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# Water resource assessment for the Southern Gulf catchments

## A report from the CSIRO Southern Gulf Water Resource Assessment for the National Water Grid

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### Important disclaimer



### CSIRO Southern Gulf Water Resource Assessment acknowledgements

This report was funded through the National Water Grid's Science Program, which sits within the Australian Government's Department of Climate Change, Energy, the Environment and Water.

Aspects of the Assessment have been undertaken in conjunction with the Northern Territory (NT) and Queensland governments.

The Assessment was guided by two committees:

i. The Governance Committee: CRC for Northern Australia/James Cook University; CSIRO; National Water Grid (Department of Climate Change, Energy, the Environment and Water); Northern Land Council; NT Department of Environment, Parks and Water Security; NT Department of Industry, Tourism and Trade; Office of Northern Australia; Queensland Department of Agriculture and Fisheries; Queensland Department of Regional Development, Manufacturing and Water

ii. The Southern Gulf catchments Steering Committee: Amateur Fishermen's Association of the NT; Austral Fisheries; Burketown Shire; Carpentaria Land Council Aboriginal Corporation; Health and Wellbeing Queensland; National Water Grid (Department of Climate Change, Energy, the Environment and Water); Northern Prawn Fisheries; Queensland Department of Agriculture and Fisheries; NT Department of Environment, Parks and Water Security; NT Department of Industry, Tourism and Trade; Office of Northern Australia; Queensland Department of Regional Development, Manufacturing and Water; Southern Gulf NRM

Responsibility for the Assessment's content lies with CSIRO. The Assessment's committees did not have an opportunity to review the Assessment results or outputs prior to their release.

This report was reviewed by Mr Mike Grundy (Independent consultant). Individual chapters were reviewed by Dr Peter Wilson, CSIRO (Chapter 2); Dr Andrew Hoskins, CSIRO (Chapter 3); Dr Brendan Malone, CSIRO (Chapter 4); Dr James Bennett, CSIRO (Chapter 5); Dr Nikki Dumbrell, CSIRO (Chapter 6); Mr Darran King, CSIRO (Chapter 7). The material in this report draws largely from the companion technical reports, which were themselves internally and externally reviewed.

For further acknowledgements, see page xxviii.

### Acknowledgement of Country

CSIRO acknowledges the Traditional Owners of the lands, seas and waters of the area that we live and work on across Australia. We acknowledge their continuing connection to their culture and pay our respects to their Elders past and present.

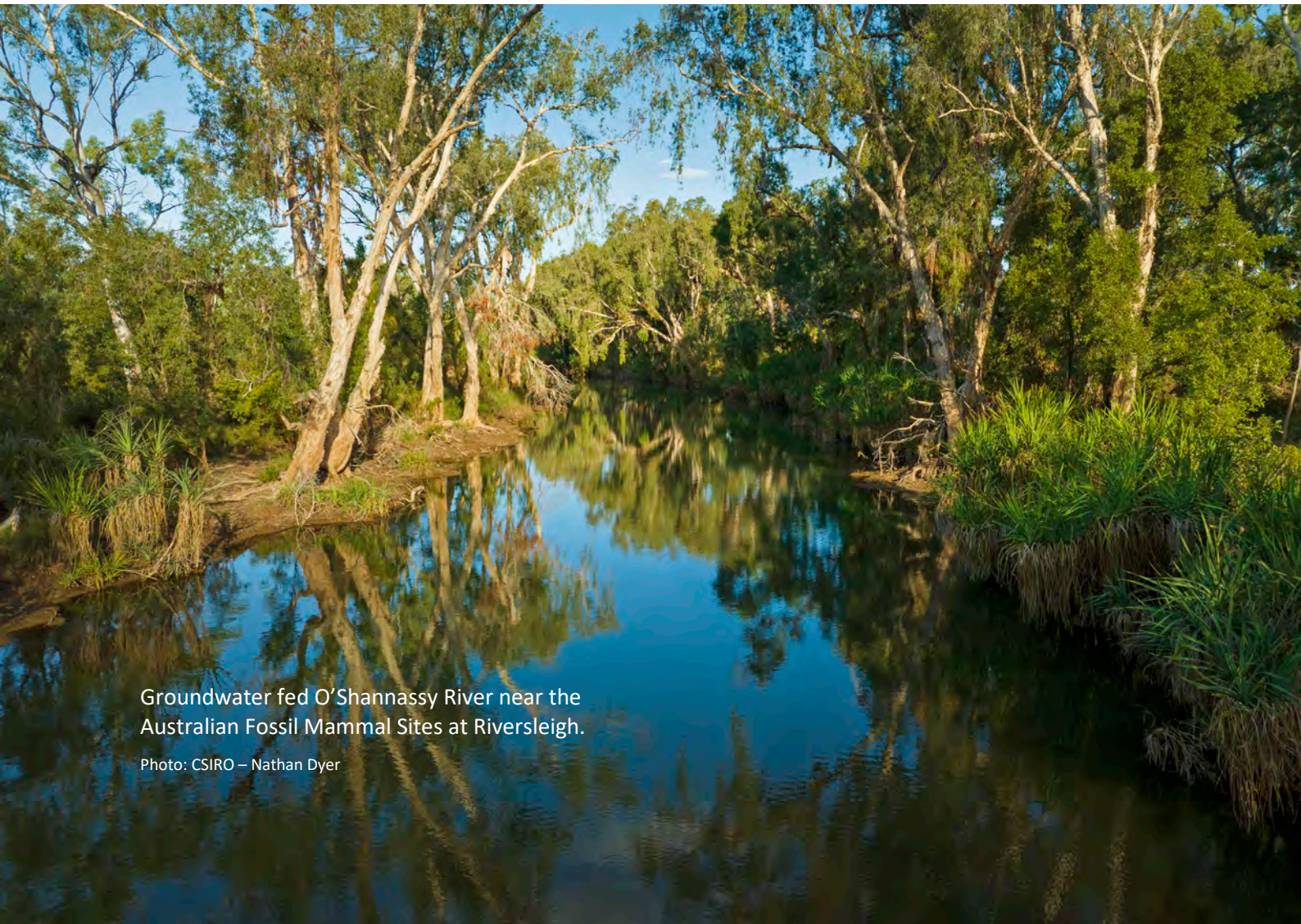
### Photo

Saltwater Arm, a tributary of the Albert River. This view typifies the tidal rivers and estuaries along the southern coast of the Gulf of Carpentaria. Source: Shutterstock

# Part I Introduction and overview

Chapter 1 provides background and context for the Southern Gulf Water Resource Assessment (referred to as the Assessment).

