Section 2

Cultural and socio-economic dimensions of the rivers

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Connecting the champions of the Lake Eyre Basin rivers

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Introduction

The free-flowing rivers of the Lake Eyre Basin mark the Basin as one of Australia's more important cultural and natural systems. It has outstanding environmental, cultural and economic value, supported by rivers, lakes and floodplains that fluctuate between highly unpredictable boom and bust cycles. Floods bring spectacular biological productivity to the rivers and their floodplains. Vast areas are inundated, becoming a magnet to millions of waterbirds, fish, frogs and invertebrates (Kingsford *et al.* 1999; Capon 2007; see Chapters 3 and 4). The conditions trigger a prolific germination of plant life, providing primary productivity (Capon and Brock 2006) on which wildlife and livestock (Phelps *et al.* 2007) depend. People too have relied on these extreme and sporadic events to replenish water resources and, for Aboriginal people, they nourish a deep history of stories and life centred on these great rivers for tens of thousands of years (see Chapters 8 and 9; Fig. 7.1). The rivers

Fig. 7.1. Aboriginal people were living on the Lake Eyre Basin rivers up to 50 000 years ago, with evidence of their ongoing connection to country clear everywhere, including these stone arrangements near Blackall in the Barcoo River catchment (photo, DATSIP Cultural Heritage Image Library).

also sustain a highly profitable organic beef industry (see Chapters 10 and 11). The floods and the outback experience are also a strong generator of tourism income (Schmiechen 2004), as people flock to see the floodwaters that occasionally reach Kati Thanda-Lake Eyre (see Chapter 13). These interdependencies are reflected in strong partnerships forged to protect the rivers.

Strong formal and informal partnerships now exist among communities involved in the management of the Lake Eyre Basin rivers and their water. These alliances were primarily catalysed by a proposal to grow irrigated cotton on the Cooper Creek floodplain, near Windorah (see Chapter 17; Table 7.1). River champions emerged from all walks of life to express deep concern about this major water resource development. They were Traditional Owners, graziers, local, state and national government members, scientists and people involved in the tourism industry. Their view of the Basin and its rivers generally ignored state political boundaries, instead recognising and embracing the importance of the connectedness of this vast river system, from north-west Queensland and the Northern Territory to Kati Thanda-Lake Eyre in South Australia. Concern about the future of the river was borne of an understanding of this connectedness, but also for the potential impacts of water resource development on cultural and environmental values. As with many rivers across the world, development of upstream water resources has had major long-term impacts on downstream ecosystems and human communities (Lemly *et al.* 2000). Avoiding such impacts became a major community focus for the management and use of water resources in the Lake Eyre Basin, underpinned by a formal and informal network of partnerships.

In 2014, the Lake Eyre Basin Partnership formed as a loose community coalition, with three regional natural resource management groups across three jurisdictions at its core: Desert Channels Queensland, South Australian Arid Lands Natural Resources Management Board, and Territory Natural Resource Management (Fig. 7.2a). In this chapter, we trace the genesis of the different partnerships and their effectiveness, culminating in the winning of the Australian Riverprize in 2014 and the International Riverprize in 2015. For the first time in the 17 years of awarding the International Riverprize, judges decided to reward a community for effectively protecting, rather than rehabilitating a major river system – the Lake Eyre Basin, one of the world's greatest inland river regions.

Challenges to sustainability – water access

Australia and many other parts of the world have generally had a strong drive to develop water resources for irrigated agriculture, rarely valuing water for the environment adequately (Gibbs 2006; Gibbs 2009). In the 1990s, integrated catchment planning was in its infancy in Australia and was poorly developed outside of highly managed systems such as the Murray–Darling Basin in south-east Australia. There was no equivalent model for managing a free-flowing river system the size of the Lake Eyre Basin. The results of scientific work about the long-term impacts of water resource developments around the world and particularly from the rivers of the Murray–Darling Basin were also rapidly accumulating. There was growing understanding of the global extremes of variability experienced by the Lake Eyre Basin rivers (Puckridge *et al.* 1998; Puckridge *et al.* 2000; McMahon *et al.* 2008a; McMahon *et al.* 2008b) and the incredible cultural, environmental and economic values that their water supported.

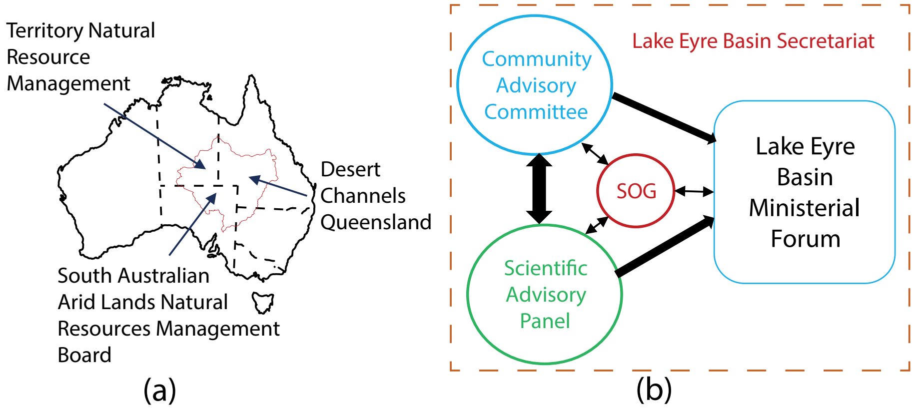

Fig. 7.2. Main formal partnerships within the Lake Eyre Basin, from 2000 onwards, supporting (a) natural resource management through the three regional bodies in the Northern Territory, Queensland and South Australia; (b) the Lake Eyre Basin Intergovernmental Agreement with two external bodies, the Community Advisory Committee and the Scientific Advisory Panel advising ministers in the Australian Government and the governments of the Northern Territory, Queensland and South Australia through a ministerial forum, supported by a senior officers group (SOG) from each government, chaired by the Australian Government. The natural resource management bodies recommend members from pastoral, Aboriginal and agricultural communities to the Community Advisory Committee. Arrows indicate formal and informal collaboration. Collaboration among the Community Advisory Committee, Scientific Advisory Panel and government officers delivers key outcomes for the sustainable management of the river basin.

A proposed water resource development at Currareva Waterhole on the Cooper Creek near Windorah in 1995 (Fig. 7.3) galvanised what was then disparate pastoral, conservation, government and scientific communities to protect the Lake Eyre Basin's magnificent rivers (Chapter 17; Table 7.1). It rapidly healed a schism created by the proposed World Heritage nomination of the South Australian part of the Lake Eyre Basin (Table 7.1), which sought global acknowledgement of the region's outstanding cultural and environmental values (Reid 1994; Morton *et al.* 1995), but which had failed to effectively engage regional communities. The proposed Currareva irrigation development, as it became known, was not the first development of the river, but it had the potential to expand into a large-scale irrigation enterprise, with devastating social and ecological consequences (Kingsford *et al.* 1998; see Chapter 17).

The community response saw the formation of the Cooper's Creek Protection Group in 1995 (see Chapter 17) to challenge the then Queensland Government's typical approach of developing water resources for irrigation without appropriate assessment of the potential impacts. The group, with conservationists and scientists, convened a scientific workshop in 1996 to look at the potential risks of major water resource development on the Lake Eyre Basin rivers and their significant natural and cultural values (Kingsford *et al.* 1998; Table 7.1). There were comparisons drawn to the neighbouring Murray–Darling Basin, with its degraded rivers and impacts on ecosystem services and livelihoods (Kingsford 2000; see Chapters 14–17). The workshop communique was sent as an open letter to the Queensland Minister for Natural Resources, calling upon governments to reject large-scale irrigation proposals because of unacceptable risks to the environment, cultural resources and people of

Table 7.1. Important community events, development proposals and government legislation (1995–2016), with their timing, description and implications affecting decisions about the sustainability of the rivers of the Lake Eyre Basin.

Event	Date	Description	Implications
World Heritage Listing – recommendation	1985	Recommendation by the Australian Government to list the Lake Eyre Basin in South Australia on the World Heritage List	Strong reaction from pastoralists claiming that this would negatively affect their livelihoods and land values
Proposal to irrigate from Cooper Creek at Currareva, near Windorah	1995	A group of developers, the Currareva Partnership, proposed to divert water (42 000 ML per year) from Cooper Creek to large storages on the floodplain for large-scale irrigation. This development was initially supported by the Queensland Government of the time, which granted water licences.	There was widespread concern within a community which was well aware of the lessons learnt from large-scale irrigation in the neighbouring Murray–Darling Basin.
Birdsville meeting		Involved disparate communities, including pastoralists, Traditional Owners, conservationists, scientists and government officers	Formation of an overarching advisory group – the Lake Eyre Basin Steering Group with representatives from the Australian Government and governments of Queensland and South Australia
Cooper Creek Scientific Workshop	1996	In response to the Currareva proposal, the Cooper's Creek Protection Group, conservationists and scientists organised a workshop to discuss the merits and potential implications of such a development.	There was widespread coverage of the workshop in the media and the communique was provided to the Queensland Government. Strong partnerships were forged.
Lake Eyre Basin Heads of Agreement	1997	The Australian, Queensland and South Australian governments signed this agreement to focus their commitment on managing the Lake Eyre Basin as a unified, connected system.	This set up the Lake Eyre Basin Intergovernmental Agreement with commitments from the two states and the Australian Government to protect the rivers of the Lake Eyre Basin.
Draft Water Management Plan for Cooper Creek		This recommended an allocation of 22 500 ML per year from the Thomson and Barcoo Rivers.	This was strongly opposed by the local community, scientists and environmentalists.
Lake Eyre Basin Coordinating Group formed	1998	Establishment of a group to represent the community and provide advice for the management of the Lake Eyre Basin	Strong leadership with semi-autonomy for directing funds and investing in the Lake Eyre Basin

Launch of Cooper Creek and Georgina– Diamantina Catchment Management Plans	2000	Cooper Creek and Georgina–Diamantina catchment committees stretched across the entire catchment and were formed by the respective governments, community members, supported by some scientific input. They delivered plans which respected the connectedness of the Basin's rivers and communities.	These plans formed the basis for all subsequent objectives of planning, providing the essential catchment focus required for protection of the river flows.
Lake Eyre Basin Intergovernmental Agreement		Formally signed by the Australian, Queensland and South Australian governments with enacting legislation the following year. As required by the agreement, the Lake Eyre Basin Ministerial Forum, and advisory groups (Community Advisory Committee and Scientific Advisory Panel) were established.	This was the critical formal process by which the governments involved provided their policy support and subsequent funding for integrated management of the Lake Eyre Basin and its rivers.
Cooper Creek Water Resource Plan		This prohibited irrigation in the Cooper Creek catchment.	This represented a fundamental change in favour of protecting the natural flow regime of the rivers of the Lake Eyre Basin.
Lake Eyre Basin Biennial Conference	2002	The agreement stipulated the provision of a biennial conference involving community, industry, scientists, government ministers and officials. The inaugural event was held in Birdsville, Queensland.	Platform for respectful discussion, information exchange and recognition of community commitment. The events, subsequently held in 2004, 2006, 2008, 2010 and 2013, served to galvanise a unifying vision for the management of Lake Eyre Basin rivers and influence government investments in Lake Eyre Basin programs and projects.
Lake Eyre Basin Intergovernmental Agreement	2004	Signed by the Northern Territory Government	The three major jurisdictions and the Australian Government were now party to the agreement.
Lake Eyre Basin Aboriginal Forum		The Lake Eyre Basin Ministerial Forum commits to Aboriginal Forums in recognition of the connection of Aboriginal people with the Basin and the importance of advice from Aboriginal people on the management of the rivers and cultural values. The inaugural event was held near Alice Springs, Northern Territory.	Aboriginal people of the Basin have an opportunity to meet and discuss issues of concern about the natural and cultural management of the Basin and make recommendations to the Ministerial Forum. Subsequent forums were held in 2006, 2009 and 2011 at locations within the Basin.

