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National Water Grid®

Water resource assessment for the Victoria catchment

A report from the CSIRO Victoria River Water Resource Assessment for the National Water Grid

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Important disclaimer

CSIRO Victoria River Water Resource Assessment acknowledgements

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

The Assessment was guided by two committees:

i. The Assessment's 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 Assessment's joint Roper and Victoria River catchments Steering Committee: Amateur Fishermen's Association of the NT; Austrade; Centrefarm; CSIRO; National Water Grid (Department of Climate Change, Energy, the Environment and Water); Northern Land Council; NT Cattlemen's Association; NT Department of Environment, Parks and Water Security; NT Department of Industry, Tourism and Trade; NT Farmers; NT Seafood Council; Office of Northern Australia; Parks Australia; Regional Development Australia; Roper Gulf Regional Council Shire; Watertrust

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 Dr Brian Keating (Independent consultant). Individual chapters were reviewed by Dr Rebecca Doble, CSIRO (Chapter 2); Dr Chris Pavey, CSIRO (Chapter 3); Dr Heather Pasley, CSIRO (Chapter 4); Mr Chris Turnadge, CSIRO (Chapter 5); Dr Nikki Dumbrell, CSIRO (Chapter 6); Dr Adam Liedloff, 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 xxv.

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

The Victoria River is the longest singularly named river in the NT with permanent water. Photo: CSIRO – Nathan Dyer

Part I Introduction and overview

Chapter 1 provides background and context for the Victoria River 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.

Jasper Gorge in Judbarra National Park is a key tourist attraction in the Victoria catchment.

Photo: CSIRO – Nathan Dyer

1 Preamble

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

1.1 Context

Sustainable development is a priority for the Northern Territory (NT) and Australian governments, and a number of strategies have been developed to progress this. The NT Government Agribusiness Strategy 2030 (undated) is a good example of what sustainable development represents, describing itself as 'a partnership to grow the size of the Agribusiness sector to $2 Billion by 2030 fostering vibrant, healthy and prosperous communities throughout the NT.' This and other strategies see the need for continued research; for example, the NT Government (2023) announced a priority action with respect to the Territory Water Plan that sought to accelerate the existing water science program 'to support best practice water resource management and sustainable development.'

For very remote areas like the catchment of the Victoria River (Figure 1-1) the land, water and other environmental resources or assets will be key in determining how sustainable development might occur. Primary questions for any consideration of sustainable 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. Understanding how people perceive risks is critical, especially in the context of areas such as the Victoria catchment, where almost three-quarters of the population is Indigenous (compared with 3.2% for Australia as a whole) and where many Indigenous Peoples still live on the same lands they have inhabited for thousands of years. Approximately 31% of the Victoria catchment is owned by Indigenous peoples as inalienable freehold.

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, mitigation of investment or environmental risks, or the construction of policy settings that can support good decision making. The Victoria River Water Resource Assessment findings summarised in this report 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.