This chapter provides the context for and critical foundational information about the Assessment, with key concepts introduced and explained.



Groundwater fed O'Shannassy River near the Australian Fossil Mammal Sites at Riversleigh.

Photo: CSIRO – Nathan Dyer

# 1 Preamble

*Authors: Seonaid Philip, Ian Watson, Cuan Petheram, Caroline Bruce*

## 1.1 Context

Sustainable development and regional economic prosperity are priorities for the Australian, Northern Territory (NT) and Queensland governments and a number of strategies have been prepared to progress this. For example, the Queensland Water Strategy looks to enable regional economic prosperity through a vision that 'Sustainable and secure water resources are central to Queensland's economic transformation and the legacy we pass on to future generations.' (Queensland Government, 2023). Acknowledging the need for continued research, the NT Government (2023) announced a Territory Water Plan priority action to accelerate the existing water science program 'to support best practice water resource management and sustainable development.'

For remote areas like the catchments of the Southern Gulf rivers, that is Settlement Creek, Gregory—Nicholson River and Leichhardt River, the Morning Inlet catchments and the Wellesley Island groups[1] (hereafter 'Southern Gulf catchments') (Figure 1-1) the land, water and other environmental resources or assets will be key in determining how sustainable regional development might occur. Primary questions in any consideration of sustainable regional development relate to the nature and the scale of opportunities (e.g. how water might be sourced to grow crops and how much water could be extracted) and their risks.

The Assessment recognises that sustainable development is not a finite concept; it depends on the different interests and perceptions brought by individuals and communities. How people perceive risks is critical, especially in the context of areas such as the Southern Gulf catchments, where about 27% of the population is Indigenous, and more than 60% for those parts of the catchments away from the population centre of Mount Isa (compared with 3.2% for Australia as a whole), and where many Indigenous Peoples still live on the same lands they have inhabited for tens of thousands of years.

Irrespective of their perspective on development, most people would agree that having access to reliable information about land and water resources enables informed discussion and good decision making. Such information includes the amount and type of a resource or asset, where it occurs in relation to complementary resources; what commercial uses it might have, how the resource changes within a year and across years; the underlying socio-economic context; and the potential impacts of development on people, land and water.

Most of northern Australia's land and water resources have not been mapped sufficiently to reliably inform resource allocation, mitigate investment or environmental risks, or build policy

[1] Only those islands greater than 1000 ha are mapped

settings that can support good decision making. The Southern Gulf Water Resource Assessment findings aim to partly address this gap, to enable better decision making on private investment and government expenditure, taking into account intersections between existing and potential resource users, and enabling net development benefits to be maximised.

The Assessment differs somewhat from many resource assessments in that it considers a wide range of resources or assets, rather than being a single mapping exercise of, say, soils. It also provides a lot of contextual information about the socio-economic profile of the catchments and the economic possibilities and environmental impacts of development. Further, it considers many of the different resource and asset types in an integrated way, rather than separately.

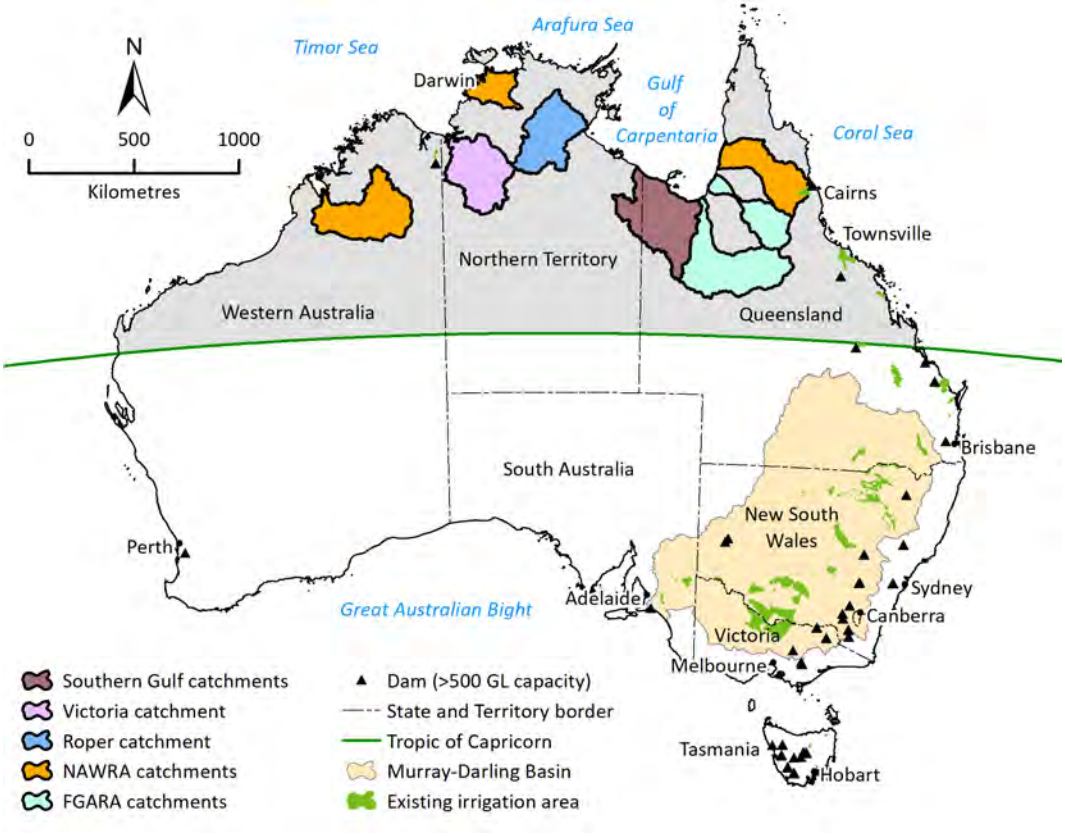



**Figure 1-1 Map of Australia showing Assessment area (Southern Gulf catchments) and other recent or ongoing CSIRO Assessments**