Floodplain graziers conference	2008	The floodplain graziers organised a conference involving people making a living from livestock grazing on the rivers of the Lake Eyre Basin and also graziers from the Murray–Darling Basin, as well as scientists.	This was a pivotal conference in connecting the grazing communities of the Murray–Darling Basin and also the Lake Eyre Basin. It established lifelong friendships but, most importantly, people living on the rivers of the Lake Eyre Basin were able to understand one potential future and its effects from the experiences of graziers on the rivers of the Murray–Darling Basin.
Inaugural State of the Basin Report		Formal report on the environmental sustainability of the Lake Eyre Basin rivers, required every decade.	Provided an opportunity for governments and the community to focus on long-term sustainability of the Basin and impetus for investment in monitoring.
Lake Eyre Basin Wild Rivers Advisory Panel		Formed for consultation of Wild Rivers legislation in the Channel Country.	Stakeholders supported Wild Rivers declarations under this legislation.
Strategic Adaptive Management approach adopted by governments	2010	The governments of the Lake Eyre Basin formally endorsed the Strategic Adaptive Management approach for managing the Lake Eyre Basin rivers.	This provided critical institutional support to an innovative approach, still in its infancy, to natural resource management.
Rivers Assessment monitoring program commences	2011	Required to support State of the Basin reporting; provided a solid investment in collection of data, primarily by government agencies in the Lake Eyre Basin.	Opportunity to learn about the Basin and its environmental attributes, as well as potentially contributing to long-term trend analyses.
Wild Rivers declarations for Lake Eyre Basin rivers		The Queensland Labor Party introduced Wild Rivers legislation, resulting in the declaration of the Channel Country rivers in Queensland.	This legislation and its subsequent policies protected the flows and floodplains of the Lake Eyre Basin rivers, until it was revoked just a few years later.
Lake Eyre Basin Under the Spotlight Conference	2013	This public conference was held in Longreach to draw attention to the potential impacts of changes to policy and legislation affecting the Lake Eyre Basin rivers.	There was good publicity about the conference with pressure exerted on the Queensland Government. Many of the authors of chapters in this book presented their work at this conference.
Revocation of Wild Rivers legislation and Wild Rivers declarations of Lake Eyre Basin rivers in Queensland	2014	The Liberal National Party revoked the Wild Rivers legislation and Wild Rivers declarations, allowing for increased trade of sleeper irrigation licences, reducing protection of floodplains and promoting irrigation.	Currently, this policy and legislative framework remain in place, creating significant vulnerability and management challenges for the rivers and the floodplains of the Lake Eyre Basin.

Fig. 7.3. Currareva Waterhole on Cooper Creek, the location of a large-scale irrigation development proposal in 1995, requiring changes to the Queensland water resource plan (photo, A. Emmott).

the river system. Similar scientific resolutions, underpinned by consistent community concern and conviction, followed in later conferences (see Chapter 17).

In 1998, an incoming Queensland Labor Government abandoned the draft Cooper Creek water plan which would have established large-scale irrigation (see Chapter 17). The plan eventually gazetted became the first in Australia to prohibit large-scale water resource development. The accompanying dialogue among community members, scientists and government resulted in innovative and visionary governance arrangements, supported by representation and communication processes and scientific input, which focused on protecting the flows of the Lake Eyre Basin rivers. This collaborative and integrative approach to planning and governance defused conflict and built trust among community, government and scientific stakeholders. Known as the Lake Eyre Basin Intergovernmental Agreement, it marked a revolutionary shift in power and influence away from mainstream government decision-making to one of collaborative, Basin-wide decision-making that transcended jurisdictional borders, involved communities and was supported by scientific evidence. This governance model has since been applied by other organisations to areas such as the Murray–Darling Basin in Australia, a well-resourced and developed river system.

With Queensland legislation enabling a review of water plans every 10 years, community concern was once again mounting about the vulnerability of the rivers to water resource developments. Wild Rivers declarations for the Lake Eyre Basin rivers, including protection of floodplains, were announced in 2011 (see Chapters 20 and 21; Table 7.1). Ultimately, this did not adequately protect river flows, with the incoming Liberal National Party Government of 2012 revoking Wild Rivers legislation to free up access to water by irrigators in the Queensland part of the Lake Eyre Basin, once again through explicit changes to the legislation in 2014 (Table 7.1).

Many partnerships – one vision

Formal and informal partnerships have flourished in the Lake Eyre Basin and its rivers over nearly three decades. Trust, respect and shared passion for the protection of Lake Eyre Basin rivers have developed among the community members living and working in the Basin and the wider community, dedicated to building and sharing knowledge of the unique 'boom' and 'bust' systems of the Basin. In 1995, a pivotal public meeting in Birdsville (Fig. 7.4), a small outback town in the middle of the Lake Eyre Basin, brought together all community interests: pastoralists; conservationists; Indigenous representatives (from the Aboriginal and Torres Strait Islander Commission); representatives from local, state and Australian governments; mining and petroleum industries; and scientists (Table 7.1). There was substantial tension over competing visions for the Basin, driven by contrasting proposals to list part of the Lake Eyre Basin as a World Heritage site and develop irrigation on Cooper Creek. At the time, few people conceived of the Lake Eyre Basin rivers as a connected freshwater system. Even fewer identified the Lake Eyre Basin as a place where human communities were connected through their shared bonds with its rivers.

The Birdsville meeting was a formal catalyst for collaboration around the sustainable use and management of water across the Lake Eyre Basin. And it succeeded: the Lake Eyre Basin

Fig. 7.4. Famous Birdsville Hotel in the outback town of Birdsville, the location for many key meetings including one in 1995, triggering the start of long and enduring partnerships among Aboriginal people, conservationists, industry, scientists, landholders and government officers (photo, A. Emmott).

Steering Group was formed, with membership from the pastoral industry, the Queensland and South Australian governments, the Australian Government, conservation groups, mining and petroleum industries, Landcare groups, Aboriginal organisations, tourist operators and local government. The Steering Group, supported by governments, communicated the value of integrated planning, governance and advice, recommending the importance of investing in science and monitoring at an unprecedented scale across the entire river basin. It was guided by principles of inclusiveness, accountability, social equity and respect for diversity, fairness, transparency, and continuous learning. Seldom has such a model emerged across such a large part of the world. There were major logistical obstacles to cooperation, particularly the scheduling of meetings and communication across the vast expanse of the Lake Eyre Basin (over 1 million km^2 of sparsely populated catchment). The group established seven key principles for protecting the rivers: promotion of ecological and economic sustainability; development and communication of a shared, strategic vision; provision of a forum for Basin-wide issues; provision of a communication channel with governments; integration of priorities for action plans and funding; facilitation of knowledge flow and development; and application of social justice principles so that diverse views were respected and considered. All principles endure today, still fundamentally underpinning the success of the various and ever-evolving partnerships within the Lake Eyre Basin which seek to manage this complex socio-ecological system.

Community-based management committees for the Cooper Creek and Georgina–Diamantina catchments were constituted soon after the establishment of the Steering Group. Uniquely in Australia, these committees extended across the borders of Queensland and South Australia and included communities from both jurisdictions. The committees were supported by funding from the Australian Government's Natural Heritage Trust and the South Australian and Queensland governments. The process dissipated upstream–downstream divides, as community members experienced the full course of the rivers through the eyes and knowledge of other community members and meetings throughout the catchment. Investment programs reflected this unifying ecological dimension, with programs such as invasive species control coordinated across jurisdictional borders. There was a common goal of protecting the river from potential threats, particularly water resource developments, invasive species (weeds and feral animals) and pollution. Communities worked hard to produce the catchment management plans launched in Birdsville in October 2000. Disappointingly, the subsequent funding model for natural resource management overlooked the opportunity for a genuine catchment-based approach in the Lake Eyre Basin by establishing jurisdiction-based regional bodies in South Australia, Queensland and the Northern Territory.

Government coordination, partnership and reporting

In 1997, the Australian, Queensland and South Australian governments signed the Lake Eyre Basin Heads of Agreement – the initial policy instrument for collaboration by governments, scientists and all sectors of the community to identify mechanisms for achieving long-term, cross-border, sustainable management of the Lake Eyre Basin and its

Fig. 7.5. Government ministers and members of the Lake Eyre Basin Coordinating Group at the signing of the Lake Eyre Basin Intergovernmental Agreement in 2004, when the Northern Territory signed (photo, V. Norris).

rivers. This culminated in the signing of the Lake Eyre Basin Intergovernmental Agreement in 2000, focusing state, territory and federal governments on protecting its free-flowing rivers (Table 7.1). The Northern Territory subsequently signed the agreement in 2004 (Fig. 7.5). This framework provided the institutional governance for an already united community, and overarching arrangements to protect the Basin through partnerships with the community, industry, scientific and government people. The focus was on 'water and related natural resources', in particular the protection of natural variability in river flows, and, although not explicit, this also included flow volumes.

Ministers focused their agencies on implementing the agreement, establishing a Community Advisory Committee and Scientific Advisory Panel in 2001 to advise the Ministerial Forum (comprising a minister from each of the signatory governments; Fig. 7.2b). These advisory bodies engage with community-driven catchment groups and regional natural resource management organisations, and are supported by a secretariat based within the Australian Government (Fig. 7.2b). The Community Advisory Committee spans the entire Basin, and represents all interests. Cultural understanding and connection of Aboriginal people to the rivers was recognised as fundamentally important, eventually manifesting in increased representation by Traditional Owners on the Community Advisory Committee. This is underpinned by six fundamental operating principles, endorsed by Ministers in June 2004: sustained involvement of Aboriginal people; face-to-face contact; coordination; observation of local protocols; promotion of mutual learning; and provision of regular feedback through an

Fig. 7.6. Landholders, Traditional Owners, scientists, government officers and industry members at the 2013 Lake Eyre Basin Biennial Conference in Port Augusta (photo, M. Turner).

