Management Plan 2018-2019

Appendix A – Summary of compliance with water quality criteria

Table 1 - Verification monitoring results

Scheme name	Parameter	Units	Frequency of sampling	Total No. samples collected	No. of samples in which parameter was detected	No. of samples exceeding water quality criteria	Min	Max	Average (Mean)	DWQMP Limit
Burdekin Falls	Treated water pH		Every 2-3 days	362	362	0	7.1	8.0	7.7	6.5-8.5
	Treated water turbidity	NTU	Every 2-3 days	362	362	0	0.00	1.96	0.16	<5 NTU
	Residual chlorine (free)	mg/L	Every 2-3 days	1086	1086	3	0.30	4.40	1.57	>0.5mg/L after 30 mins
	Treated water total chlorine	mg/L	Every 2-3 days	1086	1086	0	0.40	4.80	1.59	<5 mg/L
	E.coli	Cfu/100ml	Monthly	19	0	0	< 1	< 1	< 1	<1 cfu/100ml

Burdekin Falls Dam 2018	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
No. of samples collected	1	1	1	1	1	1	1	1	2	2	2	2
No. of samples collected in which *E. coli* is detected (i.e. a failure)	0	0	0	0	0	0	0	0	0	0	0	0
No. of samples collected in previous 12 month period	18	17	16	15	14	13	12	12	13	14	15	16
No. of failures for previous 12 month period	0	0	0	0	0	0	0	0	0	0	0	0
% of samples that comply	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Compliance with 98% annual value	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

CALCULATE PERCENTAGE USING A TWELVE (12) MONTH 'ROLLING' ANNUAL VALUE

The *Public Health Regulation 2005* (the regulation) requires that 98 per cent of samples taken in a 12 month period should contain no *E. Coli*. This requirement is refered to as the 'annual value' in Schedule 3A of the regulation.

Biosecurity

Screening ponds adjacent to the Burdekin Falls Dam pumping station will be monitored for any invasive species of fauna or flora. The arrangement will be similar to that used at the major pumping station for the Central Arizona Project. (See below)

Screening ponds at the main pumping station for the Central Arizona Project

Weed removal by automatic 'trash rakes' at the Central Arizona Project screening ponds

APPENDIX B The Burdekin Murray Scheme and The Great Barrier Reef

First flush, spillway overflows of the Burdekin Falls Dam carry the majority of pollutants out to the Great Barrier Reef. Raising the spillway height of the Burdekin Falls Dam by 15m will reduce the frequency of spillway overflow events by approximately 50%.

The following are extracts from some of the research and studies on the Great Barrier Reef:

A. Fine-suspended sediment and water budgets for a large, seasonally dry tropical catchment: Burdekin River catchment, Queensland, Australia

Zo€e T. Bainbridge1,2,3, Stephen E. Lewis1, Scott G. Smithers1,2, Petra M. Kuhnert4, Brent L. Henderson5, and Jon E. Brodie1
1Catchment to Reef Research Group, TropWATER, James Cook University, Townsville, Australia, 2College of Marine and
Environmental Sciences, James Cook University, Townsville, Australia, 3CSIRO Land and Water Flagship, ATSIP, Townsville,
Queensland, Australia, 4CSIRO, Adelaide, South Australia, Australia, 5CSIRO, Canberra, Australian Capital Territory, Australia

Abstract
The Burdekin River catchment (_130,400 km2) is a seasonally dry tropical catchment located in north-east Queensland, Australia. It is the single largest source of suspended sediment to the Great Barrier Reef (GBR**). Fine sediments are a threat to ecosystems on the GBR where they contribute to elevated turbidity (reduced light), sedimentation stress, and potential impacts from the associated nutrients.**

The focus of this study, the Burdekin River catchment (_130, 400 km2) has an annual average discharge of 9.18 million ML (range: 0.25–54.03 million ML) over a 91 year gauge record to 2012 (1921–2012) [Department of Environment and Resource Management, 2012]. The Burdekin contributes the highest suspended sediment load to the GBR (_30% of total) of all the coastal catchments, exporting an average of 3.93 million tonnes of suspended sediment annually, corresponding to an average area yield of 30 t km22 yr21 (1986–2010) [Kuhnert et al., 2012]. Historical records from inshore coral cores influenced by Burdekin River discharge and recent catchment modelling efforts suggest that annual sediment export is five to eight times higher than pre-European loads [McCulloch et al., 2003; Kroon et al., 2012]. Although low compared to tropical rivers globally (see discussion), this marked increase in export since European settlement (_1850) threatens the sensitive ecosystems of the GBR, making efforts to reduce sediment runoff from the Burdekin catchment a management priority [Bartley et al., 2014].

The BFD reservoir trapped an average of 66% (80% CI560–72) of annual suspended sediment influx over the five study years (Figure 3; Lewis et al., 2013]. The dominance of the Upper Burdekin subcatchment as a major sediment source to end-of-river export has been diminished by the construction of this reservoir and its sediment trapping efficiency.

5.6. Implications for Great Barrier Reef Management
The Upper Burdekin and Bowen River subcatchments have the highest suspended sediment yields of all Burdekin subcatchments and were the major sediment sources during this study. Their wetter coastal locations, steeper topography, and weathered geology result in high streamflow and sediment transport

efficiency. The Upper Burdekin is the major source of discharge to both the BFD and end-of-river, and the dominant source of all sediment fractions (i.e., clay, fine silt and coarse sediment) into the BFD. The BFD reservoir is an efficient sediment trap, and has reduced the suspended sediment load supplied from the large upstream catchment area (88% of the entire catchment) to end-of-river export, including the Upper Burdekin source. The reservoir has also influenced the sediment-size fractions transported from this upstream catchment area, with the finer clay fraction now dominating all sediment exported over the dam spillway to the river mouth and adjacent GBR lagoon.

The influence of this terrigenous fine sediment within the GBR has been recently highlighted by Fabricius et al. [2014], who correlated increased inshore turbidity with rainfall and runoff events from GBR Rivers such as the Burdekin. Finer sediment particles, often with an attached organic component once in the marine environment, are easily resuspended and transported along the GBR shelf (Orpin et al., 1999; Wolanski et al., 2008; Webster and Ford, 2010; Brodie et al., 2012] and are the most harmful sediment type to GBR receiving ecosystems such as corals [Fabricius and Wolanski, 2000; Weber et al., 2006; Humphrey et al., 2008],
seagrass and other associated communities such as reef fish [Wenger and McCormick, 2013].

B. A critical evaluation of coral Ba/Ca, Mn/Ca and Y/Ca ratios as indicators of terrestrial input: New data from the Great Barrier Reef, Australia

Stephen E. Lewis a,⇑, Janice M. Lough b,d, Neal E. Cantin b, Eric G. Matson b, Les Kinsley c, Zoe T. Bainbridge a, Jon E. Brodie a,d a Catchment to Reef Research Group, Centre for Tropical Water and Aquatic Ecosystem Research (TropWATER), James Cook University, Townsville, QLD 4811, Australia b Australian Institute of Marine Science, PMB 3, Townsville, QLD 4810, Australia c Research School of Earth Sciences, Australian National University, Canberra, ACT 0200, Australia d Australian Research Council Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, QLD 4811, Australia Received 27 April 2017;2.1. Burdekin River watershed

The Burdekin River watershed is the largest single contributor of freshwater and suspended sediment discharge to the GBR, north-eastern Australia (Kroon et al., 2012; Fig. 1).

The annual discharge from the river ranges from 0.25 to 54 TL over the 95-year record covering the 1921/22 to 2015/16 water years (October 1 to September
30: DNRM, 2016). Inter-annual sediment loads are also highly variable ranging from 0.004 to 15.7 Mt between the 1986/87 and 2009/10 water years (Kuhnert et al.,
2012). The dominant sediment sources are from the Upper Burdekin and Bowen/Lower Burdekin tributaries, which collectively account for >90% of the end-of-river export (Bainbridge et al., 2014; Fig. 1).