The Murray–Darling Basin and major irrigation areas and major dams (>500 GL capacity) in Australia are shown for context.

The Assessment does not take an advocacy position on development, or on particular opportunities or risks. Rather, the Assessment provides resource information in a way that can inform future decision making and policy development. The outcome of no change in land use or water resource development is also valid.

CSIRO has been leading similar assessments since 2012 (Figure 1-1). At that time, the Australian Government commissioned CSIRO to undertake the Flinders and Gilbert Agricultural Resource Assessment in northern Queensland as part of the North Queensland Irrigated Agriculture Strategy, a joint Australian Government and Queensland Government initiative. This assessment had a strong agricultural focus and developed fundamental soil and water datasets, providing a comprehensive and integrated evaluation of the feasibility, economic viability and sustainability of agricultural development in two catchments in northern Queensland (Petheram et al., 2013a,

2013b). Through this work and in response to two Australian Government white papers from 2015 (the White Paper on Developing Northern Australia (PMC, 2015) and the Agricultural Competitiveness White Paper (Commonwealth of Australia, 2015)) the Australian Government commissioned CSIRO in 2016 to undertake additional, more water-focused assessments, in the Fitzroy catchment in WA (Petheram et al., 2018a) four catchments around Darwin in the NT (Petheram et al., 2018b) and the Mitchell catchment in Queensland (Petheram et al., 2018c). Collectively these three assessments are known as the Northern Australia Water Resource Assessment (NAWRA). More recently, an assessment was released for the catchment of the Roper River in the NT (Watson et al., 2023) and simultaneous assessments have been undertaken for the catchment of the Victoria River in the NT (Petheram et al., 2024) and for the Southern Gulf catchments of the NT and Queensland, which is summarised in this catchment report. These last three assessments have also been commissioned by the Australian Government through the National Water Grid's Science Program, which sits within the Department of Climate Change, Energy, the Environment and Water.

While land, water and other environmental resources and/or assets can be put to a variety of uses (including the option of 'no change in use'), this assessment was primarily concerned with how the land and water might be used for irrigated agriculture, since that is the most likely pathway to intensified use of these resources in the coming years.

## 1.2 The Southern Gulf Water Resource Assessment

The Southern Gulf Water Resource Assessment has synthesised and summarised information from existing water, soil and other environmental resources in order to support regional and Country planning, resource management and sustainable regional development.

The Southern Gulf catchments were identified by the Australian Government as being a suitable candidate for a large-scale assessment of the water and soil resources. This was due to both interest in, and concerns about, the development of irrigated agriculture in the catchment, and interest in diversifying the economy of the region. With Mount Isa, a major mining, industrial and service centre, situated in the headwaters of the Leichhardt River, the area is seen as having the potential for overcoming some of the challenges that typify northern Australia. For example, the Queensland Government released an economic diversification strategy for North West Queensland (Department of State Development, Manufacturing, Infrastructure and Planning, 2019), which includes mining and mineral processing; beef cattle production, cropping and commercial fishing; tourism with an outback focus; and small business, supply chains and emerging industry sectors. In its 2024–25 Budget the Australian Government announced large investment in renewable hydrogen, low-carbon liquid fuels, critical minerals processing and clean energy processing (Anon, 2024). This includes investing in regions such as the North West Minerals Province, situated mostly within the Southern Gulf catchments.

The Assessment aimed to:

- improve baseline datasets of water, soil and other environmental resources and/or assets
- understand the nature and scale of potential water resource development options
- assess the potential environmental, social and economic impacts and risks of water resource and irrigation development.

Indigenous engagement, and understanding Indigenous views about and interests in development, were also high priorities for the Assessment.

It is important to note that, although these three aims are listed sequentially above, activities in one part of the Assessment often informed (and hence influenced) activities in an another part. For example, understanding ecosystem water requirements (described in Part IV of this report) was particularly important in establishing rules around water extraction and diversion (i.e. how much water can be taken and when it should be taken; described in Part III of this report). Thus, the procedure of assessing a study area inevitably involved iterative steps, rather than a simple linear process. The techniques and approaches used in the Assessment were specifically tailored to the study area.

In covering the aims listed above, the Assessment was designed to:

- explicitly address the needs of and aspirations for local development by providing objective assessment of resource availability, with consideration of environmental and cultural issues
- meet the information needs of governments as they assess sustainable and equitable management of public resources, with due consideration of environmental and cultural issues
- address the due diligence requirements of private investors, by exploring questions of profitability and income reliability of agricultural and other developments.

The Assessment built on previous studies, synthesised some new data and employed an experienced science team, with quality assured through peer-review processes.

The Assessment consulted with Traditional Owner representative agencies and reviewed literature relating to the Southern Gulf catchments and from previous Assessments within catchments of the Gulf of Carpentaria. Under the guidance of the Carpentaria Land Council Aboriginal Corporation, the team remodelled its method of consultation to engage each Prescribed Body Corporate with information about the Assessment and to address questions about their preferred approach for consultation and potential future collaboration on local issues.

The Southern Gulf Water Resource Assessment, which incurred delays in 2021 due to the COVID-19 pandemic, took just over 3 years to complete, between 1 July 2021 and 30 September 2024.