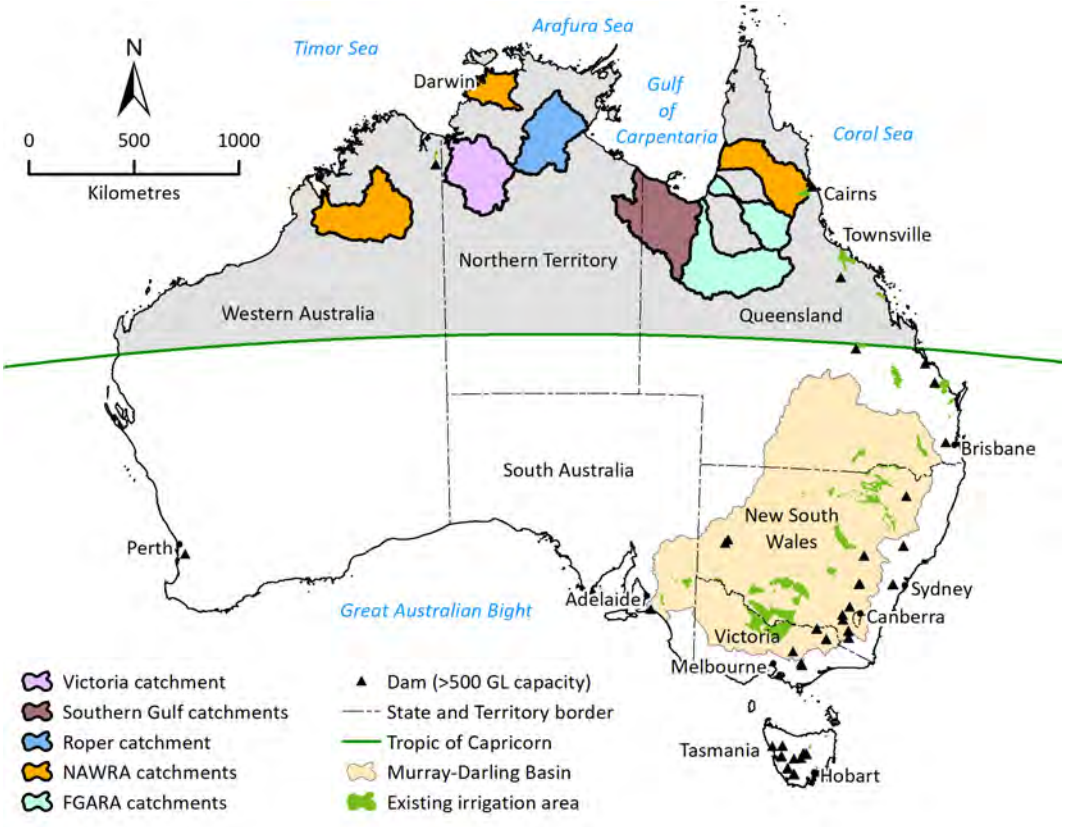

Figure 1-1 Map of Australia showing Assessment area (Victoria catchment) and other recent or ongoing CSIRO Assessments

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

The Assessment 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 catchment, 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.

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 Victoria catchment in the NT (summarised in this catchment report) and the catchments of the Southern Gulf rivers (hereafter 'Southern Gulf catchments'), that is, Settlement Creek, Gregory—Nicholson River and Leichhardt River, Morning Inlet and the Wellesley Island groups[1] of the NT and Queensland (Watson et al., 2024). These last three assessments have again 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 Victoria River Water Resource Assessment

The Victoria River Water Resource Assessment has undertaken fundamental baseline data collection on water, soil and other environmental assets in order to support regional and Country planning, resource management and sustainable development.

The Victoria catchment was identified by the Australian and NT governments 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. With the proximity of the Victoria River catchment to Kununurra and the Ord River Irrigation Area (ORIA) one of the major agriculture centres in northern Australia, the area is seen as having the potential for overcoming some of the challenges that typify agriculture in northern Australia.

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
- understand the water values, rights, interests and development goals of Indigenous communities
- assess the potential environmental, social and economic impacts and risks of water resource and irrigation development.

It is important to note that, although these four 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

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

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.

Drawing on the resources of all three tiers of government, the Assessment built on previous studies, drew on existing stores of local knowledge and employed an experienced science team, with quality assured through peer-review processes.

The 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 Victoria catchment. 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 Australian governments. 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 which 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 Victoria catchment 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 Victoria catchment, 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 shows 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 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 25th 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.