A major dam (Burdekin Falls Dam: BFD) was completed in 1987 capturing 88% of the watershed area and traps a large proportion (66% on average between 2005/06 and 2009/10) of the suspended sediment delivered upstream of the dam (Lewis et al., 2013). Hence the construction of the BFD has reduced the suspended sediment load exported from the Burdekin River and considerably reduced the contribution of the Upper Burdekin tributary to the end-of-river sediment loads (Lewis et al., 2009).

2.2. Coral records of Burdekin runoff

Luminescence records from inshore coral cores highlight the variability in annual discharge of the Burdekin River over the past _350 years where the frequency and intensity of large discharge events increased _1860 CE and has increased further since _1950 CE (Hendy et al., 2003; Lough et al., 2015). Importantly, these periods also coincide with increases in coral Ba/Ca, Mn/Ca and Y/Ca ratios which have been interpreted as evidence for increased sediment export from the Burdekin River (McCulloch et al., 2003; Lewis et al., 2007). As discharge is a component of the suspended sediment load (i.e. a product of flow volume and suspended sediment concentration), it is important to examine periods where changes in the suspended sediment concentration occurs such as during drought-breaking floods (McCulloch et al., 2003) and before and after dam construction. It is estimated that the mean annual (water year) Burdekin River sediment load reduced from 5.9 to 7.3 Mt to 4.6 Mt due to sediment trapping in the BFD (Lewis et al., 2009).

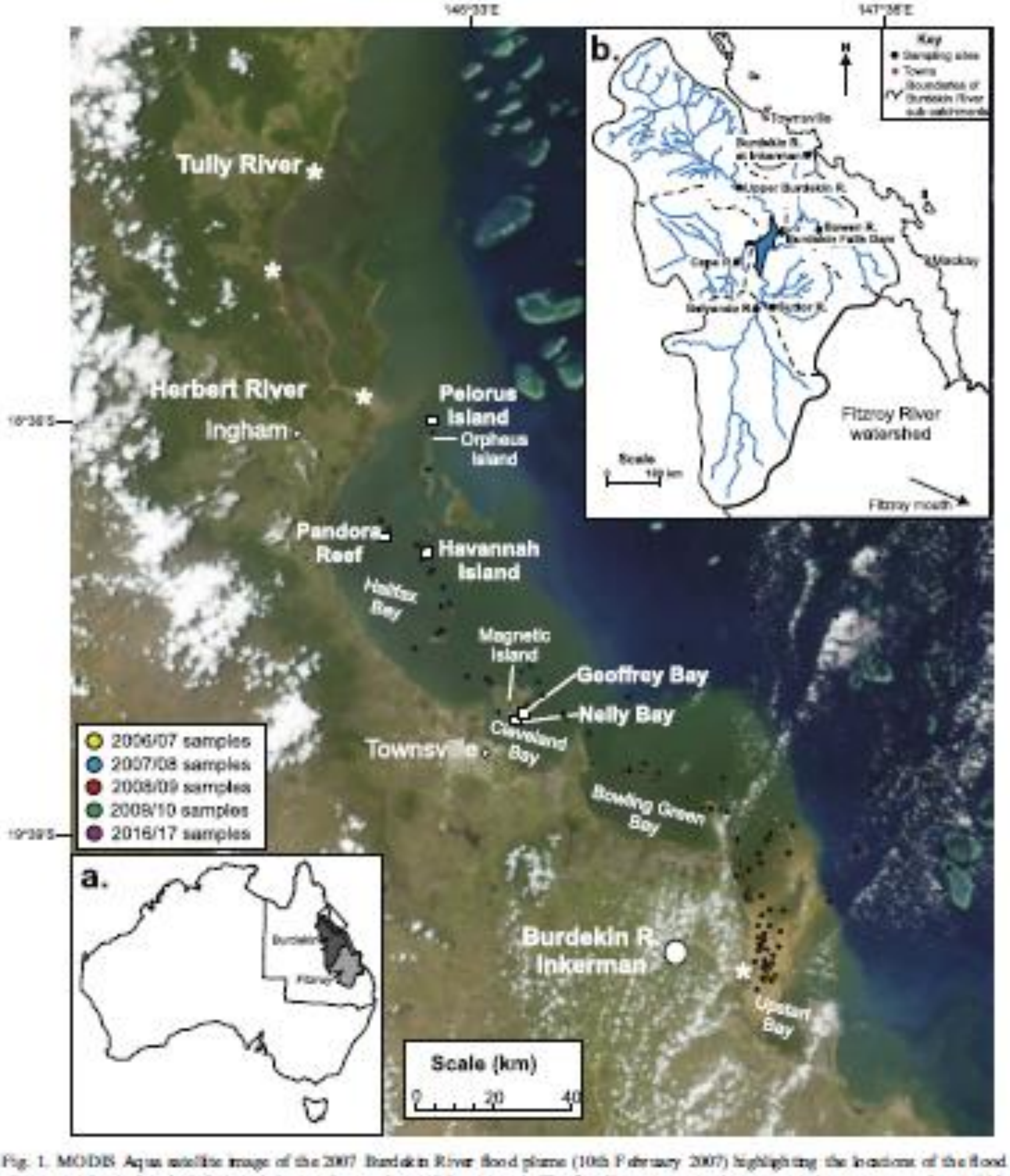


Fig. 1. MODIS Aqua satellite image of the 2007 Burdekin River flood plume (10th February 2007) highlighting the locations of the flood plume samples (colored circles) and the coral core sites (white squares). The flooding event was due to an active monsoon phase which delivered above average rainfall and flooding across the northeast tropical coast including the Burdekin watershed. Note location of the Burdekin, Herbert and Tully River mouths (white stars). The insert maps shows the location of the Burdekin and Fitzroy watershed within Australia (a) and the key Burdekin River tributary sampling sites (b).

C. The relationship between Burdekin River discharges and photic depth in the central Great Barrier Reef

Murray Logan1, Katharina Fabricius1, *, Scarla Weeks2, Marites Canto2 Sam Noonan1, Eric Wolanski3 and Jon Brodie3 1 Australian Institute of Marine Science, PMB No 3, Townsville, Queensland 4810, Australia 2 Biophysical Oceanography Group, School of Geography, Planning and Environmental Management, University of Queensland 3 TropWATER, James Cook University, Townsville 2013

Summary extracts

Understanding the effects of terrestrial runoff on coastal water clarity in coral reefs exposed to river discharges of nutrients and sediments is of key concern. Light availability is a key resource for photosynthetic organisms including benthic algae, seagrass and corals.

Substantial effort has therefore been made to reduce the terrestrial runoff of nutrients and sediments into the Great Barrier Reef, however effects have been predicted to become measurable in the marine environment only at a time scale of decades (Brodie et al. 2012, The State of Queensland and Commonwealth of Australia 2009) despite small recent reductions in end-of-river sediment and nutrient loads after farm management was improved under the Reef Rescue initiative (Queensland 2013).

The study shows that mean annual water clarity is strongly related to the freshwater discharge volumes of the Burdekin River, and is thus also related to its discharge of phosphorus and nitrogen.

The study therefore suggests that low annual sediment and nutrient loads in the Burdekin River are likely to result in significantly improved water clarity downstream of the river mouth and across much of the continental shelf during the wet season and throughout the following dry season.