### 1.2.1 Scope of work

The Assessment comprised activities that together were designed to explore the scale of the opportunity for water resource development in the Southern Gulf catchments. A set of technical reports was produced as part of the Assessment (listed in Appendix A) from which the material in this catchment report was largely drawn.

Functionally, the Assessment adopted an activities-based approach to the work (which is reflected in the content and structure of the outputs and products, as per Section 1.2.3) with the following activity groups: land suitability; surface water hydrology and climate; groundwater hydrology; agriculture and socio-economics; surface water storage; Indigenous water values, rights, interests and development goals; and ecology.

In stating what the Assessment did, it is equally instructive to state what it did not do.

The Assessment did not seek to advocate irrigation development or assess or enable any particular development; rather, it identified the resources that could be deployed in support of potential irrigation enterprises, evaluated the feasibility of development (at a catchment scale) and considered the scale of the opportunities that might exist.

In doing so, the Assessment examined the monetary and non-monetary values associated with existing use of those resources, to enable a wide range of stakeholders to assess for themselves the costs and benefits of given courses of action. The Assessment is fundamentally a resource evaluation, the results of which can be used to inform planning decisions by citizens, investors, a range of organisations and the various tiers of government: local council, and the NT and/or Queensland governments and the Australian Government. The Assessment does not replace, or seek to replace, any planning processes; it does not recommend changes to existing plans or planning processes.

The Assessment sought to lower the barriers to investment in the Assessment area by addressing many of the questions that potential investors would have about production systems and methods, crop yield expectations and benchmarks, and potential profitability and reliability. This information base was established for the Assessment area as a whole, not for individual paddocks, projects or businesses.

The Assessment identified those areas that are most suited for new agricultural or aquaculture developments and industries, and, by inference, those that are not well suited. It did not assume that particular sections of the study area were in or out of scope. For example, the Assessment was blind to issues such as land-clearing regulations that may exclude land from development now, but might change in the future.

The Assessment identified the types and scales of water storage and access arrangements that might be possible, and the likely consequences (both costs and benefits) of pursuing these possibilities. It did not assume that particular types or scales of water storage or water access were preferable to others, nor did it recommend preferred development possibilities.

The Assessment examined resource use unconstrained by legislation or regulations, to allow the results to be applied to the widest range of uses, for the longest time frame possible. In doing so, it did not assume a particular future regulatory environment, but did consider a range of existing legislation, regulation and policy, and the impact of these on development.

It was not the intention – and nor was it possible – for the Assessment to address all aspects of water, irrigation and agriculture development in northern Australia. Important aspects not addressed by the Assessment include the impacts of irrigation development on terrestrial ecology.

### 1.2.2 Plausibility of development pathways

To understand how the hydrology, ecology and economic factors in the Southern Gulf catchments interact with and respond to various types and scales of development, a wide range of potential development scenarios were examined. These ranged from small incremental increases in surface and groundwater extraction to water volumes defined only by the physical limits of the catchment. These scenarios disregarded regulatory considerations (related to, for example, water, land tenure or land clearing) that may exclude land from development now but might change over time to permit new prospects in the future. The likelihood of various scenarios will be strongly

influenced by the regulatory framework at any point in time and by community acceptance of irrigated agriculture, and its benefits and risks.

One way of understanding the nature and likely scale and rate of change in irrigated agricultural development, and to have meaningful discussions about future prospects in the Southern Gulf catchments, is to examine the scale and historical rate of change in irrigated agriculture across northern Australia.

Preliminary data from a recent analysis by the Assessment team show that in 2023 there were about 62,000 ha of irrigated agriculture across the 310 million ha of northern Australia, as defined below. This is equivalent to about 0.02% of the land area.

There are many definitions of northern Australia. The one used for these area estimations is defined as that part of northern Australia west of the Great Dividing Range and north of the Tropic of Capricorn (Figure 1-1) but including all of the NT, and all of the Gascoyne catchment, which includes the Carnarvon Irrigation District. The definition includes the intensively developed Ord River Irrigation Area (ORIA) in WA. However, the intensively developed catchments east of the Great Dividing Range that flow into the Great Barrier Reef lagoon (such as the Burdekin catchment) were not included because their biophysical and socio-economic settings are very different (Petheram and Bristow, 2008). For example, this eastern area contains cities such as Townsville and Cairns, and large irrigation areas such as the Burdekin Delta and Burdekin Haughton Water Supply Scheme. By comparison with the 62,000 ha of irrigated agriculture noted above, there are more than 350,000 ha of land developed for irrigation in these eastward-flowing catchments and about 2.4 million ha of land that has been developed for irrigated agriculture in the Murray–Darling Basin.

There was a net increase of approximately 1300 ha per year of irrigated land across northern Australia (as defined above) during the 24 years between 1999 and 2023. About 26% of this increase was in the ORIA (WA), and about 18% in the Daly River catchment (NT), with the remainder of the increase across 18 other catchments.

There are few reasons to suggest that the average rate of increase in irrigated land over the next few years will be very different to that seen between 1999 and 2023, notwithstanding that the NT Land Corporation announced a preferred developer in early 2022 of 67,500 ha of land in the NT (considered as Ord Stage 3), which is likely to be a mix of irrigated and mostly rainfed cropping land, but is dependent on existing water capture and storage as part of the ORIA.

There are also signs that the northern jurisdictions are taking a more conservative approach to release of water than they have in the past. For example, the NT Government's (2024) policy for taking surface water in the wet season allows for a default maximum take of 5% 'of the 25$^{th}$ percentile of total flows for the three highest flow months of the year based on the previous 50 years flow or modelled rainfall data of the river basin.' This is a reduction from its previous policy of 20% of river flows at any time in any part of a river. Similarly, the Western Australian Government has taken a conservative approach to water planning in the Fitzroy catchment in the Kimberley, and the Queensland Water Strategy (Queensland Government, 2023) now has a priority to 'Increase First Nations' access to and ownership of water, and greater inclusion of cultural values and traditional knowledge in water decisions.'