Aboriginal Forum. The Scientific Advisory Panel (Fig. 7.2b) provides scientific expertise on ecology, hydrology and socio-economics. Member scientists are often actively doing research in the Basin. The natural resource management bodies are also closely connected to this process, with several members on the Community Advisory Committee (Fig. 7.2a,b).

Critically, the agreement requires governments to meet regularly through a Ministerial Forum, involving relevant ministers from the Australian, Northern Territory, Queensland and South Australian governments (Fig. 7.2b). These forums provide the opportunity for candid interactions between governments, as well as a mechanism for leaders of the Community Advisory Committee and Scientific Advisory Panel to raise key issues. Biennial conferences are another requirement of the agreement, convened in different locations around the Basin until the most recent in Port Augusta in 2013 (Table 7.1, Fig. 7.6). These events brought together the general community, Traditional Owners, industry, scientists, government policy-makers, and managers to share current state of knowledge of the Basin, and nurture cross-sector and cross-border collaboration. As well, Lake Eyre Basin Aboriginal Forums, last held in 2011 (Table 7.1), were a pathway for Aboriginal people to provide strong input into the management of the Basin (see Chapter 8).

The agreement also made a commitment to science, through the Lake Eyre Basin Rivers Assessment and reporting on the state of the Lake Eyre Basin every 10 years (Table 7.1). This was in addition to the independent science carried out by researchers. The Rivers Assessment involved surveying biophysical processes and functions of the Lake Eyre Basin rivers, as well as identifying potential threats (e.g. invasive species). The first State of the Basin Report was for 2008 (Lake Eyre Basin Scientific Panel 2009), with the next assessment due in 2018. These reports and independent scientific research continue to generally support assessments that the Lake Eyre Basin and its rivers remain in excellent ecological condition. However, extinction of small to medium endemic mammals is widespread in the Lake Eyre Basin (Chapter 6). Also, exotic invasive species remain an ever present and serious problem (see Chapters 1 and 3).

Communication – wide and effective

Three key principles continue to drive effective communication across the Lake Eyre Basin: maintenance of good stakeholder relationships; active fostering of shared responsibility; and acknowledgement that people and place are inseparable. The Lake Eyre Basin, like all large river basins in the world, has a diverse mix of communities with wide ranging values and aspirations. Effective communication needs to operate over more than 1500 km, where population density is only one person/20 km^2. This remains a challenge.

The community and science advisory committees have met more than 30 times since the commencement of the Lake Eyre Basin Intergovernmental Agreement to discuss local and Basin-wide issues and provide recommendations to communities and governments. These regular, funded gatherings, open to interested observers, are touchstones of community 'reality check' and scientific rigour, providing forums for new ideas, problem solving and raising key issues requiring collaborative community and government attention. Meetings have typically been held in different locations around the Basin, allowing members to learn about and share in the challenges of managing such a large river system. However, uniting the community for the protection of one of the world's great river systems remains a complex and costly endeavour.

Over the decades, news of potential threats has been rapidly communicated throughout the community, and governments have been held to account for policies and legislation which did not reflect the broader community vision of river protection. There is particular vigilance about the potential impacts of water resource development on the rivers' precious resource, water. Any extraction has implications for downstream ecosystems and communities. Advisory groups have critically reviewed the water planning and protection measures of different states, consistently highlighting the values and importance of the rivers of the Lake Eyre Basin, and criticising the Liberal National Queensland Government (2012–15) for weakening river protections and promoting irrigation (see Chapters 17, 20 and 21; Table 7.1). The original scientific workshop in 1996 at Windorah and other key conferences have maintained strong pressure on governments, including the Windorah floodplain graziers conference in 2008 and the Lake Eyre Basin Under the Spotlight conference in Longreach in 2013 (Table 7.1). Diverse and effective communication, built on more than three decades of collaboration and trust, was essential for all processes. Communities of the Lake Eyre Basin have used these cohesive communication networks to actively influence government decisions and policies.

In 2000, the magnificent 'Heart of Australia' Lake Eyre Basin poster, with a map of the Basin and its people and environments, became the centrepiece of a carefully planned and well-executed awareness-raising program (http://www.lakeeyrebasin.gov.au/resources/maps). It created a powerful sense of place for people, conveying compelling messages about the Basin's unique landscape features, catchment connectivity, cultural assets, environmental values and land uses. Its publication signalled the start of broad, sustained, formal communication within and beyond the Basin, well supported by the Intergovernmental Agreement. The poster adorns nearly every roadhouse, pub or tourist information centre in the Basin, generating continual interest and conversation about the Basin and its people. The popularity of the poster has seen it updated and reprinted twice since its first release. Many other communication initiatives have since served to increase community awareness of the unique values of the Basin. The *Lake Eyre Basin People and Passion* project includes evocative short films from the heart of Australia (http://www.dcsolutions.org.au/showcase/#&panel1-1), made possible by a collaboration between the Ministerial Forum's Community Advisory Committee, Desert Channels Queensland and Territory Natural Resource Management. The films feature over 20 distinctive characters of the Basin – pastoralists, botanists, Indigenous rangers, ecologists, Traditional Owners and tourism operators. Their inspiring stories tell of personal passion and drive to care for the Basin's rivers, wildlife and floodplains. As well, the Australian Broadcasting Corporation featured the floods of 2010–11 in a magnificent television documentary, followed by a book (Lockyer 2012) showcasing the Basin's people and communities, spectacular landscapes, desert wildlife and the often dramatic and unpredictable natural cycles of life in the Basin.

A poster titled *Lake Eyre Basin Aboriginal Way*, featuring images, maps and quotations about the enduring connection of Aboriginal people to the Basin and its rivers, was published in 2017. The culmination of extensive and respectful engagement of Aboriginal groups from across the Basin, this was arguably a ground-breaking communication project with few parallels in Australian catchment management.

Championing future sustainability of the rivers

Scientific understanding about the ecological values of the river and the Basin has continued to increase, as has awareness of the impacts of water resource developments on communities and ecosystems in other inland river basins. Rigorous science over three decades has produced a deep understanding of the boom and bust cycles of the rivers, while the Lake Eyre Basin Rivers Assessment tracks the condition of the rivers. Regional bodies (Fig. 7.2a) have focused on land management programs, in particular the control of invasive species, as well as community education and engagement. There will be increasing pressure on governments and communities to develop the rivers of the Lake Eyre Basin (see Chapter 22), even if this is through indirect impacts such as mining exploration and development (see Chapter 19). The history of Lake Eyre Basin partnerships has taught us that government policies can easily change in favour of development, with individuals willing to promote such approaches (see Chapter 17). Policy settings and legislation in Queensland relating to water resource management are crucial, as this is where most of the river flows in the Lake Eyre Basin originate (see Chapter 20). Until clear legislative and policy frameworks are in place to protect the rivers, river flows will remain vulnerable to development.

At a local and basin scale, there is increasing impetus for focused monitoring, targeting objectives related to management. It is no longer sufficient to simply understand environmental values – our growing scientific knowledge must influence management. To this end, governments of the Lake Eyre Basin endorsed a new Strategic Adaptive Management framework for the rivers in 2010 (Table 7.1). This framework involves a rigorous process where values inform a vision which can then drive development of a hierarchy of objectives linked to monitoring and science (Fig. 7.7; Kingsford *et al.* 2011;

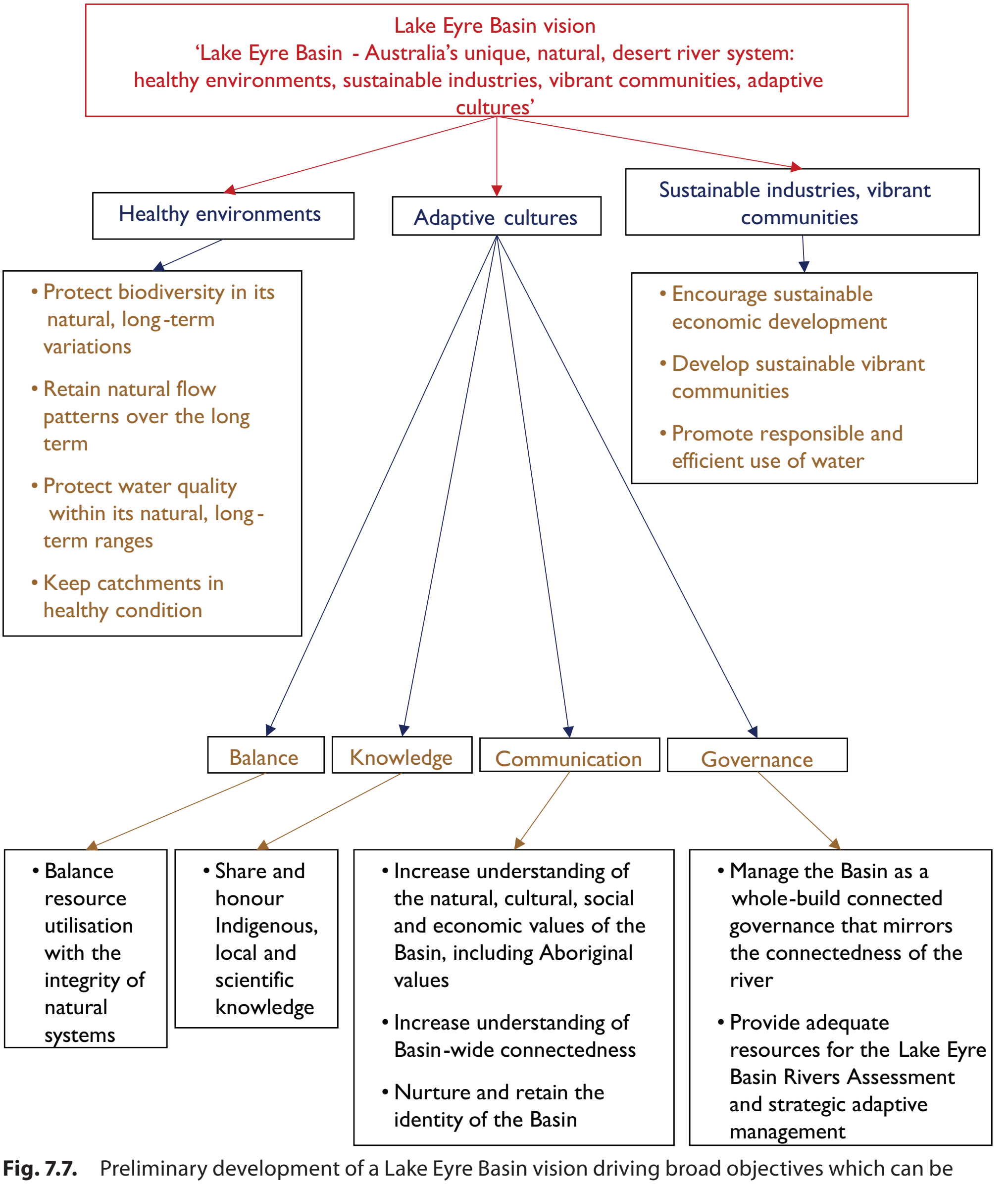

Fig. 7.7. Preliminary development of a Lake Eyre Basin vision driving broad objectives which can be further developed at the local scale with specific measureable objectives. Linked to monitoring and management, the objectives were developed through extensive consultation via the formal structures of the Lake Eyre Basin Intergovernmental Agreement process (Fig. 7.2b) (adapted from http://www.lakeeyrebasin.gov.au/sitecollectionimages/resources/87758eea-58f4-40fd-a0c6-615a0319d385/files/leb-ministers-report-2013.pdf).