D. 2017 Scientific Consensus Statement extracts
LAND USE IMPACTS ON GREAT BARRIER REEF WATER QUALITY AND ECOSYSTEM CONDITION

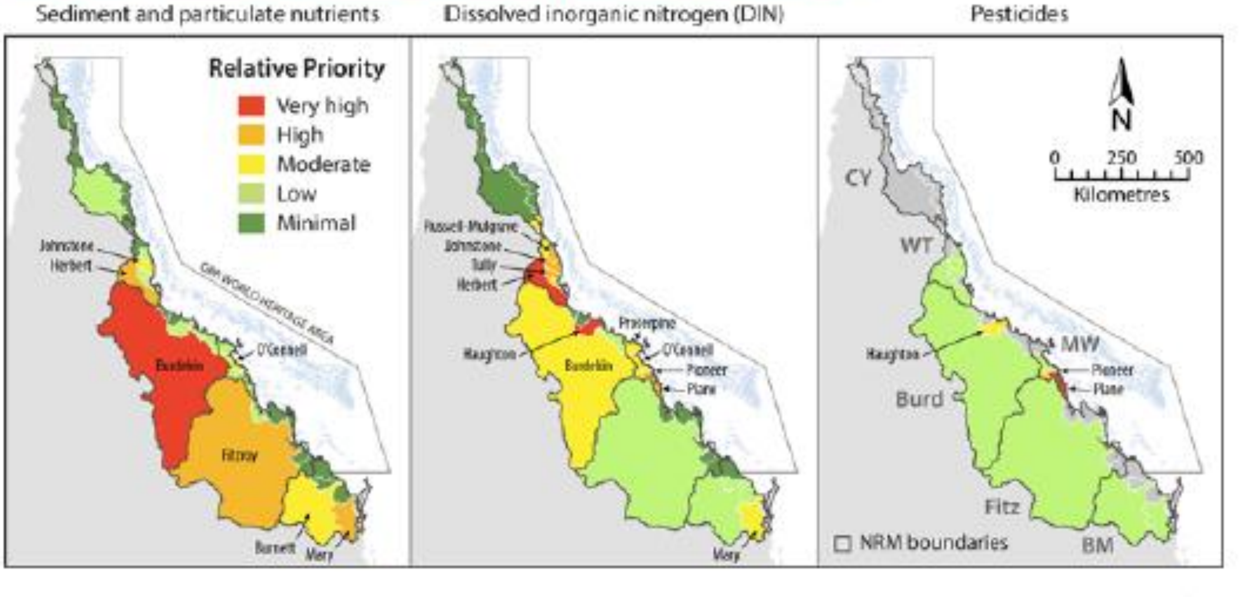
The 2017 Scientific Consensus Statement reviews and adds to the scientific knowledge of water quality issues in the Great Barrier Reef from the 2013 statement. It draws heavily on the regional water quality improvement plans and supporting studies, specific research and monitoring results as well as published science to date related to ecological processes operating in the Great Barrier Reef.

Lead authors: Jane Waterhouse, Britta Schaffelke, Rebecca Bartley, Rachel Eberhard, Jon Brodie, Megan Star, Peter Thorburn, John Rolfe, Mike Ronan, Bruce Taylor and Frederieke Kroon. **Independent Science Panel:** Roger Shaw, Eva Abal, Mike Grundy, Peter Doherty, Hugh Yorkston, Graham Bonnett, Andrew Ash, Jenny Stauber and Bronwyn Harch.

Catchment-scale management priorities
Several catchments contribute to the highest exposure of coastal or marine ecosystems to pollutants, and are considered a high priority for water quality improvement. These include the Mulgrave-Russell, Johnstone, Tully, Herbert, Haughton, Burdekin, Pioneer, Plane, Fitzroy and Mary catchments. Social and economic information is required to prioritise efforts within catchments.
Summary of evidence
The highest priority areas for reducing fine sediments, dissolved inorganic nitrogen and pesticides loads delivered to the Great Barrier Reef are shown in Figure 3. They are:

- Fine sediment and particulate nutrients: Burdekin, Herbert, Fitzroy and Mary catchments
- Dissolved inorganic nitrogen: Herbert, Haughton, Mulgrave-Russell, Johnstone, Tully and Plane catchments.
- Pesticides: Plane, Pioneer and Haughton catchment

Figure 3: Map illustrating the relative spatial priorities for water quality improvement in the Great Barrier Reef catchments based on the assessment of pollutant exposure and risk to coastal and marine ecosystems. Note this is a result of the biophysical assessment only, and results for particulate nutrients have been extrapolated from the fine sediment assessment and were not considered independently. Social and economic factors should determine priorities within catchments.



E. Freshwater impacts in the central Great Barrier Reef: 1648–2011

J. M. Lough1,2 • S. E. Lewis3 • N. E. Cantin1 Received: 9 December 2014 / Accepted: 30 March 2015 / Published online: 10 April 2015

Abstract

The Australian summer monsoon is highly variable from year to year resulting in high variability in the magnitude and extent of freshwater river flood plumes affecting the Great Barrier Reef (GBR). These flood plumes transport terrestrial materials and contaminants to the reef and can have significant impacts on both water quality and ecosystem health.

The reconstructed Burdekin River flow for 2010–2011 was in the top four highest flows of the past 364-yr along with 1991, 1870, and 1974, and the 10-yr period 2002–2011 was one of the four wettest in the re-construction (Table 5).

The 364-yr Burdekin River flow reconstruction places three of the most extreme flows within the past 40 yr (1974, 1991, and 2011). This is of concern given the impact of these high flow events on GBR water quality and observed detrimental impacts on the reef ecosystem.