Figure 1-2 shows the number of large dams (defined here as having a storage capacity of 10 GL or greater and are listed in the Australian National Committee on Large Dams database) constructed across Australia and northern Australia (west and east of the Great Dividing Range) over time. Over the past 40 years only nine large dams have been constructed across all of northern Australia (including the east coast), and only three of these nine dams were constructed for supplying water for irrigation, rather than for supplying water for mining or urban use. One of the three dams was also listed as having the purposes of flood mitigation, recreation and water supply for urban use. All three of the dams constructed to supply water for irrigation are east of the Great Dividing Range. No large dam has been constructed anywhere in northern Australia for the supply of water for irrigation for more than 25 years.

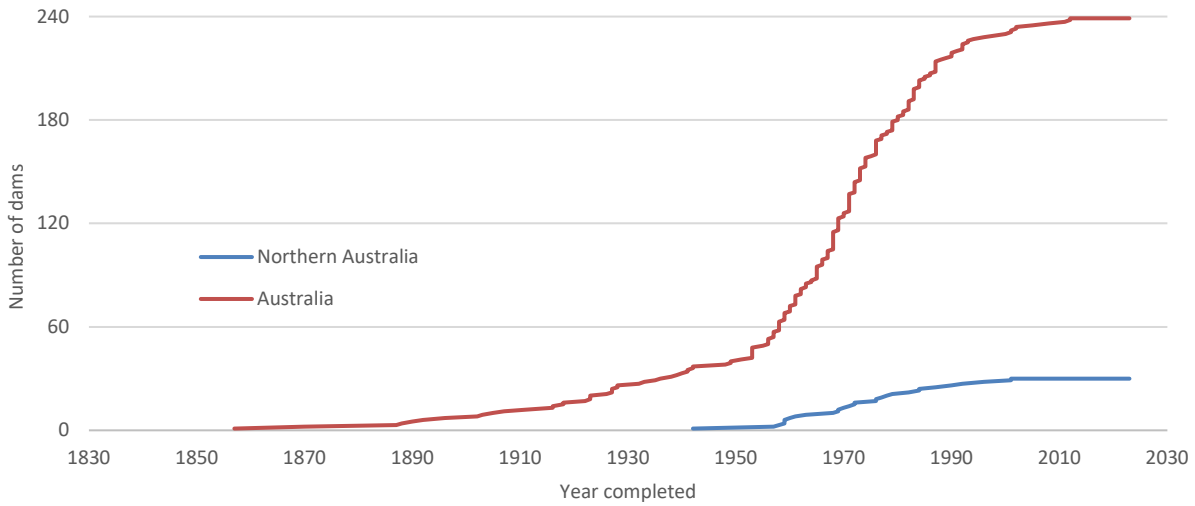



**Figure 1-2 Number of large dams constructed in Australia and northern Australia over time**

Large dams are defined as dams with a storage capacity of 10 GL or greater and are listed in the Australian National Committee on Large Dams database.

Irrespective of the physical resources that may support water and irrigated agricultural development in the Southern Gulf catchments, if the future trajectory of irrigation development is similar to historical trends, the scale of future irrigation development in the Southern Gulf catchments is likely to be modest and unlikely to encompass large dam development.

### 1.2.3 Assessment products

The Assessment produced written and internet-based products. These are summarised below, and the written products are listed in full in Appendix A. Downloadable reports and other outputs can be found at:

https://www.csiro.au/southerngulf

#### Written products

The Assessment produced the following documents:

- technical reports, which present scientific work in sufficient detail for technical and scientific experts to independently verify the work
- a catchment report, which combines key material from the technical reports, providing well-informed but non-scientific readers with the information required for informed judgments about

the general opportunities and risks for, and costs and benefits associated with, water resource development, including irrigated agriculture or aquaculture

- a summary report, which is provided for a general public audience
- a factsheet, which provides a summary of the key findings for the Southern Gulf catchments for a general public audience.

### Audiovisual product

The following audiovisual product was produced by the Assessment:

- a video, providing an overview of the work.

### Internet-based platforms

The following internet-based platforms were used to deliver information generated by the Assessment:

- CSIRO Data Access Portal – a portal that enables the user to download key research datasets generated by the Assessment
- NAWRA Explorer – a web-based tool that enables the user to visualise and interrogate key spatial datasets generated by the Assessment
- internet-based applications that enable the user to run selected models generated by the Assessment.

## 1.3 Report objectives and structure

This is the catchment report for the Southern Gulf catchments. It summarises information from the technical reports for each activity and provides tools and information to enable stakeholders to see the opportunities for development and the risks associated with them. Using the establishment of a 'greenfield' (not having had any previous development for irrigation) irrigation development as an example, Figure 1-3 illustrates many of the complex considerations required for such development; key report sections that inform these considerations are also indicated.

The structure of the Southern Gulf catchments report is as follows:

- Part I (Chapter 1) provides background, context and a general overview of the Assessment.
- Part II (Chapter 2 and Chapter 3) looks at current resources and conditions within the catchments.
- Part III (Chapter 4 and Chapter 5) considers the opportunities for water, agricultural and aquaculture development based on the available resources.
- Part IV (Chapter 6 and Chapter 7) provides information on the economics of development and a range of risks of development, as well as on those risks that might accompany development.