Kingsford and Biggs 2012). It aims to provide explicit objectives at the fine scale, linked to a Basin-scale vision and informing on-ground management with continuous learning and scientific evidence. To our knowledge, implementation of this framework has never been attempted at the scale of an entire river basin elsewhere in the world. A small-scale trial of this approach is underway in the Coongie Lakes region in South Australia, using funding from the International Riverprize.

Most importantly, the Strategic Adaptive Management approach engages stakeholders in management and the environmental indicators relevant to management, linked to an overarching vision. This provides the template for exploring trends in indicators and the potential need for management intervention, followed by assessment of management success. This critical framework began through the development of visions by different organisations within the community (e.g. catchment management committees and regional natural resource management bodies). The Community Advisory Panel and Scientific Advisory Panel then integrated these visions to develop a working vision for the entire Lake Eyre Basin, reflected in coarse-scale objectives (Fig. 7.7). The progressive implementation of Strategic Adaptive Management will be far reaching, linking visions and objectives to actual monitoring and management. It provides the opportunity for governments and communities to improve the value of their investments in the management and monitoring of Lake Eyre Basin rivers, and to report the outcome of management actions.

The vision (Fig. 7.7) formally recognises the uniqueness of the Lake Eyre Basin and its values. It specifies the free-flowing status of this natural desert river system. The social, economic and environmental dimensions are captured, recognising the industries and communities so important in sustaining a large and complex socio-ecological system. It also specifies what is critically important – Lake Eyre Basin rivers need to remain healthy. Industries need to respect this by ensuring they are sustainable. There is an increasing need to also understand the importance of ecosystem services delivered from natural cycles of the river system to the economy and to the social and cultural aspects of people's livelihoods. Equally important is a clear understanding of the potential costs of water resource developments on this unique environment and its people (see Chapter 18). And our communities need to maintain their vibrancy and ability to engage and interact in this harsh climate. The incredible natural variability of the Lake Eyre Basin and its rivers imposes adaptation on all pursuits, people and industries. 'Adaptive cultures' describes not only the willingness of the people of the Lake Eyre Basin to embrace change, but also the importance of effective partnerships and communication, and a commitment to adaptive management, where knowledge is underpinned by clear objectives and the best science.

Conclusion

The story so far for the Lake Eyre Basin rivers and their communities is one of these communities driving the future. There have been challenges and failures, but the partnerships in the Lake Eyre Basin generally remain committed to the sustainability of the rivers. 'Prevention is better than a cure', in relation to the impact of water resource development, has been a strong and consistent theme of the last three decades of Lake Eyre Basin community partnerships.

Communities and their governments continue to articulate the importance of protecting the natural flows of rivers in the Lake Eyre Basin. Echoed in the Intergovernmental Agreement, this goal is reflected in relevant water plans and environmental protection measures from the Basin to the local scale, including in the Cooper Creek Water Resource

Plan, the Coongie Lakes Ramsar Management Plan, and the now revoked Wild Rivers legislation. Future sustainable management of the rivers of the Lake Eyre Basin remains fundamentally in the hands of the people who care about this unique environment – the Lake Eyre Basin champions – and in their ability to influence their governments to protect the unique cultural and environmental values of the region.

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8

Looking after the rivers – a view from nearly 50 000 years of experience

Scott Gorringe

Introduction

Many people who come to visit this country, the Lake Eyre Basin and its rivers, for more than one day gain a connection to it. Multiply this feeling of connection over 50 to 100 years and talk to families who have settled in the Channel Country and you appreciate their love of this country and its waters. Now I challenge you to imagine almost 50 000 years of connection and cultural obligation to a land (Tobler *et al.* 2017) and tell me that's not significant. Connecting with this country makes you feel responsibility for it and its waters.

Many of us care deeply about this country and its rivers. It feels good to have a responsibility and an obligation that's bigger than you. I belong to the Mithaka people. Our mob are the Kurrithala Tjimpa (Black Hawk) and our country is bordered by Cooper Creek (east) and the Diamantina River to the west. Kirrenderri is what we call this country, but now it's called the Channel Country. Mithaka people feel it's not only our right but it's also our responsibility to look after the country and its rivers. Wahlduru is our name for the three rivers, the Cooper, Diamantina and the Georgina Rivers, which may be different to the names given to them by other Aboriginal mobs in this region. My mob has been connected continuously to country and its waters for tens of thousands of years. I believe that I have approval to speak on behalf of these waters and this country. I have a responsibility, a right and an obligation to do this. I grew up on the Cooper; that's where I learnt to swim, near the bridge on the Cooper near Windorah (Fig. 8.1). Most of our Christmases and all of our school break-ups were on the river. We drink the water out of the Cooper.

These rivers and this country sustained thousands of peoples over tens of thousands of years. They provided food and water for us, as well as food and water for our food – the mussels (Fig. 8.2), fish and birds. And they are also the sites of our birthing places and our resting places. These are strategically scattered across the country, not far from water. Along these waterways, you will find the foundation of our stories: Mowana (budgerigar), Multhuri (pelican), Magwiri (stork), Miljoori (spoonbill), Munkerran (white ibis) and many more. They represent our families, the names for our clans and language groups, all of which inform us of our place in this country.

All along these iconic rivers, you will find the foundations of our stories; they either start or end at the significant waterholes. The stories connect us all the time and help us to remember the ways that we are supposed to be. These same stories informed a people for thousands of years. They continue to form the bases for our governing laws and our

Fig. 8.1. Cooper Creek waterholes near the bridge at Windorah where we used to swim and I grew up (photo, R. T. Kingsford).

Fig. 8.2. Aboriginal people are connected to the rivers of the Lake Eyre Basin, reflected in our history everywhere, including this enormous midden of mussel shells near Coongie Lake on the Cooper (photo, R. T. Kingsford).

relationships, and they connect country and water to the people and maintain our way of being. These stories include the wood duck, the pelican and the famous two-boys story.

The rivers were also our trading routes where we met, shared with, and learnt from neighbours. The rivers of the Lake Eyre Basin give us our swimming holes, our fishing holes and our camping places, and they provide a haven for us to go when we need to reflect and reconnect. These waters are the basis for the strong relationships between land, plant, animal and humans over thousands of years.

My journey so far – looking after the rivers

Of course, throughout my childhood I was intimately connected with the rivers, through my experiences and the stories of my family. Most recently, I became engaged with the governance of the Lake Eyre Basin rivers, through my membership of the Lake Eyre Basin Community Advisory Committee (2009–12) (see Chapter 7). I then spent nearly two years (2010–13) on the Queensland Government's Wild Rivers Advisory Panel, negotiating an agreement to protect these rivers under Wild Rivers legislation (see Chapters 17, 20 and 21). I worked with passionate and committed people from all walks of life, including government officers, pastoralists, environmentalists and scientists, who are still with us on this journey. It was a privilege to work with them to develop long-term, sustainable and equitable protection for this country and its rivers. All relevant stakeholders on the committee agreed and in good

Fig. 8.3. About 70 Aboriginal people attended the Aboriginal Forum in Tibooburra in 2011, where we discussed the future of the rivers of the Lake Eyre Basin, identifying some powerful initiatives to pursue (Tables 8.1 and 8.2, photo, M. Turner).

Table 8.1. Themes and relevant resolutions from the 4th Lake Eyre Basin Aboriginal Forum, held in Tibooburra on 13–15 September 2011.

Themes	Resolutions
Science and management	Allow transfer of information across the Basin
	Share outcomes and learnings
	Increase the communication of progress and outcomes
	Lists of project work to be published, distributed and updated
Extractive industries and groundwater (esp. coal seam gas)	Fully funded Lake Eyre Basin Rivers Assessment (LEBRA), including groundwater
	Consultation and participation of communities, including Traditional Owners (selected by Lake Eyre Basin Traditional Owners)
	Reliable, updated information system with public access
	High level of recognition of risks associated with extractive industry
Traditional ecological knowledge	Share and teach traditional ecological knowledge using new technology and on-country, on-ground activities
	Respecting and honouring through consultation and networking
	Lake Eyre Basin or national policy on traditional ecological knowledge and water research
National Centre for Aboriginal Water Research	Link science to traditional ecological knowledge
	Integrate into national policy agenda to ensure policy outcomes for all
	Consider groundwater and surface water as a connected resource
	Provide credible evidence to support/raise profile of cultural knowledge to inform/guide national and state and territory policy
	Aboriginal water allocations – to provide water for cultural, social, economic purposes determined by Aboriginal people
Cultural water and land management plan, Lake Eyre Basin Authority – sustaining the effort	Co-management of Lake Eyre Basin (e.g. through a unified management authority for the Basin); support current Lake Eyre Basin as a Ministerial Forum initiative
	Dual leadership/management by Aboriginal people and community – including a power of veto over unwanted development
	Tied to an action plan which is outcome-oriented and brings solutions to problems

faith signed a formal agreement to protect the rivers under the Bligh Labor Government's Wild Rivers legislation. The agreement would result in protected areas and protect these rivers and their community, including the economic, cultural and environmental values.

Aboriginal engagement focused in 2011 at an Aboriginal forum in Tibooburra when ~70 Aboriginal people from across the Lake Eyre Basin met to discuss the future of the rivers (Fig. 8.3). Over three days, we agreed on some powerful directions for the management of the Lake Eyre Basin and its rivers (tables 8.1 and 8.2). We identified key themes, resolutions and activities (Table 8.1). For science and management, we needed to see the transfer and sharing of information and to be informed about what projects were underway and how we could be involved.

In relation to extractive industries, we believed that the Lake Eyre Basin Rivers Assessment was critical and that the development of extractive industries should be done in

Table 8.2. The Tibooburra Resolution, consisting of an eight-point declaration from the 4th Lake Eyre Basin Aboriginal Forum, held in Tibooburra on 13–15th September 2011 on protection of rivers in the Lake Eyre Basin by Wild Rivers legislation in Queensland.