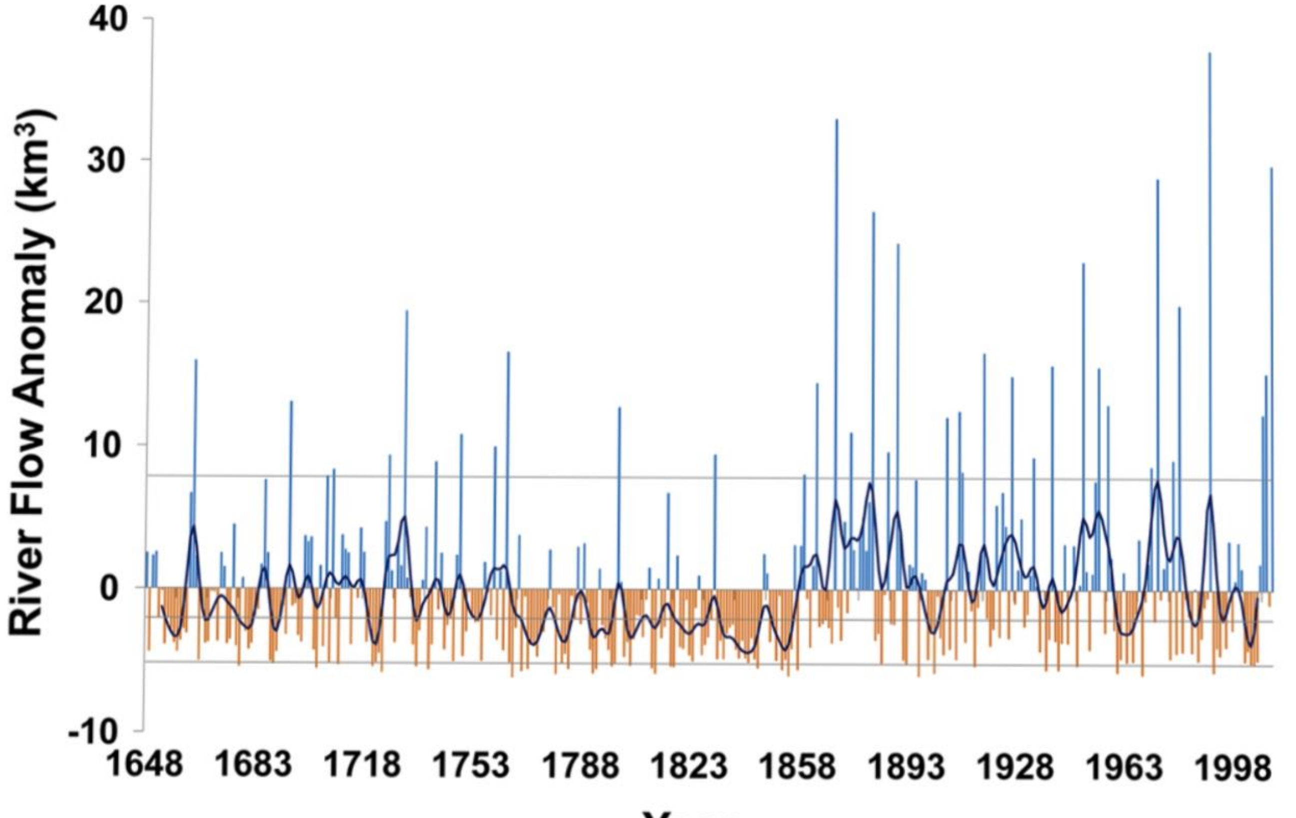


Fig. 5 Reconstructed Burdekin River flow as anomalies from 1648 to 2011 average, 1648–2011. *Dark blue line* is 10-year Gaussian filter. *Horizontal grey lines* are 90th percentile, median and 10th percentile relative to whole record length

As the world continues to warm it is, therefore, likely that freshwater (and associated terrestrial materials) delivery to inshore and mid-shelf reefs of the GBR will occur more frequently with significant consequences for ecosystem health.

The primary influences are land-use contributions of pollutants, the volume and timing of seasonal rainfall and subsequent run-off events, which are determined by the monsoonal climate and extreme weather events (cyclones), tidal regimes and currents. These factors influence the relative risk of different pollutants at particular locations and to different habitats in the Great Barrier Reef and its catchment.

The basin-scale assessment (estimated by linking the results to end-of-catchment dissolved inorganic nitrogen loads) indicates that the Burdekin Basin has the greatest contribution to total suspended sediments risk to surveyed seagrass and total seagrass area.

Management units that contribute the greatest potential pesticide exposure to floodplain wetland ecosystems are the Herbert and Lower Burdekin.

The greatest exposure of coral reef and seagrass to fine sediment is from the Burdekin, Fitzroy, Mary, Herbert, Johnstone and Burnett basins. The Burdekin and Fitzroy basins also contribute the greatest fine sediment risk to seagrass ecosystems.

The Herbert and Lower Burdekin contribute to the greatest exposure of floodplain wetland ecosystems to pesticides.

For coral reefs, the greatest likelihood of exposure to anthropogenic fine sediments was in the Burdekin Marine Zone because it has the largest area in the highest likelihood of exposure categories (13 km2)

For surveyed seagrass, the greatest likelihood of exposure to anthropogenic fine sediment was in the Burdekin Marine Zone, because it has the largest area in the highest likelihood of exposure categories (363 km2).

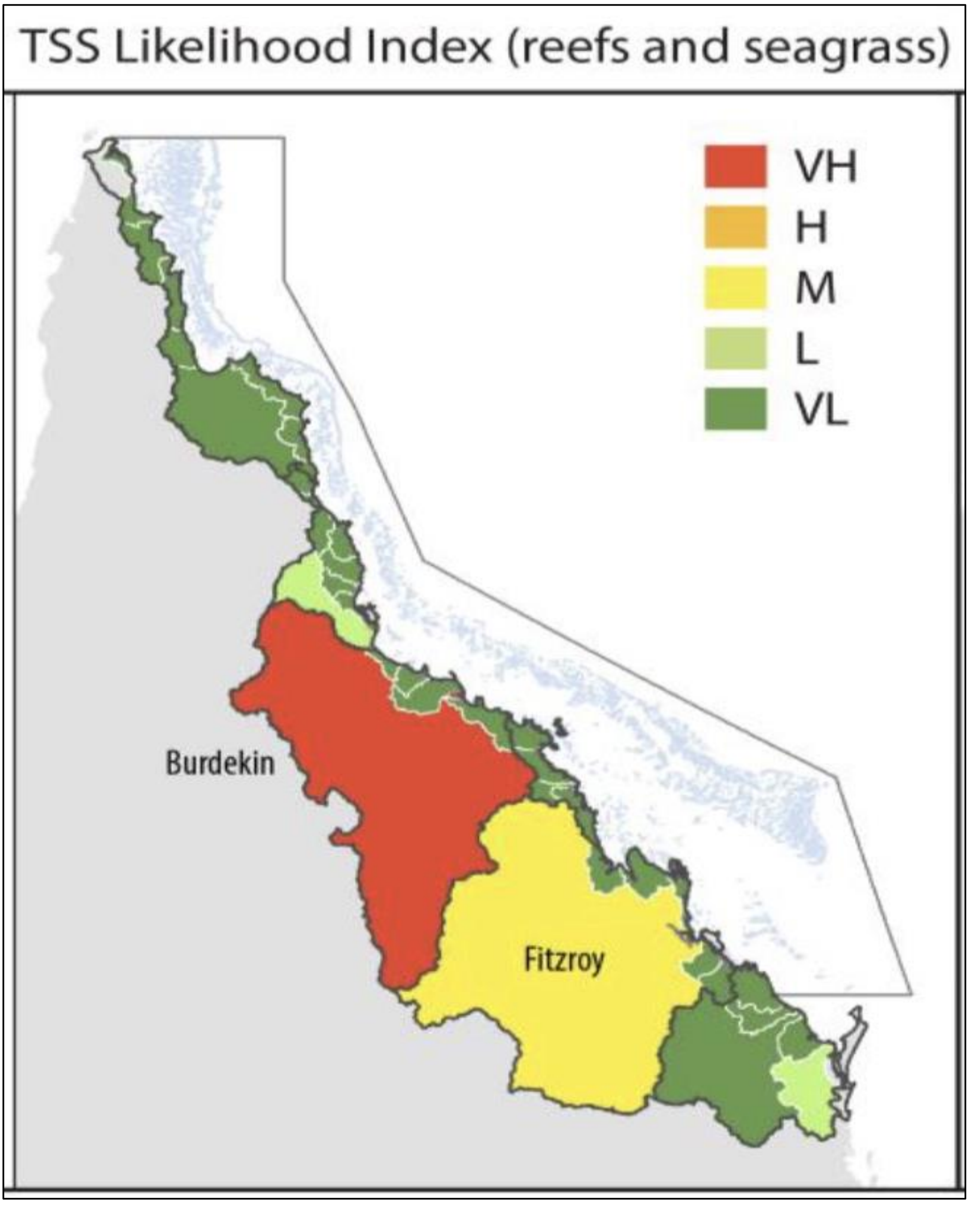
When the seagrass and coral reef Indexes are combined, the dominance of the Burdekin Basin is evident, with an Index almost double that of any of the other basins.

The greatest area of risk to the total seagrass area from not meeting benthic light thresholds is in the Burdekin Marine Zone (700 km2).

The assessment of the likelihood of exposure of coral reefs and seagrass to TSS shows that the Burdekin, Fitzroy and Herbert basins are the highest contributors to coral reef and seagrass exposure across the Great Barrier Reef.

The greatest exposure of coral reef and seagrass to fine sediment is from the Burdekin, Fitzroy, Mary, Herbert, Johnstone and Burnett Basins. The Burdekin and Fitzroy basins also contribute the greatest fine sediment risk to seagrass ecosystems.