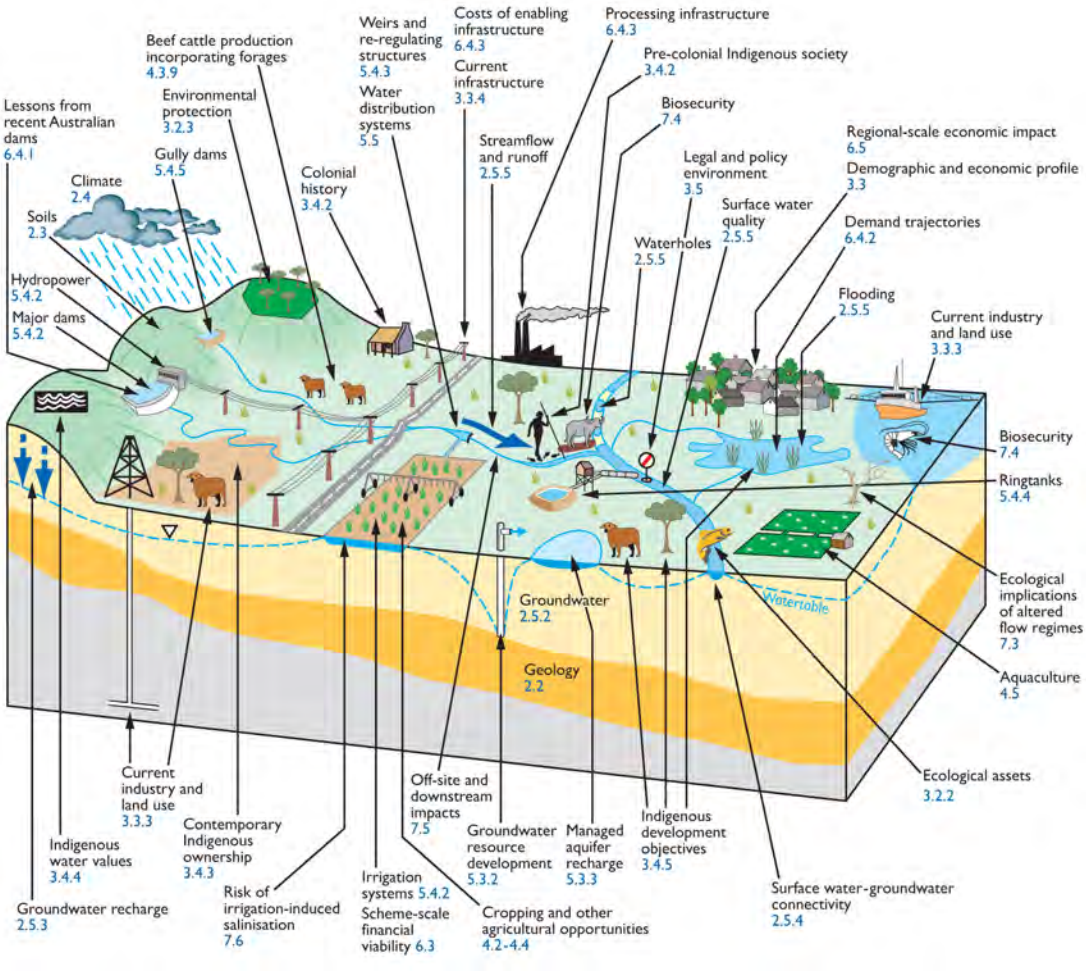



**Figure 1-3 Schematic of key components and concepts in the establishment of a greenfield irrigation development**

Numbers shown in blue refer to sections of this report.

### 1.3.1 Part I – Introduction

This part of the report provides a general overview of the Assessment. Chapter 1 (this chapter) covers the background and context of the Assessment. Key findings can be found in the front materials of this report.

### 1.3.2 Part II – Resource information for assessing potential development opportunities

Chapter 2 is concerned with the physical environment, seeking to describe the soil and water resources present in the Southern Gulf catchments, including:

- geology and physical geography: focusing on those aspects that are important for understanding the distribution of soils, groundwater flow systems, suitable water storage locations and geology of economic significance
- soils: covering the soil types within the catchment, the distribution of key soil attributes and their general suitability for irrigated agriculture

- climate: outlining the general climatic circulatory systems affecting the catchment and providing information on key climate parameters of relevance to irrigation under current and future climates
- hydrology: describing and quantifying the surface water and groundwater hydrology of the catchment.

Chapter 3 is concerned with the living and built environment, providing information about the people and the ecology of the Southern Gulf catchments and the institutional context of the catchments, describing:

- ecology: ecological systems and assets of the Southern Gulf catchments, including the key habitats, key biota and their important interactions and connections
- socio-economic profile: current demographics, and existing industries and infrastructure of relevance to water resource development in the Southern Gulf catchments
- Indigenous values, rights, interests and development objectives.

### 1.3.3 Part III – Opportunities for water resource development

Chapter 4 presents information about the opportunities for irrigated agriculture and aquaculture in the Southern Gulf catchments, describing:

- land suitability for a range of crop × season × irrigation type combinations, and for aquaculture, including key soil-related management considerations
- cropping and other agricultural opportunities, including crop yields and water use
- gross margins at the farm scale
- prospects for integration of forages and crops into existing beef enterprises
- aquaculture opportunities.

Chapter 5 presents information about opportunities for extracting and/or storing water for use in the Southern Gulf catchments, describing:

- groundwater and subsurface storage opportunities
- surface water storage opportunities in the Southern Gulf catchments, including major dams, large farm-scale dams and natural water bodies
- estimates of the quantity of water that could be pumped or diverted from the Nicholson, Gregory and Leichhardt rivers and their major tributaries
- water distribution systems (i.e. for conveyance of water from a dam and application to a crop)
- costs of potential broad-scale irrigation development.

### 1.3.4 Part IV – Economics of development and accompanying risks

Chapter 6 covers economic opportunities and constraints for water resource development, describing:

- balance of scheme-scale costs and benefits
- cost–benefit considerations for water infrastructure viability

- regional-scale economic impacts of irrigated development.

Chapter 7 discusses a range of risks of development, including those that might accompany development, describing:

- ecological impacts of altered flow regimes on aquatic, riparian and near-shore marine ecology
- biosecurity risks to agricultural or aquaculture enterprises
- potential off-site impacts (due to sediment, nutrients and agri-pollutants) to receiving waters in the catchments
- irrigation-induced salinity due to rising watertables.