Resolutions
1. Declare the Cooper Creek, Georgina and Diamantina Rivers as Wild River Areas under the *Wild Rivers Act*.
2. Commit resources for Traditional Owner rangers in the three river basins under its policy to deliver 100 Indigenous Wild River rangers; starting with five rangers (including ranger coordinators) for each of the three river basins – 15 Indigenous rangers in total.
3. Support and resource an Aboriginal organisation which reflects their governance structure to oversee the Wild Rivers Rangers program within the Cooper Creek, Georgina and Diamantina Rivers for the Aboriginal Traditional Owners of these water systems.
4. Incorporate water allocations under each Wild River declaration for Aboriginal water allocation for Traditional Owners to decide its use.
5. Maintain the Aboriginal heritage and cultural landscapes of the three Wild River areas, by supporting management in accordance with the Aboriginal traditions and customs for the areas (joint management).
6. Exclude coal seam gas and shale gas projects, along with other mining and resource extraction, from the High Preservation Areas and Special Floodplain Management Areas; and regulate coal seam gas and shale gas activities in the Preservation Areas.
7. Ensure sustainable pastoral activity in the Wild River areas by committing land protection officers to monitor and restrict overstocking.
8. Call on the South Australian/New South Wales/Northern Territory governments to support the protection of the Lake Eyre Basin region with a commitment to a Wild River-type legislation.

collaboration with Traditional Owners. There was also a strong emphasis on the importance of traditional knowledge and its role in informing decision-making, as well as linking into a National Centre for Aboriginal Water Research. For management, we wanted to see co-management arrangements, including the establishment of a Lake Eyre Basin Authority focused on solutions to problems (Table 8.1). We also developed an eight-point declaration, related to Queensland Wild Rivers legislation, known as the Tibooburra Resolution (Table 8.2). This was provided to all political parties in Queensland, emphasising our commitment to protect Cooper Creek, the Georgina River and the Diamantina River, as wild rivers.

The Liberal National Party Government in Queensland (2012–15), at the time, led by Premier Campbell Newman, was no longer committed to Wild Rivers and chose to ignore us. The Liberal National Party made three contradictory election promises: retain, renew and then revoke the declaration of Wild Rivers. They 'shifted the goal posts'. The Liberal National Party Government instead established a new advisory process, forming the Western Rivers Advisory Panel (see Chapter 20), ignoring the fact that the Wild Rivers legislation consultations had finished and all parties had agreed. The new advisory process opened it all up again, allowing potentially vested interests to change the original agreement. I was not invited to be on the new committee. The new committee had virtually the same interests although notable absences of representation of South Australian or environmental interests. This committee was given quite different political riding instructions. They were told to allow irrigation and to 'ditch' the Wild Rivers legislation and its declarations for the Channel Country rivers and come up with something new. It was a complete waste of time and money, and served only one purpose – revocation of the Wild Rivers legislation by the Liberal National Party.

It also devalued the work of dedicated people who fought to protect these rivers. Most disappointing, the government abused its powers, choosing to ignore and disengage with people who thought differently about sustainability. It pandered to a small vocal pro-development lobby and adopted an ideological approach to the development of the rivers, favouring the march of exploration and development of gas resources. Nobody talked to me about what I thought and in fact I was actively disengaged by the Liberal National Party on this issue, perhaps because of my publicly vocal opposition to development at the expense of the rivers. I am angry, frustrated and cynical with people in positions of power, particularly politicians for abusing their power to drive their own agendas. They are supposed to be governing for people like me as well.

The results of this advisory process came in, with predictable results and consequences. Sadly, the recommendations, while protecting the rivers to some extent, allowed development of existing sleeper licences (water) for small-scale irrigation and did not completely protect these rivers (Western Rivers Advisory Panel 2013) in the same way that the Wild Rivers legislation did (see Chapters 20 and 22). It opened up potential for development of the floodplains by oil and gas interests which may affect floodplain flows (see Chapter 22). The Newman Government ignored due process, the community and expert advice. We must continue the fight to protect these three rivers from the creeping insidious irrigation development that has killed off the rivers of the south in the Murray–Darling Basin, the dollar driven coal seam gas (CSG) operators and the government/mining alliance who abuse their power in order to push their own agendas. It could be said that some governments (at all levels) utilise mining (for infrastructure) to avoid their responsibilities to regional communities.

Of most concern is the 'watering down' of protection measures for floodplains and major tributaries that were in the Wild River declarations (see Chapter 21). These allow for developments of critical areas, including the potential establishment of oil and gas exploration platforms and infrastructure which could affect the flow patterns of the Channel Country (see Chapter 19).

In 2013, the Minister for Natural Resources in Queensland, the Honourable Andrew Cripps, advocated that small-scale irrigation could bring jobs to local communities in western Queensland (http://www.abc.net.au/site-archive/rural/qld/content/2013/02/s3685477.htm). It doesn't matter how big or small the irrigation is – it takes away water used by the river downstream and on floodplains. With small-scale irrigation, there are licences that can be bought, sold and traded, potentially driving up development as in the Condamine–Balonne (see Chapters 14, 15 and 21). The relaxation of protection measures opens up the potential for mining to impact on these rivers and their floodplains. I'm not against mining or progress. Yet I am against development at the expense of country and its waters. Such decisions by governments are dangerous and irresponsible to our country and its waters – one that we have been responsibly managing for a long time.

Let's please learn from the past. Look around the world. Look in our own backyard at the Murray–Darling Basin. We have had to spend billions of dollars trying to sort that system out because it was over allocated for irrigation. We (Lake Eyre Basin Traditional Owners) are all frustrated because we worry about the future of these rivers, the future of this region. Strangely enough, the very reason driving the economic sustainability decisions could very well destroy this region. What I, and many others, believe is that this region needs the water flows, as well as their pristine qualities, to remain as they are to ensure economic sustainability. The removal of the Liberal National Party from power in January 2015 provided us with a new opportunity to reclaim sustainability for these rivers and revisit the public policies that gave them protection, particularly the Wild Rivers legislation. In recent years, the political arguments about Wild Rivers legislation have been dominated by the views of Aboriginal leaders in northern Queensland. If Aboriginal representatives in northern Queensland desire something different to us, then we support their vision, as I would hope they would support ours. These two regions are vastly different in all aspects: culturally, economically, environmentally and socially. We Aboriginal representatives of the Channel Country have a different view. We believe that the Wild Rivers declaration for the Lake Eyre Basin rivers protected these rivers for future generations, reflecting our people's custodianship for tens of thousands of years. As well, it enables us and others to engage in development activities in this region while significantly reducing the chances of the destruction of these important waterways.

Culturally the waters of the Lake Eyre Basin are highly significant to all our 'mobs' across the region and downstream. The Dierri, Wonkamurra, Wangkumarra and the Boothamurra mobs down towards Kati Thanda-Lake Eyre are worried about what Queensland can do to the rivers that flow down to the lake or 'Mowana', as Mithaka call it. The Dierri call it Kati Thanda, a name officially recognised in 2013. Mowana is the budgerigar. Our people have known forever that when Mowana were many, the water reached Kati Thanda-Lake Eyre, and the season would be good and food plentiful.

Conclusion

In the recent period of Liberal National Party Government in Queensland, policies and management were focused on mining, leading towards potentially destroying this magnificent natural system. New government regimes will take power and there will always be a constant turnover of governments with new agendas, but they all need to recognise that the people of the Lake Eyre Basin want to protect our rivers for future generations. These rivers are more than just a resource for making money. They are significant to this country as its birds, animals, its people and their stories and dreams depend on the rivers. And it doesn't matter what colour you are. Just the thought of someone wanting to destroy this unique, iconic river system, which is really significant to this region, this state, the country and the world, is crazy. I can't understand it. We Lake Eyre Traditional Owners want developers to back away from this country and our waters, if they are contemplating anything that threatens these magnificent cultural and environmental values. We do not want irrigation or gas that will destroy our country and its waters. As long as these rivers are okay, we're okay.

Finally, let's get more sophisticated. We can create jobs through the protection of these rivers, not through the destruction of them, and we can build a sustainable future for ourselves and our environment, one that Aboriginal people have maintained for tens of thousands of years. It's been our obligation for millennia to look after these waters and not to harm them. Governments may have taken away our rights and responsibilities for other things, but they are not taking this responsibility from me. I grew up on Cooper Creek and I know its future depends on the free-flowing water that comes down. We have a collective obligation to keep the Lake Eyre Basin rivers safe.

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9

Caring for our sacred waterways – learning from our past

Colin Saltmere

Introduction

I am one of the Indjalandji-Dhidhanu people from the headwaters of the Lake Eyre Basin catchment, at the top of the catchment of the Georgina River. My father was an Alyawarr man. He was born under a sacred tree at Lake Nash (Alpurrurulam) on the Georgina River (Fig. 9.1). My mother's mother's tribal name was Marrarru, the name of a Dreaming that passes through the country where she was born, on Barkly Station. This is also the name of a tree on the Georgina River near Camooweal. The Indjalandji-Dhidhanu people are the Traditional Owners of our country; our custom holds our law for that country. And part of our law and my ancestral line is rain-making. My grandmother's brother and my great-grandfather before him were both rain-makers. They used to meet with the Alyawarr men,

Fig. 9.1. The Georgina River catchment flows south of Mt Isa to join Eyre Creek and eventually the Diamantina River, south of the town of Birdsville and along the way supplies incredible floodplains and lakes. The Georgina River has many culturally significant sites for Traditional Owners, up and down the river and its floodplains.

from the Sandover region, near Ampilatwatja and Amaroo, and also with Waanyi and Kalkadoon men, for ceremonies. Their ceremonies were held all up and down our river. Some were near Urandangie, downstream from Boundary Gully. One corroboree travelled with our people from Camooweal, down the Georgina River, across onto the Hamilton River and finally onto the Diamantina River. A few elders still carry on the ceremonies today. These ceremonies are designed to maintain alliances and religious customs.

Our people first met the Europeans in the early 1860s. This was graphically described by John Sutherland, the first European settler through our country, who brought 8000 sheep to the Georgina at Lake Mary in 1864 (Sutherland 1913). He was aiming to graze them on what is now Rocklands Station. After droving, over the dry country, he arrived at Lake Mary. The sheep smelt water and charged at the river where our mob was camped, with their campfires. This European and his sheep scattered my people. Big droughts followed, through to 1869, and there was inevitable conflict over access to water between my people and the settlers (Dugalunji Aboriginal Corporation 2015). Our stories tragically reflect this troubled history. My mother's grandmother lived through the struggles, telling her story to my mother, who was a little girl. Her family and tribe were attacked and bayonetted by troopers at Louie Creek at Lawn Hill (Roberts 2005, pp. 233–234). Many died but my great-grandmother managed to flee. Conflict erupted everywhere. My people retaliated to save their precious drinking water, by spearing cattle that were dying and polluting all the waterholes. This is a history inevitably tied to water in this dry country. It is not surprising that our people care so much about our precious water resources (see Chapter 8).

The rivers

The rivers were the trade routes between tribes living in the Lake Eyre Basin and elsewhere. The Georgina River was one of the biggest trade routes in Australia as Aboriginal people moved shells from the Gulf and Arnhem Land all the way into South Australia. The stimulant, pituri, was also a highly sought after commodity, derived from the leaves of the corkwood tree (*Duboisia hopwoodii*). Around Carlo Station near Boulia, the most potent pituri produced from the plants grew in the sand hills. It was mixed with the best ashes along the Georgina River to make a highly valuable commodity which was fought over and traded for ochre and chisel blades, up and down the river.