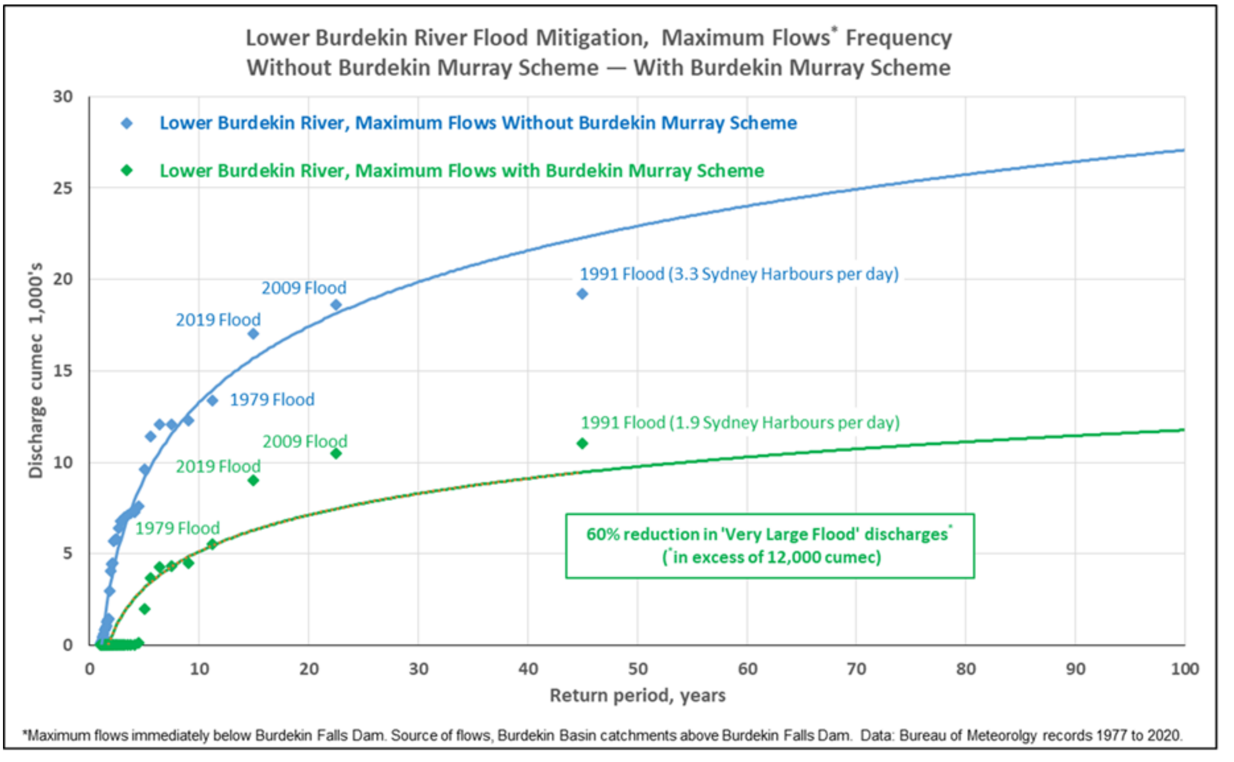
The Herbert and Lower Burdekin contribute the greatest exposure of floodplain wetland ecosystems to pesticide pressures. The Herbert, Lower Burdekin, Belyando, Pioneer and Plane contribute the greatest Areas of greatest fine sediment exposure to marine ecosystems are the Burdekin, Fitzroy, Mary, Herbert, Johnstone and Burnett.

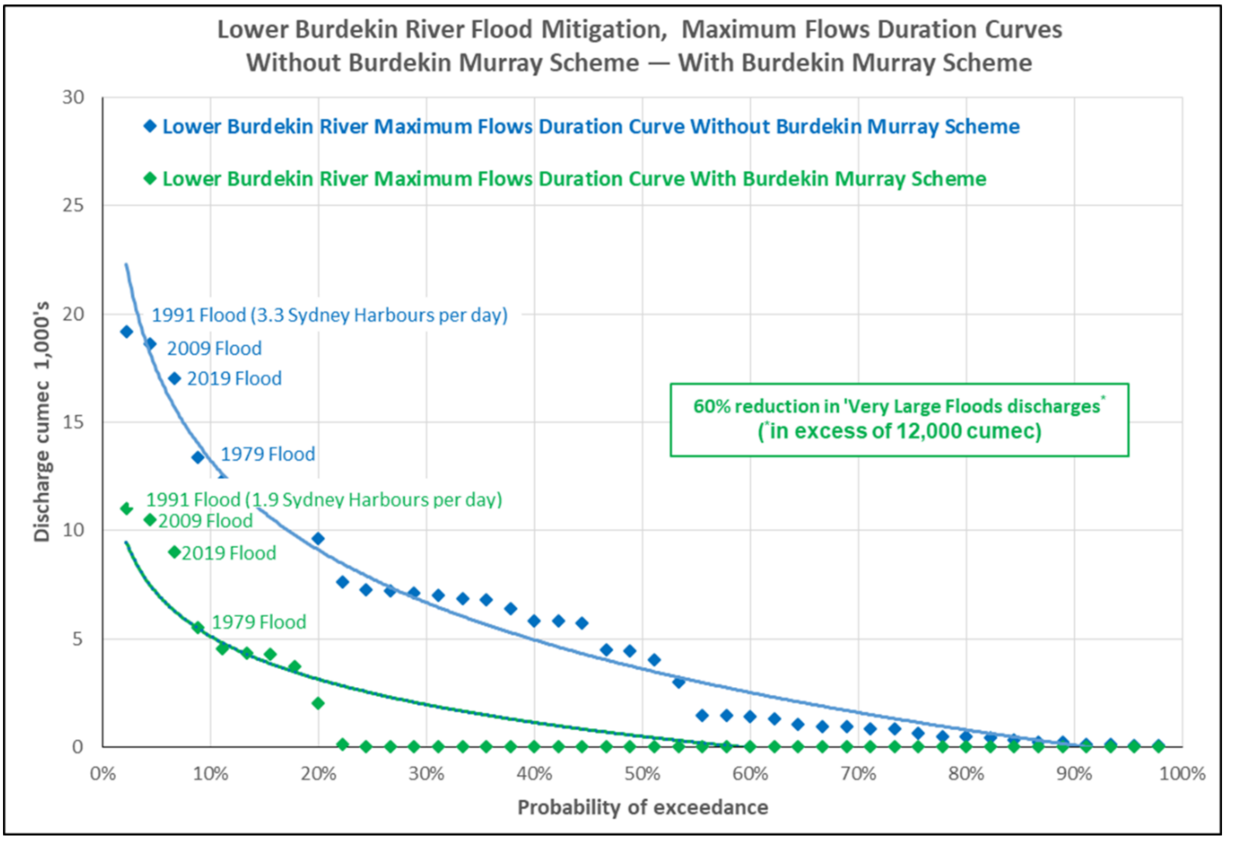


The Burdekin and Fitzroy basins also have the greatest TSS risk to seagrass exposure of floodplain ecosystems to pesticide pressures.

APPENDIX C, D Flood mitigation in the Lower Burdekin River, Elimination of zero river flows

The BMS will reduce the intensity of major floods and reduce the frequency of general flooding in the Lower Burdekin River





The BMS will end zero flows and provide year-round regular flows in the western flowing, major rivers.