### 1.3.5 Appendices

This report contains three appendices:

Appendix A – list of information products

Appendix B – shortened forms and units

Appendix C – list of figures and list of tables.

## 1.4 Key background

### 1.4.1 The Southern Gulf catchments

The Southern Gulf catchments (Figure 1-4) have an area of 108,200 km$^2$ and encompass the Settlement Creek (17,600 km$^2$), Gregory–Nicholson (52,200 km$^2$), Leichhardt (33,400 km$^2$) and Morning Inlet (3700 km$^2$) catchments and some of the islands of the Wellesley Island groups[2]. The majority of the published information from these catchments is focused on the Queensland portion of the area (79% of the Assessment area). Less well known, and more remote, is the 21% of the study area in the NT. The Assessment area has a population of approximately 22,500, the majority residing in the major regional service centre Mount Isa (18,000) and smaller centres at Doomadgee (1400), Gununa (1025) and Burketown (200) (ABS, 2021). The nearest major city and population centre is Townsville (192,768 in the 2021 Census), approximately 900 km by road from Mount Isa. The climate of the Southern Gulf catchments is hot and semi-arid to dry subhumid. The majority of streams and rivers are ephemeral, with a notable exception being the Gregory River and its tributaries Lawn Hill Creek and O'Shannassy River, into which groundwater discharges from karstic carbonate rocks in their headwaters. As a proportion of its median annual streamflow, the water in the Leichhardt River is more heavily regulated than most other rivers in northern Australia west of the Great Dividing Range. Several large reservoirs in the catchment of the Leichhardt River, namely Lake Julius (108 GL capacity) and Lake Moondarra (107 GL capacity) are used conjunctively to supply water for urban, mining and industrial use around Mount Isa and Cloncurry. Lake Moondarra is also used by Mount Isa residents and others for recreation. A low weir (of less than 1 GL capacity) upstream of the road crossing impounds water on the Nicholson River downstream of Doomadgee.

[2] Only those islands greater than 1000 ha are mapped.

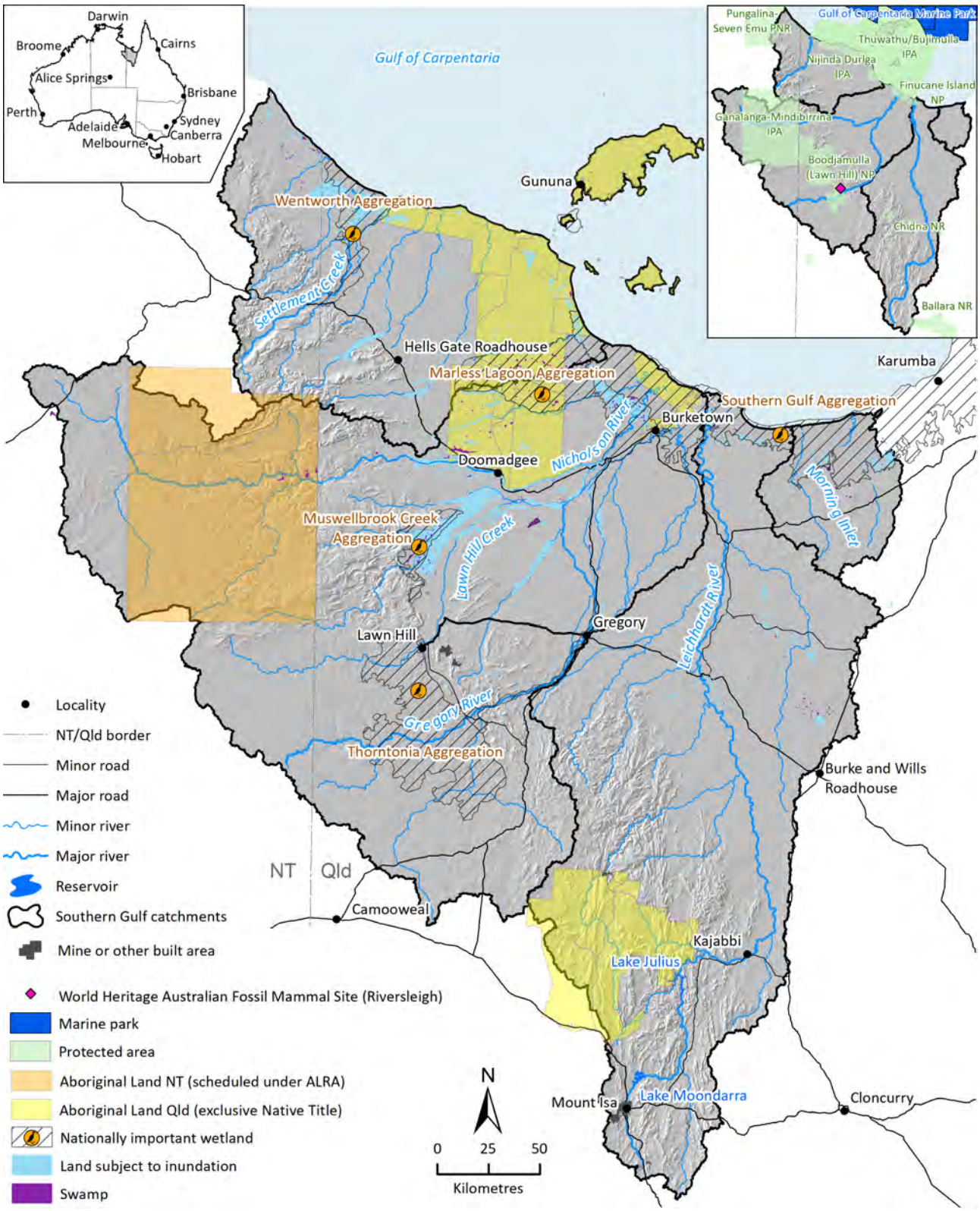



**Figure 1-4 The Southern Gulf catchments**

ALRA = *Aboriginal Land Rights (Northern Territory) Act 1976.* IPA = Indigenous Protected Area; NP = national park; NR = nature refuge.