The Georgina River has enormous cultural significance with sites ranging up to 10 km on either side of the river and all along it. It provides ecosystem services in the form of our bush foods, such as freshwater fish, mussels and plants such as water lilies (*Nymphaea georginae*) and nardoo (*Marsilea drumondii*) (Dugalunji Aboriginal Corporation 2012). We Traditional Owners remain concerned about modern demands on these rivers, particularly from pastoralism, tourism, feral animals, weeds, erosion and sedimentation. Tourists are increasingly coming to this country, seeking out this wild and magnificent place (Schmiechen 2004), but they need to be managed. They also need to appreciate the system's cultural and environmental values. Ignorant, careless and thoughtless tourists can damage the river banks and vegetation and pollute the rivers with litter and waste. For example, the fascination with campfires can mean culturally significant trees, with scars made by our people, are cut down.

Invasive species are an ongoing problem. Recently, red claw crayfish (*Cherax quadricarinatus*) invaded the Georgina River (see Chapter 3), muddying the waters and proliferating after the 2009 floods. We run an Indigenous ranger program, involving rangers who tackle weeds and feral animals throughout the Lake Eyre Basin. The impact of livestock on our waterholes also represents a continuing problem. Feral pigs and cattle can degrade vegetation and the banks of waterholes and pollute them with their waste. By working with local pastoralists, we have had some success in restricting access by cattle to the river beds near Camooweal.

Our underground rivers

Few people in the Lake Eyre Basin or the rest of Australia know of the amazing underground rivers in the Georgina River catchment, including Nowranie Creek. Camooweal Caves National Park (Wiliyan-ngurru) has an extensive network of caves (Fig. 9.2), connected by sinkholes, formed when water over millennia has dissolved the dolomite deposited by ancient seas ~550 million years ago. Our stories tell us the caves were created by a giant ridge-tailed goanna (*Varanus acanthurus*) that used to live there – the ancestor of the resident monitor lizards. The caves fill with water during the wet season, creating one of the bigger underground river systems in the world, stretching for 36 km and 150 m deep. There are ~180 sinkholes, from Alpurrurulam (Lake Nash) in the south, right up to where the Gregory and Georgina Rivers meet in the north. Special animals have adapted to this cave life. For

Fig. 9.2. The underwater tunnels inside Great Nowranie Cave, in the Camooweal Caves National Park, in the Georgina River catchment, a sacred place for Traditional Owners, where sustainability is vulnerable following revocation of Wild Rivers legislation in Queensland (photo, Liz Rogers).

our people, the sinkhole complexes are sacred sites. These cave systems catch, hold and filter the underground water that we all rely on in the Barkly Tablelands. The revocation of the Georgina River/Diamantina River Wild River declaration (see Chapters 20 and 21) has made these systems particularly vulnerable to the increasing interest in petroleum and gas exploration (see Chapter 19).

Our history and engagement

Our people are documenting the cultural and environmental values of these magnificent surface and underground river systems. This includes capturing how they change with dry and wet seasons. We are training the next generation of Aboriginal people, providing them with the skills and qualifications to work in construction, mining, and land and water management. The mining industry employs many Indigenous people, providing an opportunity to educate our people about country as well as a source of employment. We provide basic skills training, but also focus on imparting cultural knowledge and an understanding of the importance of Aboriginal religion, culture, and traditional methods of land and water management. Our Indigenous land and sea rangers are increasingly deployed in our national parks.

Conclusion

There is a sad and long history of conflict, often over water, between our people and European settlers. We don't want to fight again over water; these wonderful rivers below and above the ground are irreplaceable. We need to work together and look after them. We need to listen to Traditional Owners of the country and their knowledge of how the rivers work and their deep cultural significance. It is incumbent upon us to find ways to protect the cultural and environmental health of the rivers of the Lake Eyre Basin, now and into the future.

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10

River sustainability – essential for the livelihoods of landholders

Angus Emmott

Introduction

The people involved in the management of the Lake Eyre Basin are among the most dedicated and united in their commitment to the long-term sustainability of these magnificent rivers (see Chapter 7). They come from many walks of life with a common purpose: to protect and sustainably manage these river systems. Sustainable management began with the first people, establishing 17 Aboriginal language groups across the Lake Eyre Basin. Landowners, like me, followed later and now live along the rivers of the Lake Eyre Basin. There are others who live outside the Lake Eyre Basin, sometimes regarded as not having such a strong stake, who also care deeply about the long-term sustainability of these magnificent rivers. These include the non-government organisations, government organisations and scientists (see Chapters 7 and 17). From a local's point of view, we owe a great debt to all these contributors to the debate about the future of this great river system. All these people have brought their experience and deep love of country to their commitment to protect the rivers and not make the same mistakes as were made for many of the world's rivers and wetlands (Kingsford *et al.* 2016).

My family lives on the Thomson River (Fig. 10.1), south-west of Longreach. The river flows southwards, joining with the Barcoo River to become Cooper Creek, the world's largest creek. The Lake Eyre Basin also has the Diamantina and Georgina Rivers and a host of other small rivers across western Queensland, which can eventually flow through to Kati Thanda-Lake Eyre in South Australia. My family has lived in this landscape since my grandmother drew the property in a ballot in 1915, as part of the scheme to open up the larger 'super properties' to more families, encouraging settlement in these rural areas. I am the third generation of my family to live on this land, following the original Aboriginal custodians. We rely on the floods from the rivers for our livelihood, with large areas of floodplain on the property. The floods bring nutrients and water, which stimulate pasture growth on which our cattle thrive. I love this country and its range of different habitats. My other great interests are the ecology of this land and its rivers, and the flora and fauna that make up this ecosystem. These interests have provided me with opportunities to interact and work with scientists from many national and international institutions.

Lake Eyre Basin – a special place

The Lake Eyre Basin is a wonderful system for both the environment and the people. It covers about one-seventh of Australia where a comparatively small population supports a range of sustainable industries (Kingsford *et al.* 2014). The Lake Eyre Basin has places of

Fig. 10.1. The Thomson River flows through our cattle property to join the Barcoo River and form Cooper Creek. Booms in flows and floods bring the double bonus of improved grazing pastures for our livestock and an incredible boom in biodiversity, which is my passion (photo, A. Emmott).

huge significance to local residents, other Australians and internationally. We have some of the most incredible wetlands in Australia. The river is central to our life; it provides for all people and biodiversity along its length, right down to its end at Kati Thanda-Lake Eyre. These rivers keep the towns, tourism and the rural industries going (see Chapters 11 and 13), as all are reliant on the dividends delivered by the floods. Our beef industry works on the basis of taking livestock out when it's dry and bringing them in, following the wet season. Our rivers are among the most variable in the world (Puckridge *et al.* 1998; McMahon *et al.* 2008). In our Thomson River, the flow regime depends on rainfall patterns in the north-east of the Basin, determining our incredible cycles of 'boom and bust' (see Chapter 1). The booms come with big wet monsoon seasons that can extend down into the headwaters of our major rivers, the Georgina River, Diamantina River and, where we live, Cooper Creek. Cyclones are particularly important in producing large rainfall events, which then drive the flows in the rivers, pushing large pulses of water down the system and causing extensive flooding that triggers a wildlife boom. Unusually, our rivers decrease their flow as they progress down the catchment. They start in high rainfall areas and increase until they reach the large floodplains of the Channel Country and then decrease their flow (Knighton and Nanson 1994) because the floodplains act like a natural sponge.

It takes huge and rare rainfall events to produce enough waters to flood the 80 km-wide floodplain, south of the town of Windorah, called the Channel Country. These floods make it one of the best 'naturally irrigated' pastures in the world. For people depending on the

Fig. 10.2. Floods and small flows are critical in maintaining the triple bottom line for pastoralists living on the rivers of the Lake Eyre Basin. They replenish waterholes for drinking cattle and stimulate tremendous growth in floodplain pastures for the beef industry (photo, A. Emmott).

river and the large floods, we look to the north, knowing that it is not just one flood but sequences of floods which are critical (Puckridge *et al.* 2000) for the river to flow all the way to Kati Thanda-Lake Eyre. The boom periods are essential not only for the people living on the river, providing water and grazing for livestock (Fig. 10.2) and the flood-dependent living animals and plants, but also for the terrestrial ecology. Rainfall and flooding underpin the ecology of the deserts. During boom periods, there is tremendous productivity, triggering incredible breeding by animals, including reptiles, frogs and small mammals (see Chapter 6). Inevitable dry periods follow, such as those experienced in 2013–15, following extensive floods in 2009–11. Even in such dry periods, there are often small river flows, which are critically important for our livelihood and the ecology of these systems (Hamilton *et al.* 2005; Bunn *et al.* 2006). These flows top up the waterholes, providing environmental, social and economic relief from the long dry periods.

The future of the Lake Eyre Basin

The Lake Eyre Basin is remarkably unscathed by human impacts; it is in great shape (Kingsford *et al.* 2014). I like to describe it as pristine even though we know there are human impacts wherever we go (see Chapter 22). You cannot say this of many other rivers of the world. We've got rivers here that work and do not cost anything to manage. They're doing what rivers are meant to do. Compare this river basin with its cousin to the south-east, the Murray–Darling Basin – a system with serious sustainability issues (see Chapters 14–16).

Many people living in the Lake Eyre Basin have family or friends from the Murray–Darling Basin and so there is a good appreciation of its significant environmental problems, straining from over use. Far too much water was extracted from the Murray–Darling Basin. The problems started small and increased (see Chapter 15). A few people wanted to extract 'a little bit of water', often complaining that it was going to waste when it went past them. This was the history of the Murray–Darling Basin and the overdevelopment of its rivers. We have to do much better for the sustainability of the rivers of the Lake Eyre Basin.

We live on the world's driest inhabited continent, and water is scarce and critical. We need to be smart. Life out here in the arid zone of Australia is predicted to become even more difficult with climate change impacting Lake Eyre Basin rivers. The signs are clear as temperatures rise (Reisinger *et al.* 2014). Increasingly longer periods of high temperatures, above critical thresholds, are particularly concerning. Temperatures in March 2015 may be a portent of a grim future. We experienced one of the hotter autumn periods ever recorded, with temperatures exceeding 40°C for 20 consecutive days. Extreme heat waves during summer have killed birds, kangaroos and occasionally domestic pets in outback Australia.

The projections are for increasingly intense rainfalls, separated by long, dry periods (Greenville *et al.* 2012). This inevitably means either extremely high flows or long periods of low flows or no flow in the rivers. This has major implications for the last remaining waterholes in the Channel Country and in South Australia, which act as refuges (Hamilton *et al.* 2005). These habitats provide oases in a desert landscape for aquatic animals and also terrestrial animals. It is critical that we allow all floods to run unimpeded. Low flows can be particularly critical during the long dry periods (Bunn *et al.* 2006). For those of us who depend on the water of the rivers, it is going to be harder and drier, with potentially more intense floods but long, dry periods in between.