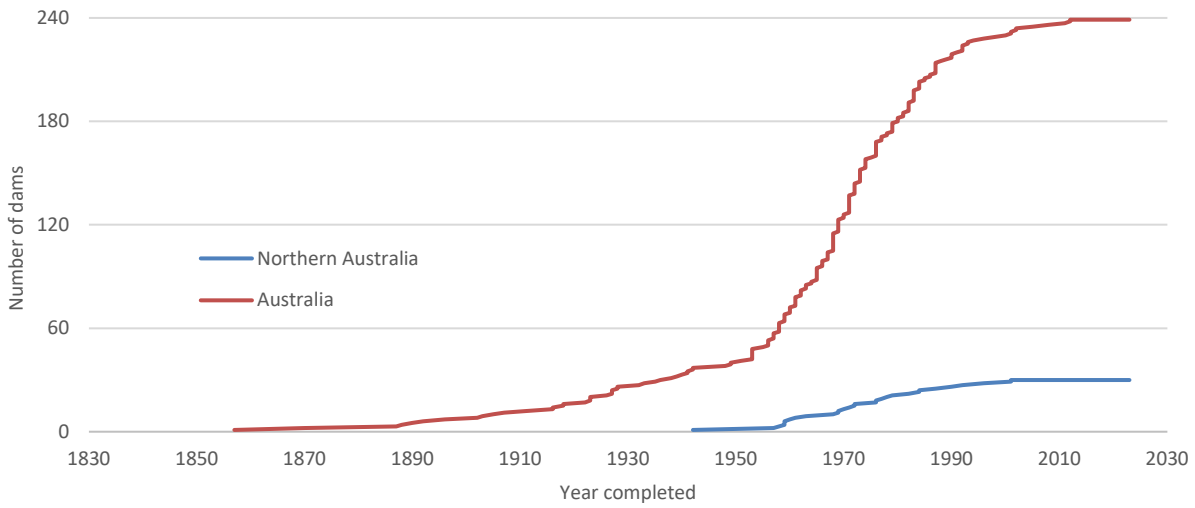

Figure 1-2 Number of large dams constructed in Australia and northern Australia over time

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 Victoria catchment, if the future trajectory of irrigation development is similar to historical trends, the scale of future irrigation development in the Victoria catchment 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/victoriariver

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 Victoria catchment 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 Victoria catchment. 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.

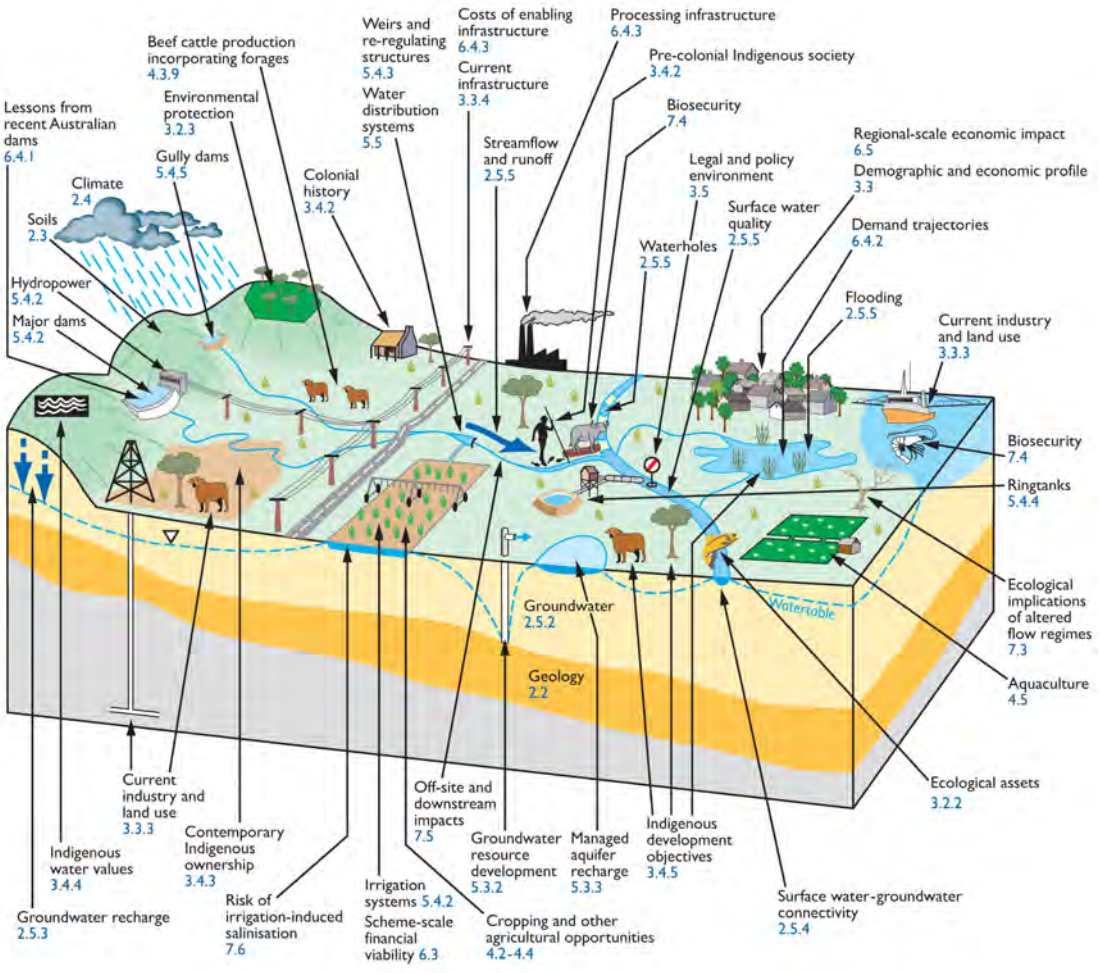

Figure 1-3 Schematic of key components and concepts in the establishment of a greenfield irrigation development

Numbers shown in blue refer to sections of this report.