The main land uses in the Assessment area are grazing native vegetation (77% of the Assessment area), and conservation and natural environments (16%). Cropping (both rainfed and irrigated) are sparsely practised (<0.04%). Mining, while a significant economic activity in the Assessment area, uses less than 1% of the land area. Protected areas located in the Southern Gulf catchments include the United Nations Educational, Scientific and Cultural Organization World Heritage–listed Australian Fossil Mammal Sites (Riversleigh); three Indigenous Protected Areas, namely Ganalanga–Mindibirrina, Nijinda Durlga and Thuwathu/Bujimulla; and Boodjamulla (Lawn Hill) and Finucane Island national parks and other conservation parks. In addition to these protected areas, the Southern Gulf catchments contain 13 nationally significant wetlands listed in the Directory of Important Wetlands in Australia.

### 1.4.2 Wet–dry seasonal cycle: the water year

Northern Australia has a highly seasonal climate, with most rain falling during the 4-month period from December to March. Unless specified otherwise, this Assessment defines the wet season as being the 6-month period from 1 November to 30 April, and the dry season as the 6-month period from 1 May to 31 October. However, it should be noted that the transition from the dry to the wet season typically occurs in October or November, and the definition of the northern wet season commonly used by meteorologists is 1 October to 30 April.

All results in the Assessment are reported over the water year, defined as the period 1 September to 31 August, unless specified otherwise. This allows each individual wet season to be counted in a single 12-month period, rather than being split over two calendar years (i.e. counted as two separate seasons). This is more realistic for reporting climate statistics from hydrological and agricultural assessment viewpoints.

### 1.4.3 Scenario definitions

The Assessment considered four scenarios, reflecting combinations of different levels of development, and historical and future climates, much like those used in the Northern Australia Sustainable Yields project (CSIRO, 2009a, 2009b, 2009c), the Flinders and Gilbert Agricultural Resource Assessment (Petheram et al., 2013a, 2013b), the Northern Australia Water Resource Assessments (Petheram et al., 2018a, 2018b, 2018c) and the Roper River Water Resource Assessment (Watson et al., 2023):

- Scenario A – historical climate and current development
- Scenario B – historical climate and future development
- Scenario C – future climate and current development
- Scenario D – future climate and future development.

#### Scenario A

Scenario A and its subsets, Scenario AN and Scenario AE, assume a historical climate. The historical climate series is defined as the observed climate (rainfall, temperature and potential evaporation for water years from 1 September 1890 to 31 August 2022). All results presented in this report were calculated over this period, unless otherwise specified. Historical tidal data were used to specify downstream boundary conditions for the flood modelling.

Scenario A assumes current levels of surface water development and that existing water licence holders use their full entitlement. For more information see the companion technical report on river model simulation in the Southern Gulf catchments (Gibbs et al., 2024). Strategic reserves are not included under Scenario A.

Scenario AN assumes no water resource development.

Scenario AE assumes current levels of surface water development, estimates actual use of the existing entitlement holders and applies this over the entire historical period. Strategic reserves are not included.

The results under scenarios AN and AE only differ from the results under Scenario A in the Leichhardt catchment, because other catchments in the study area have no or very small (≤5 GL/year) entitlement volumes.

### Scenario B

Scenario B is historical climate and future hypothetical development assessed at approximately 2060. Scenario B uses the same historical climate series as Scenario A. River inflow was modified to reflect potential future development. Potential development options are entirely hypothetical and were devised to assess the response of hydrological, ecological and economic systems to future development ranging from small incremental increases in surface water through to extraction volumes representative of the likely physical limits of the Southern Gulf catchments (i.e. considering the co-location of suitable soil and water). Price and cost information was indexed to December 2023 unless otherwise specified. The impacts of future hypothetical developments on existing licence holders in the Leichhardt catchment are reported.

The impacts of changes in flow due to this future development were assessed, including impacts on:

- instream, riparian and near-shore ecosystems
- Indigenous water values
- economic costs and benefits
- opportunity costs of expanding irrigation
- institutional, economic and social considerations that may impede or enable adoption of irrigated agriculture.

### Scenario C

Scenario C is future climate and current levels of surface water assessed at approximately 2060. Future climate impacts on water resources were explored within a sensitivity analysis framework by applying percentage changes in rainfall and potential evaporation to modify the 132-year historical climate series (as in Scenario A). The percentage change values adopted were informed by projected changes in rainfall and potential evaporation under Shared Socio-economic Pathways (SSP) 2-4.5 and 5-8.5 as defined in the IPCC Sixth Assessment Report on climate change (IPCC, 2022). SSP 2-4.5 is broadly considered representative of a likely projection given current global commitments to reducing emissions, and SSP 5-8.5 is representative of an (unlikely) upper bound.

### Scenario D

Scenario D is future climate and future hypothetical development. It uses the same future climate series as Scenario C. River inflow was modified to reflect future hypothetical developments, as in Scenario B. Therefore, in this report, the climate data for scenarios A and B are the same (historical observations from 1 September 1890 to 31 August 2022), and the climate data for scenarios C and D are the same (the above historical data scaled to reflect a plausible range of future climates).

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# Part II Resource information for assessing potential development opportunities

Chapters 2 and 3 provide baseline information that readers can use to understand what soils and water resources are present in the Southern Gulf catchments and the current living and built environment of the Southern Gulf catchments. This information covers:

- the physical environment (Chapter 2)
- the people, ecology and institutional context (Chapter 3).

The Leichhardt River downstream of its junction with Gunpowder Creek. Loamy and clayey-surfaced friable soils are adjacent to the river. Treeless alluvial clay plains can be seen in the distance.

Photo: CSIRO – Nathan Dyer