We have a collective responsibility for the sustainability of the Lake Eyre Basin. The management of the Basin has required a joint, cooperative approach between the states of South Australia, Queensland, the Northern Territory and the Australian Government. This is achieved through the Lake Eyre Basin Intergovernmental Agreement (see Chapter 7). It aims for cooperative management, focusing on maintaining naturally variable flow regimes and water quality which fundamentally underpin the health of these systems. It takes a precautionary approach to management. Over the past 20 years, we have had thousands of people involved in hundreds of meetings to give effect to this agreement. Community, industry and science have worked together to chart a sustainable path to the future (see Chapter 7).

Once again, there are multiple threats to this agreed future along the Lake Eyre Basin rivers, particularly from mining and irrigation (see Chapters 19 and 20). Many people believe that the Lake Eyre Basin is not suitable for these developments. Most people involved in advising governments about the Lake Eyre Basin over the last 20 years are committed to ensuring the rivers are not regulated or large amounts of water diverted. As with the Murray–Darling Basin rivers, talk is about a little bit of development (see Chapter 22), but history can have an unhappy habit of repeating itself.

As someone who loves this river and depends on it, I don't accept that diversion of water from this river is sustainable to satisfy the greed of a few. It is unacceptable, given the importance of flows and our collective majority commitment to keeping this river flowing naturally. So we have a choice for the future of our rivers. We can treat them with the respect they deserve and have sustainable industries. Or we can take the greedy path and start destroying our rivers, affecting the sustainability of this unique river system and our future.

Conclusion

The Lake Eyre Basin is an amazing place, but it is also fragile because it is so dry. We depend on the river and its natural flow patterns for our long-term sustainability. It is our life support system. Ultimately, the 'triple bottom line' depends on maintaining the ecology and building a strong society and economy, supported by sustainable ecosystems. Without the natural flows, we will not be able to support our sustainable organic beef industry, wool and ecotourism throughout the Lake Eyre Basin. We cannot afford to develop the rivers of the Lake Eyre Basin – they are our triple bottom line.

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11

Clean green beef – the importance of free-flowing rivers in the Lake Eyre Basin

David Brook

Introduction

My wife Nell and I, with our family, own and operate 30 000 km^2 of certified organic farms for beef production in the pristine Channel Country, on the floodplains of the Georgina and Diamantina Rivers. The floodplains, covering ~50 000 ha, are the most productive part of our properties (Fig. 11.1). The bush poet Colleen McLaughlin beautifully captured the essence of our Diamantina country as well as our lives and sentiments in her poem 'Song of the River' (McLaughlin 2006).

Song of the River – Colleen McLaughlin (2006)
I am swinging to the northward, I am curving to the south,
I am spreading, I am splitting, running free.
I am creeping past the sandhills, going steady as the land fills,
For all my channels lie ahead of me.
Through the grasslands and the mulga, past the rocks, eroded bare,
I will cover up the secrets buried deep.
For if man thinks he can beat me, I will tell him, come and meet me,
But the signs to show the way are mine to keep.
Because I'm Diamantina, and I rule the great outback.
I'm its heartbeat, I'm its keeper, it's my land.
With my channels full and flowing, and the grasses, green and growing,
I'm the power that man must learn to understand.
I will take your heart and hold it. I will commandeer your soul –
If you listen to my voice and stand up tall.
If you can hear me singing, and your answer comes back ringing,
Then I'll know that you have recognised my call.
For this is my direction, as the sovereign of this land,
You must learn to read the rhythm of its ways.
If you want to know and share it, do not take its heart and tear it,
For I'll tell you now – the loser always pays.
Listen hard – I'm Diamantina – and the sand hills and the plains
Need my water as their lifeblood – it's my land.
Should my channels cease their flowing, then with dusty, dry winds blowing,
I know you have not learned to understand.

Fig. 11.1. The incredibly productive floodplains of the Georgina and Diamantina Rivers are the lifeblood for our livestock grazing, with periodic flooding providing boom periods when we can produce prime quality organic beef for export (photo, R. T. Kingsford).

The river system

This is what this river means to us; we cannot do without it. We care for our land, the Lake Eyre Basin and the Channel Country rivers, and we manage these systems sustainably, generating an income but also looking after the country and its rivers. The rivers flow through inland Queensland to Lake Eyre and South Australia. With their expanding floodplains and adjoining fertile land, they have long been home to Indigenous families, outback settlements, towns and a highly respected cattle and sheep production industry. The big rivers flow south, taking their water from areas with high rainfall into our dry country (Fig. 11.1). Where we live, the Georgina, Burke and Hamilton Rivers join below the town of Boulia to become Eyre Creek. This spreads out into a magnificent expanse of floodplain. Further east, there is the Diamantina River, which flows past my hometown of Birdsville, and the Thomson and Barcoo Rivers join to become Cooper Creek, north of Windorah.

In 2006, our country was in the middle of one of our worst droughts in the last hundred years but, during March, Cyclone Larry crossed the coast of Queensland, devastating coastal settlements and agriculture. The cyclone then moved across northern Australia to the Georgina catchment where it rained heavily, producing a mighty river which made its way slowly south. This water gave much needed relief to all the cattle properties and the small towns, including Boulia, all the way to Kati Thanda-Lake Eyre. This water in the Georgina catchment reached our cattle property in the middle of May and filled Muncoonie Lake in early September. It still had about another 300 km to go to Kati Thanda-Lake Eyre, filling channels and floodplains along the way and providing nutrients. If this river's flow was diverted or changed, then the river would not reach all the places in the catchment it flows to now.

Livestock production

The famous Australian stockman, Sir Sidney Kidman, recognised the productivity of the rivers for cattle in the early 20th century and established a chain of stations along the mid to lower floodplains of these rivers where the country is most fertile. These rivers sustain Indigenous Australians (see Chapters 8 and 9) and the animals and plants they have relied on for tens of thousands of years (see Chapter 1). My family and many others have followed this productive path in the footsteps of Kidman. I was brought up on one of these properties. Following the early explorers, small settlements and livestock production were established along these rivers. The next wave arrived when access roads were opened up and visitors began to experience the outback.

In the early 1990s, Prime Minister Paul Keating declared an intention by the federal government to nominate the Lake Eyre Basin of South Australia as a World Heritage site (see Chapter 7) and we were advised that grazing would not be permitted. An intense period of political lobbying followed, finally defeating the initiative. This galvanised the community. We needed to demonstrate that we were good stewards of the Lake Eyre Basin rivers, receiving benefits from this amazing environment but also managing for sustainability (see Chapter 7). Food and water are among the most important issues of today and we rely on both. We produce high-quality beef from our cattle, relying on the floods that produce a 'boom' in the pasture. Our production faces challenges, particularly the 'boom and bust' nature of our country and the long distances to our markets. In 1995, a group of cattle producers formed the Organic Beef Export Company and focused on marketing our sustainable production as 'clean and green'. We began production in 1998, producing ~10 000 kg a week, and today we have increased eightfold, producing 80 000 kg per week, from 15 properties covering 6–8 million ha, mostly in the Lake Eyre Basin.

We focus strongly on sustainable cattle production (Fig. 11.2). We have no need for and do not use growth promotants, drenches for parasites, fertilisers or supplementary feeding. We are officially certified as organic. We also look after our cattle on the way to their markets, feeding them organic hay during resting stops. We avoid overgrazing of our country by shifting our cattle away during the dry times so that vegetation can recover quickly after rains. This continues to pay dividends. Our organic product commands an extra 50 cents a kilogram in the markets, generally 15–20% but sometimes as much as 50% above the market price. We have regular visits from our buyers, inspecting the sustainability of our operations. Certified organic beef is now an established line in supermarkets and hamburger chains in Australia and around the world. We export to Hong Kong, Japan, Korea, Malaysia, Middle East, North America, Indonesia, Singapore and Taiwan. Demand is far outstripping supply.

In Australia, organic beef production has nearly tripled between 2004 and 2012 (Monk *et al.* 2012), increasing by 127% between 2011 and 2014, more than doubling to be worth $198 million (Australian Organic Ltd 2014). I believe that in the future Australia will be the

Fig. 11.2. Organic cattle production from the floodplains of the Lake Eyre Basin rivers is a long-term sustainable industry which commands a premium but would be threatened by development of rivers and reduction in flooding (photo, D. Brook).

world's most important country for organic beef produce. Consumers choose to purchase organic products because they are chemical-free, nutritious and tasty. Organic products may provide children with their best building blocks for a healthy life, particularly pleasing for me as an organic producer. We also market the Channel Country of the Lake Eyre Basin, the people and tourism to the world. This concept is not new. The wine industry adopts a similar approach, marketing regions and wines in Australia, including the highly successful Hunter Valley, Barossa Valley and Margaret River. We can do more here in the Channel Country of the Lake Eyre Basin. We already have a good identity.

Sustainability

Resource degradation is increasingly an international, national and local concern. I liken our Lake Eyre Basin to the great natural icons of Australia; we need to look after it in the same way as we look after them. Think of Sydney's magnificent harbour with its bridge and Opera House, or Uluru. Damage to these national treasures would cause uproar and substantially affect environmental and economic sustainability, particularly tourism. The Lake Eyre Basin is an icon of our country and the world (see Chapter 7). It is a large area with a large range of values respected and exploited by people for generations. It has great rivers, cultural history and even the Great Artesian Basin, one of the world's greatest underground water sources.

The Lake Eyre Basin has oil and gas resources (see Chapter 19), bush tracks, wildlife and blue skies that draw visitors (see Chapter 13). Wise use of these resources is essential if we are to benefit in the long term from this special environment. We have to plan well. The people of the Lake Eyre Basin are not demanding massive developments and so there should be no rush to exploit the values that are special to all of us. It is all about wise use. What is wise use? Is it measured in money or sustainability? High-value mining resources are generally extracted over a short period of time (see Chapter 19), whereas beef production and tourism deliver low to medium value over generations. All industries need to be sustainable with appropriate regulation to ensure there is no damage to the Lake Eyre Basin (see Chapter 22). We still want visitors from here, other parts of Australia and overseas to be able to experience the incredible diversity of our country for centuries to come.

Governments need to protect the values of the Lake Eyre Basin river systems, particularly the Channel Country rivers. It is critical that the rivers be allowed to flow uninterrupted, following their natural behaviour. Water management plans guided by scientific knowledge need to adequately protect the rivers (see Chapter 22). Downstream habitats and values cannot survive if we divert, diminish or corrupt the free-flowing nature of our rivers. This has allowed a clean and green livestock industry, our organic enterprise, to prosper in one of the drier parts of Australia. It has also fostered a tourism industry, which grows rapidly with improved access. When the great rivers flow to Lake Eyre, they bring unimaginable numbers of bird life and publicity to our region. We need to live in harmony with these values and demonstrate that our industries of livestock production, mining, tourism, towns do not degrade our great environment. All industries have to be clean and green, with a strong sustainability focus. We need to keep it this way.