The structure of the Victoria catchment 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 catchment.
- Part III (Chapter 4 and Chapter 5) considers the opportunities for water and 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.

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 Victoria catchment, 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 Victoria catchment and the institutional context of the catchment, describing:

- ecology: ecological systems and assets of the Victoria catchment, 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 Victoria catchment
- Indigenous values, rights, interests and development objectives, generated through the direct participation of Victoria catchment Traditional Owners.

1.3.3 Part III – Opportunities for water resource development

Chapter 4 presents information about the opportunities for irrigated agriculture and aquaculture in the Victoria catchment, 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 Victoria catchment, describing:

- groundwater and subsurface storage opportunities
- surface water storage opportunities in the Victoria catchment, 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 Victoria River and its major tributaries
- water distribution systems (i.e. for conveyance of water from a dam and application to the 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 catchment
- 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 – lists of figures and tables.

1.4 Key background

1.4.1 The Victoria catchment

The Victoria catchment has an area of 82,400 km^2 and lies within the NT, extending from the Joseph Bonaparte Gulf in the north, along and to the east of the NT–WA border, to the Tanami Desert in the south (Figure 1-4). The climate is hot and semi-arid. The catchment has a complex geological history comprising outcropping rocks and sediments that were deposited, and in some cases modified, over five major geological eras. In the central parts of the catchment, harder more-resistive sandstones form ranges and gorges, while to the east the topography varies from steep hills to undulating plains. The Victoria catchment is sparsely populated with a total population of approximately 2000 (ABS, 2021), with small population centres at Kalkarindji, Timber Creek, Yarralin, Daguragu, Amanbidji and Nitjpurru (Pigeon Hole). The largest of these settlements is Kalkarindji, with a population of 383 at the 2021 Census. There are also some smaller Indigenous communities, outstations and roadhouses. Indigenous Peoples in the Victoria catchment have retained strong ties to one another and to local cultural landscapes, but either chose or were obliged to move into the aforementioned larger settlements. Contemporary Indigenous residential populations include those with recognised traditional ownership rights and connections to the Victoria catchment, as well as people whose primary cultural connections lie elsewhere. Kununurra (population 4515 in 2021) is the closest urban service centre and is approximately 85 km by road from the western boundary of the catchment. The nearest major city and population centre is the NT capital, Darwin (the population of the Greater Darwin area was 139,902 in 2021), approximately 600 km by road from Timber Creek.

The Victoria River is approximately 560 km in length, from south of Kalkarindji to Entrance Island at the river mouth. The main agricultural land use in the Assessment area is for grazing native vegetation (62% of the area). Aboriginal freehold tenure makes up 31% of the area, which includes the 16% of the catchment which is national park. The Bradshaw Field Training Area occupies 7%, to which access is restricted. The protected areas in the Victoria catchment and the marine region include one gazetted national park (Judbarra), a proposed extension to an existing national park (Keep River), two marine national parks, two Indigenous Protected Areas and two Directory of Important Wetlands in Australia sites. In the north of the Assessment area lies the Bradshaw Field Training Area, an Australian Government facility, with its southern boundary following the Victoria River. Cropping (both rainfed and irrigated) are very sparsely practised (<0.02% of the catchment area).