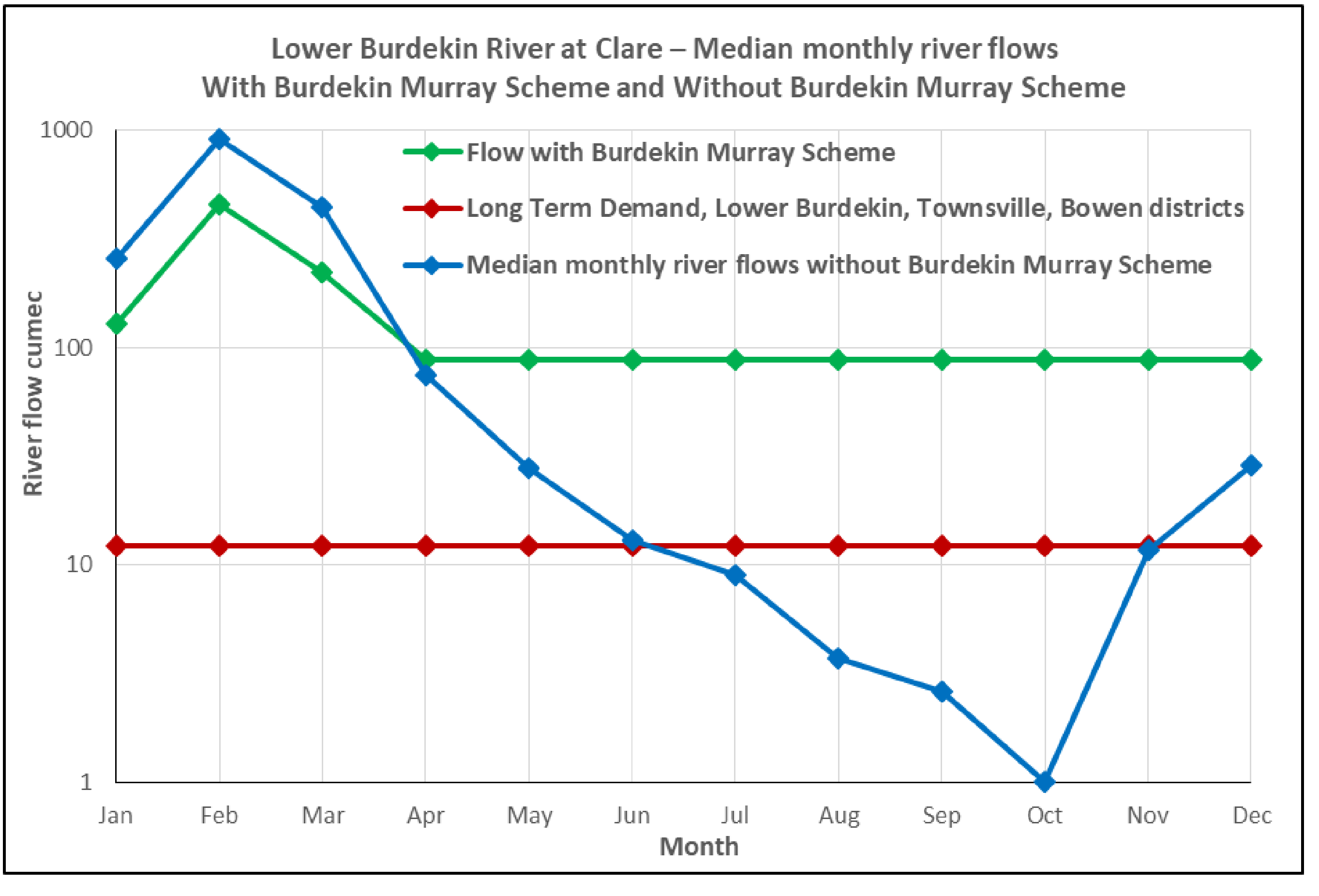
Examples of flows are shown below for the Lower Burdekin, Flinders, Cloncurry and Thomson Rivers in northern Queensland.

Flow in the Lower Burdekin River at Clare

Sources
Townsville Regional Water Security Assessment, Qld Gov. 2014
Burdekin Dam Wall Raising Feasibility Report for the Qld Gov. 2018
Water for Bowen, Report to Sunwater 2006
Median Monthly River Flows Lower Burdekin River, Bureau of Meteorology

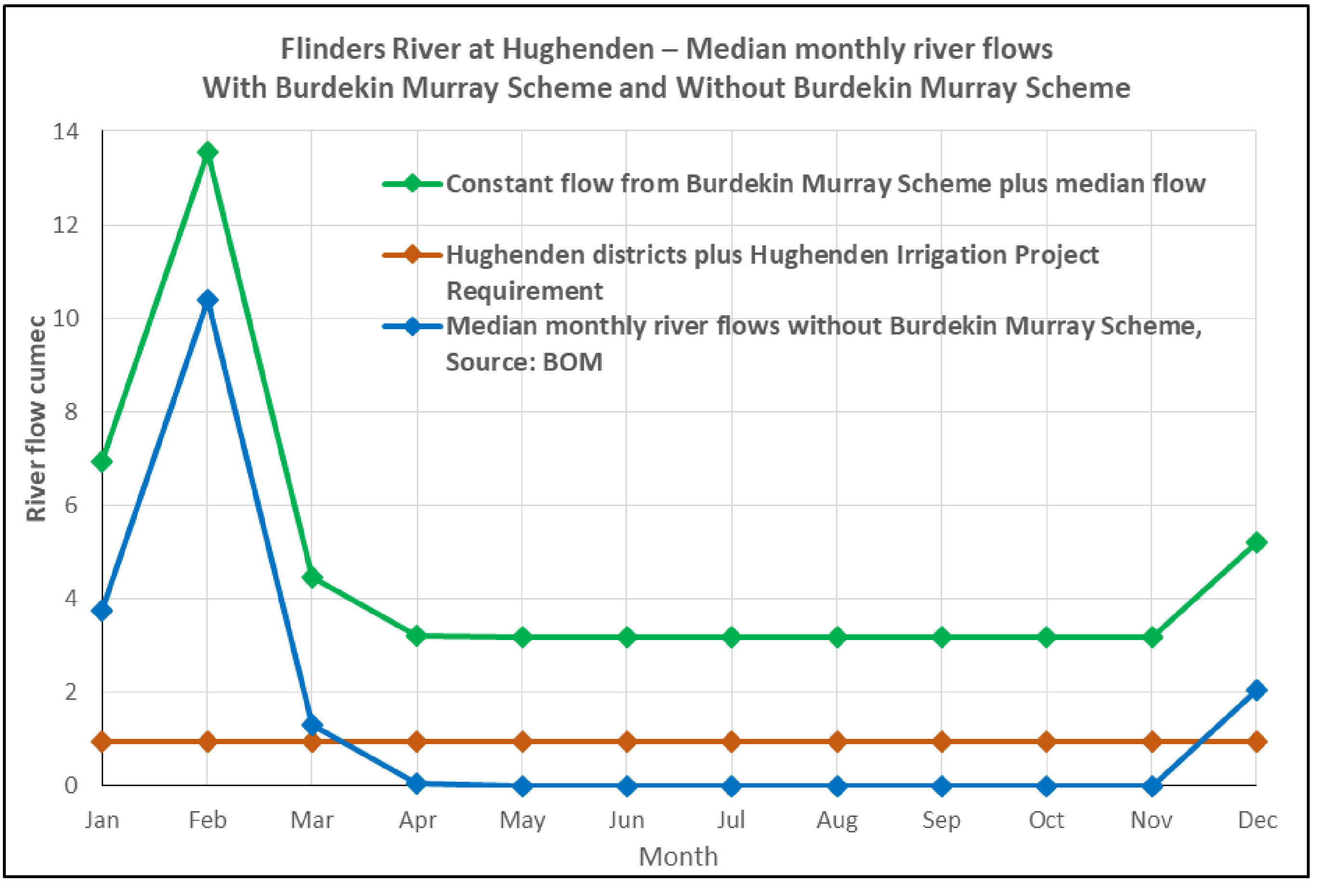
Water is extracted from the Lower Burdekin River at Clare for the Burdekin Haughton Scheme which distributes water for irrigation customers in the lower Burdekin River region and provides water for the Townsville.
The BMS will also allow water from the Lower Burdekin River to augment water supplies in the Bowen region. The water is currently used for:

- Irrigation water for farmers
- Urban water supply for Townsville and Thuringowa
- Industrial water for local business including quarries and sugar mills
- Supplement to groundwater supplies.



Flow in the Flinders River at Hughenden

Sources
Department of Natural Resources, Mines and Energy Queensland, 2019. Hughenden regional water supply security assessment 2019.
15 Mile Irrigated Agricultural Development (Hughenden Irrigation Project), Qld Coordinator-General's evaluation report 2019.
Median Monthly River Flows Flinders River, Bureau of Meteorology



Flow in the Cloncurry River

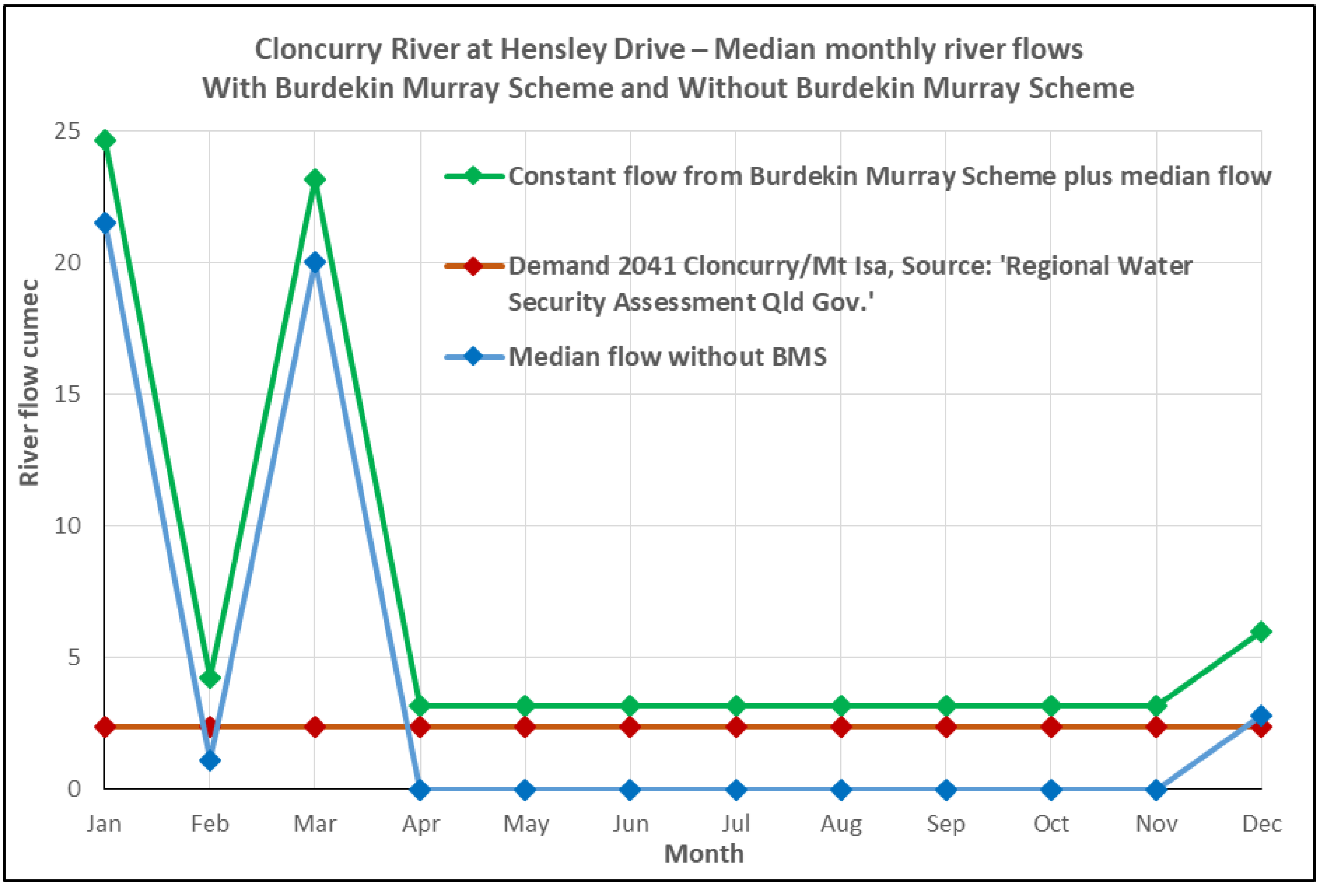
Sources

Projected annual demand for Cloncurry, Mount Isa districts, Town supply and Mining (for failure rate of less than 1 in 115 years, 75,000 ML/year)

Department of Natural Resources, Mines and Energy Queensland, 2019.

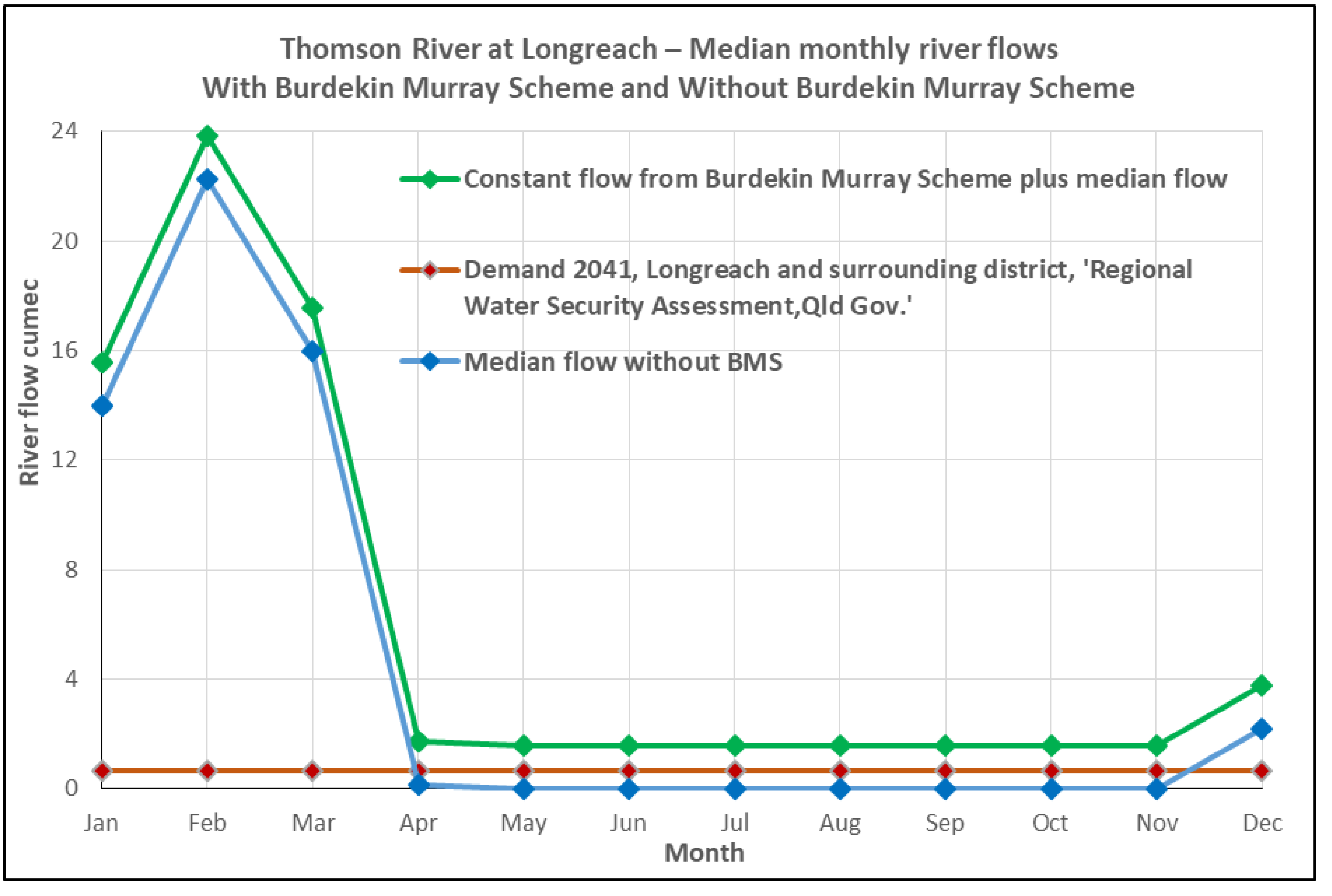
Cloncurry regional water supply security assessment, Qld Gov. 2019.