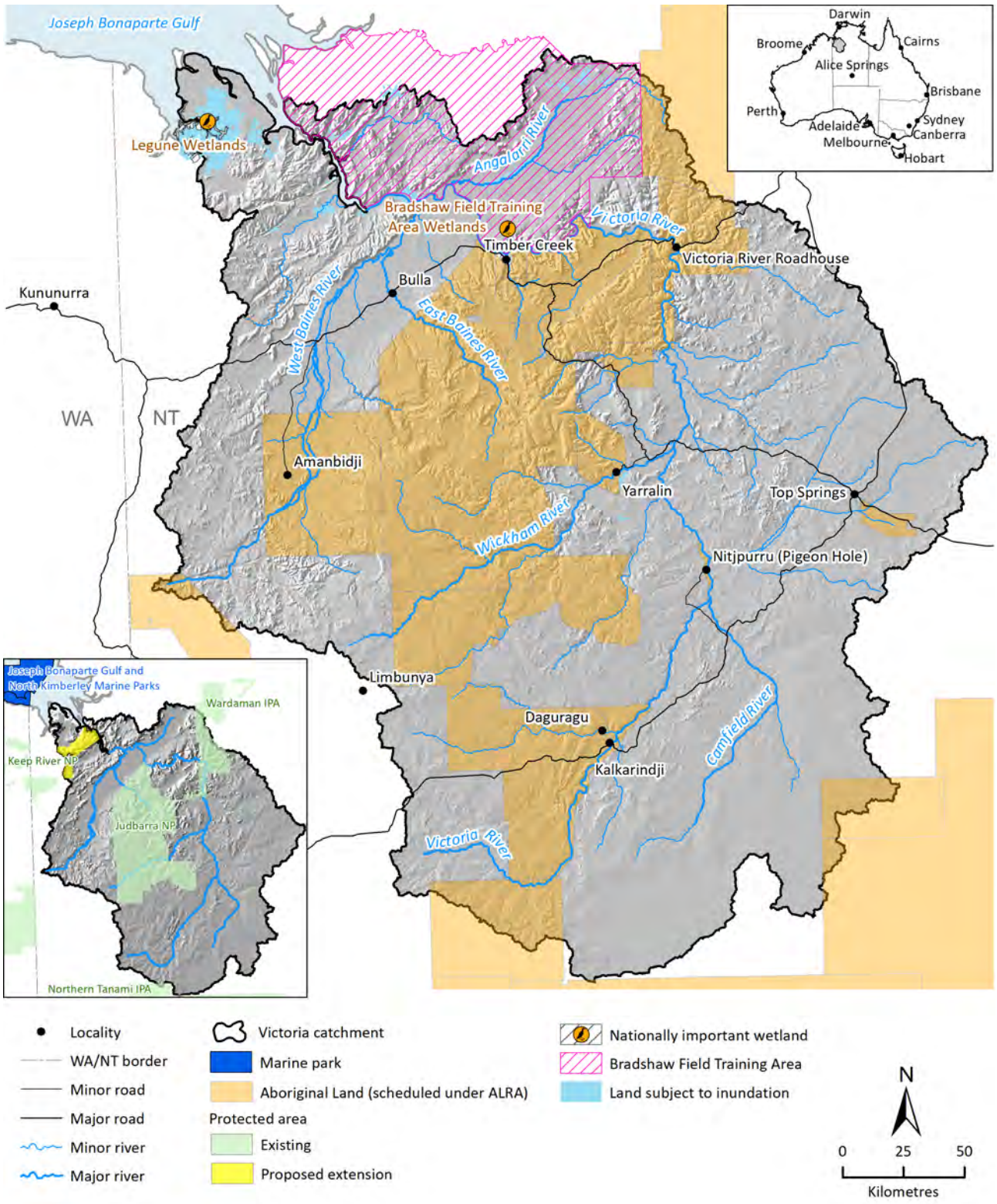

Figure 1-4 The Victoria catchment

Land without colour overlay is pastoral leasehold land. ALRA = *Aboriginal Land Rights (Northern Territory) Act 1976*; IPA = Indigenous Protected Area; NP = national park.

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 assumes a historical climate and current levels of development. 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 are calculated over this period, unless otherwise specified.

Current surface water licence entitlements in the study area are about 152 GL. However, 150 GL of entitlements are located in the catchment of Forsyth Creek, which discharges into the Joseph Bonaparte Gulf adjacent to the Victoria River and was not included in the river modelling scenarios. Current surface water licence entitlements in the Victoria catchment are small (<2 GL/year), which is the equivalent of 0.04% of the median annual flow of the Victoria River. Consequently, Scenario A assumes no existing surface water extractions. Scenario A was used as the baseline against which assessments of relative change were made. Historical tidal data were used to specify downstream boundary conditions for the flood modelling.

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, groundwater recharge and flow, and agricultural productivity were 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 and groundwater extraction through to extraction volumes representative of the likely physical limits of the Victoria catchment (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 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 and groundwater development 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, groundwater recharge and flow and agricultural productivity were modified to reflect potential future development, 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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