Median River Flows Cloncurry River, Bureau of Meteorology

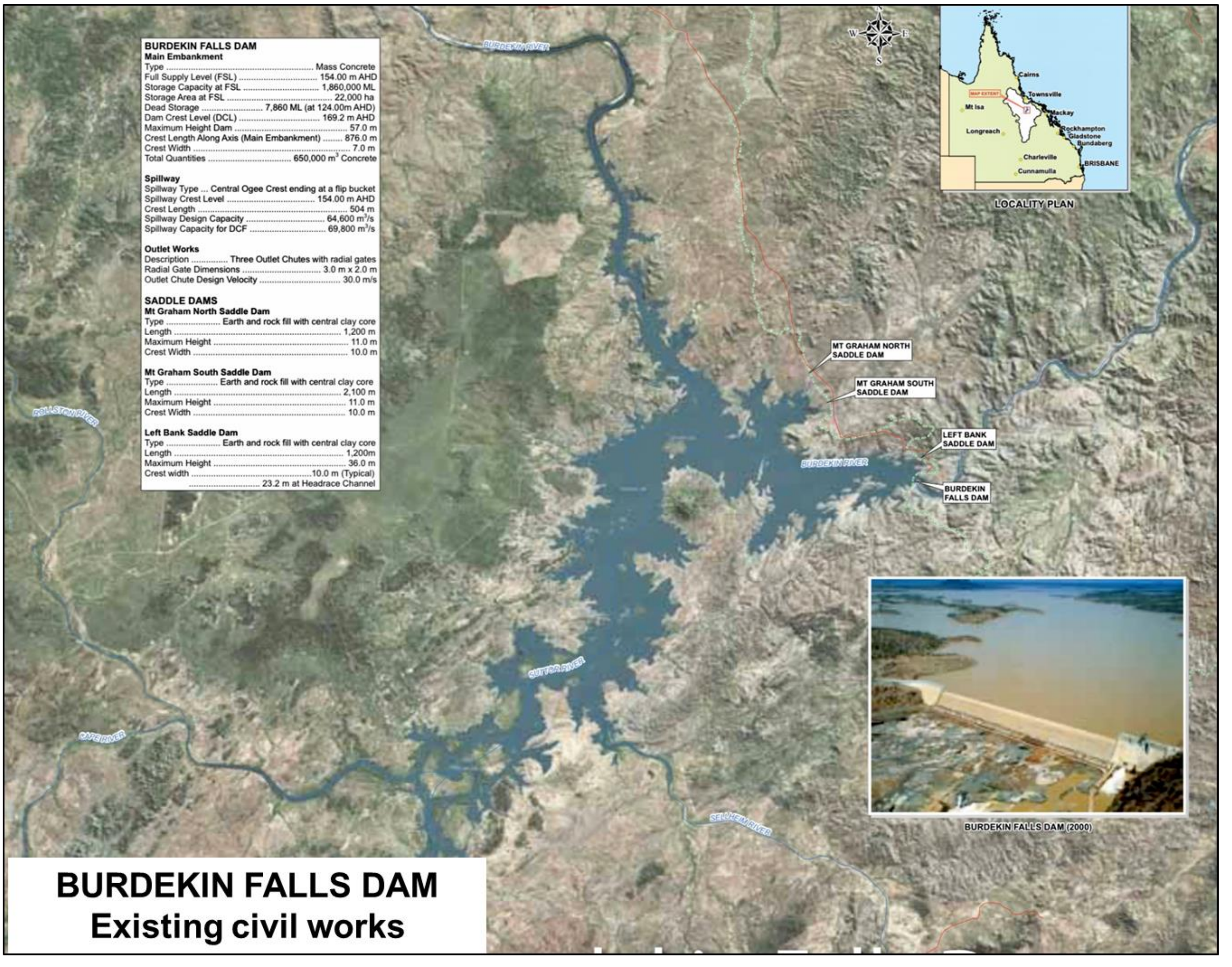


Flow in the Thompson River at Longreach

Sources
Projected annual demand for Longreach
Longreach regional water supply security assessment, Qld Gov. 2019.
Median River Flows Thomson River, Bureau of Meteorology



APPENDIX E Specific works related to raising the wall of the Burdekin Falls Dam



Specific works related to raising the wall of the Burdekin Falls Dam by up to 6 metres
Queensland Government, Initial Advice Statement, June 2020

NB Works required related to raising the wall of the Burdekin Falls Dam by 15 metres will be similar

The proposed works include:

- Raising of the spillway by at least 2 m and up to 6 m
- Associated raises of the left and right abutments to contain the selected design flood (Probable Maximum Flood PMF)
- Raising of the Left Bank and Mt Graham saddle dams to contain the selected design flood
- Construction of a new right bank saddle dam
- Adjustments to apron and splitter piers, and roadworks realignment on Right Abutment extension, and roadworks on access road to the dam North of Mount Graham North Saddle Dam and the North Abutment Saddle dam depending on final design and raised height.
- In order to undertake those works, the following is required: establishment of site offices, storages/stockpile areas, lay down areas – where possible will be located in similar locations as the original works (such as cleared and car park areas around the current recreational facilities)
- Re-establishment of construction camp
- Re-establishment and establishment of temporary haul roads as required

- Establishment of concrete batching plants
- Development of material extraction and borrow areas including:
- Re-establishing quarries that were utilised during the original construction of the dam for rock, sand and gravel, all of which are located within approximately 5 km of the dam site, and establishing new quarries for rock, sand and gravel within approximately 10 km of the dam site as the former quarries are unlikely to be able to supply all the material required.
- If the water storage is at high water levels, temporary lowering of the water level will be required for safety reasons and to access the top of the main spillway
- Realignment of the road leading to the right abutment, and
- Upgraded facilities (water and wastewater).
- At the conclusion of works, the construction camp will be removed, the recreational facilities reinstated and a site rehabilitation program undertaken.
- Clearing of vegetation from within the increased inundation area (in accordance with a strategy to be developed).
- Removal of redundant or otherwise dangerous infrastructure (houses, other buildings, fuel tanks, yards, fences, windmills, powerlines (by the infrastructure owner) etc.
- Treatment of contaminated land.
- Replacement of Scartwater crossing on the Suttor River.
- Replacement and realignment of several rural roads or farm accesses.
- Replacement and/or realignment of power supply and telecommunications to farms (by the infrastructure owner).
- Relocating private infrastructure required to support continued use of land not affected by the Project e.g. existing farm pumps used to access water from the dam.
- Throughout the construction phase, exclusion of public access from the vicinity of construction is anticipated.
- Public access to other parts of the lake area is expected to be restricted only where warranted for public safety.