Conclusion

The Lake Eyre Basin rivers are a long way from intensive agriculture and use of chemicals. The rivers and floodplains of the Channel Country are proving to be ideal for successful organic livestock production. Prices and demand have grown, allowing the industry to become increasingly environmentally and economically sustainable. We continue to brand our industry with this regional identity, also benefiting tourism. My plea is for wise use of our Lake Eyre Basin resources. We already have vibrant and viable agricultural and tourism industries. Those of us who live on the upper reaches of the Lake Eyre Basin understand our rivers. We know how important they are for downstream communities. We must not divert or diminish the volume and quality of water which flows naturally into Lake Eyre. The community in the Lake Eyre Basin can be a world leader in managing this amazing river system for future generations.

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12

A life living between a river and a creek

Leonie Nunn

Introduction

I describe what this river means – from my heart. Cooper Creek is an incredible system, sometimes a creek and other times a raging river. The Cooper is folklore in our home, reflecting the heroics of my father who 'swam' 600 bullocks across the flooded Cooper in 1949 on the Birdsville Track (Fig. 12.1). There was a cairn erected to mark this feat, as no one had done it for 30 years. My grandmother chided him about his celebratory photograph in the Adelaide Advertiser: 'at least you could have had a shave'. My childhood was also coloured by Tom Kruse the mailman, a legendary outback character, who linked our remote communities (Fig. 12.2). I remember going down to dry bed of the Cooper in the 1960s with

Fig. 12.1. The Cooper flows down from south-western Queensland, past the town of Innamincka to fill the Coongie Lakes system, and then flows south to the lower Cooper lakes where the Birdsville Track crosses the river (dry in this photograph from October 2016). The punt (on the left of the photograph) takes cars across the river when it has water. This was near where my father heroically 'swam' 600 bullocks across the swollen river in 1949 (photo R. T. Kingsford).

Fig. 12.2. Tom Kruse and his family, the outback mailman, was a legend in the Lake Eyre Basin, connecting communities with his dependable mail deliveries, sometimes delayed by the floods. He was a vivid part of my childhood memory (photo, Kruse Family Collection, http://www.lastmailfrombirdsville.com).

my mother, Mrs Kruse and her son Jeffrey to meet the great Tom Kruse. He was late again, delayed by a Cooper flood upstream, and so we had to camp in the dry bed of the Cooper. We came back later to see the floods cut the Birdsville Track and so we had to cross by the Cooper by punt (Fig. 12.1).

My memory is punctuated by flood times. They were markers in my life. I was palpably excited by my next big flood in the 1970s, when I was 19. Then I deeply understood the importance of floods, unencumbered by my early innocence. In the 1970s, our outback community descended on the river, from far and wide, to fish and camp. It was a momentous time. One flood followed another in an incredible sequence of floods that eventually filled Lake Eyre. I was astounded by the magnitude of the flood when I visited the great lake in 1975. It seemed that we were out at sea, speeding across its waves in our boat. I returned in 1977 when I began teaching at Oodnadatta and there was still water in the drying lake, now an amazing pink colour.

Six years later, I was the teacher in the small town of Stonehenge, between the Thomson River and Vergemont Creek, tributaries of the Cooper. Here, the country was different but the floods were just as important, a powerful force shaping our community. I watched the vast 2000 flood in wonder, every morning, as it crept across the floodplain. Sometimes it even made waves. We couldn't move for nine weeks but no one complained.

The river

This river is integral to our lives. It affects us physically and spiritually. Its dry years and flood years determine what we do and how we live. Our stories and memories are woven together by its booms and busts. Water connects our community from top to bottom, over vast distances. The river's behaviour underpins our myths. For example, Laddie Milson lived on the river for many years and always used to say 'if the river isn't running before Christmas, it is going to be a dry year but if it is, the good times are coming'. For our family, we watch and wonder what happens in Pie Melon Gulley, the tiny creek on our place, feeding the great river. When it rained and rained in 1990, I took my children to the creek where I told them how this water would run into the Thomson River, and then join the Cooper, eventually running into Lake Eyre. Now 20 years later, my children have grown up and live and work on the Cooper and the Diamantina River. Another generation deeply understands the paramount importance of this great river and its floods. I think, learn and care deeply about this river. Increasingly, I have become concerned about its future.

In 2007, I became a member and soon after the chair of the Cooper Creek Catchment Committee, followed by a stint serving on the board of Desert Channels Queensland, the regional natural resource management body (see Chapter 7). Another world opened up for me. Despite living on the river, I was for the first time exposed to its vulnerability, particularly the insidious threat of irrigation, so often sanctioned by water planning. I was appalled by how few checks and balances existed on diversions of the river's precious water. I innocently believed the river that had flowed uninterruptedly for millennia was safe and little could threaten the river I loved. It came as a great surprise to me that no one knew how much water people took from the river. My questions reverberated around our meetings – unanswered. What stopped a person taking more water than their licence allowed if no one measured it? Even if the legal take was exceeded, there was an inconsequential fine – certainly no deterrent. I realised I was not alone. Others continually asked the same probing questions, with equal frustration. There was a strong partnership of fellow custodians (see Chapter 7).

Then everything crystallised when I attended the 2008 conference at Windorah (see Chapter 7), sponsored by the Australian Floodplain Association. People like me, living on the rivers, talked of our collective experience. We heard the sad stories of lost rivers from landholders in the Murray–Darling Basin (see Chapters 14–16). Landholder stories were the same from each of the Macquarie, the Lower Balonne, the Lachlan and Murray Rivers, all experiencing widespread severe damage caused by diversions of precious river water upstream for irrigation. It had had a huge impact on their lives. It showed me how my river could easily be changed forever, affecting the land, people and social fabric of our community. In 2012, the Liberal National Party Government arrived with a new agenda (see Chapter 17). For us, it was on again – the push for small-scale irrigation on the rivers of the Lake Eyre Basin. The government's 'spin doctors' tried to convince us that new technology changed the equation. But you can't make more water. There is a limit to how much water can be diverted before affecting people and environments downstream. Now, there is another 'elephant in the room' – mining (see Chapters 19 and 20). It has a place in our economy and we need it, but this does not give the industry any right to destroy our rivers. We have to have the right policies and regulations in place (see Chapter 22).

Conclusion

Our river is intermittent and fragile. It is one of the last great free-flowing river systems in the world and in good condition. But to us who live and work here, this river means much more. It's our lives and has been for generations; we have to make sure it flows freely for future generations. My family's lives are intertwined with this great river system. Our community is galvanised to protect its future and stop potential damage from increasing diversions of water for irrigation or mining. We all have a great passion for the river, reflected by its tremendous unpredictability. It needs all its flow for its environment and people. We need to protect this mighty river at the level of the entire river basin for our future, and for future generations.

13

Kati Thanda-Lake Eyre – not just a wildlife paradise but also an economic lifeline

Trevor Wright

Introduction

Kati Thanda-Lake Eyre, the new name for Lake Eyre rightly reflecting its Aboriginal connection, and its rivers are increasingly on the tourist map around Australia and the world, a reflection of their magnificent cultural and environmental values. Despite this, the tourism industry and its capacity to cater for increasing numbers of visitors is not well developed in many parts of the Lake Eyre Basin (Schmiechen 2004). There is much less known about the sustainable economic values which flow when people are provided opportunities to appreciate these values through tourism. My business is tourism, focused on Lake Eyre. We have already shown that our business is growing and primarily because of the status of this river basin and the water it occasionally delivers to Lake Eyre. It is very important that the river continues to flow uninterrupted, not only for its environmental and cultural values, but also to support the sustainable businesses in the river basin such as ours, which is so dependent on tourism. People come to visit Lake Eyre because it is one of Australia's natural wonders. Lake Eyre and its boom and bust cycles are our big draw card.

I live almost a stone's throw away from Kati Thanda-Lake Eyre. We charter aircraft from William Creek, Marree and Coober Pedy to fly over Lake Eyre (Fig. 13.1). This aerial perspective gives people a wonderful idea about the sheer size of this magnificent wetland. We also provide accommodation, fuel and supplies for tourists. The floods make a huge difference to our small communities in South Australia, substantially increasing the number of visitors to our region and their financial contribution. Tourism provides jobs. When water flows into the lake, it triggers the movement of mainly retired and semi-retired people to our remote region, often fuelled by stories in the media. The lake is increasingly important as an economic resource as tourism grows.

Our Lake Eyre economy

The value of Kati Thanda-Lake Eyre to our region's economy really began during the floods of 2000, when public interest in the lake began to grow. About five years later, flows reached the lake with a small flood, which produced another spike in tourism. The floods of 2010 moved interest and numbers to an unprecedented level as it became widely known that the rivers were flowing into Lake Eyre, popularised by the magnificent ABC documentaries also captured in a book (Lockyer 2012). About 99% of our visitors are Australians, predominantly 'baby-boomers' keen to visit Lake Eyre once in their lifetimes. They come mostly from

Fig. 13.1. Our tourist flight business out of William Creek on the western edge of Kati Thanda-Lake Eyre has grown considerably as people have continued to want to see the magnificent environments of the Lake Eyre Basin rivers whether in flood or dry times (photo, R.T. Kingsford).

Melbourne, Sydney, Brisbane and Perth. We are also increasingly seeing international tourists, mainly from the United States and Europe. Our tourist season usually starts in April, with numbers growing significantly over the winter but the season increasingly extends through November. Many travel through the Flinders Ranges before coming to Kati Thanda-Lake Eyre.

The air flights reflected the extraordinary level of interest during the 2011 flood of Lake Eyre, as people flew from the major urban centres. Apart from our operations (Fig. 13.1), there were special air charters using Fokker 50s (a 50-seat aircraft) while QantasLink brought a Dash 8 aircraft chartered from Brisbane. Alliance Airlines, who predominantly service the mines, also flew tourists to see Lake Eyre. Not only did this influx of tourists come to see Lake Eyre but they also often stayed overnight in the outback towns and got supplies when the aircraft had to refuel in Birdsville, Broken Hill, Coober Pedy and Innamincka. The 2010–11 flood had a dramatic impact on our business.

We have our flight operations centre at William Creek, which usually has 12–20 people in the dry times but these numbers swell to 200–300 people when the floods come into the lake. In normal dry years, our company usually runs three or four small, single-engine aircraft, with our three pilots taking tourist flights over the Lake and its rivers (Fig. 13.2). In the flood years of 2010 and 2011, we had to employ 22 pilots and 18 aircraft. We flew more than 22 000 people over the lake, constantly flying between February and

Fig. 13.2. Kati Thanda-Lake Eyre is one of Australia's great natural wonders, revealing incredible colours and vistas whether flooded or dry (photo, R.T. Kingsford).

November. Each person paid $180–200 for their lifetime flight of an hour over the lake. A few people would also fly up the rivers to Birdsville, Bedourie and Innamincka over a couple of days, staying overnight in one of these towns. Our biggest challenge was coping with the demand for good accommodation. The demand to see the lake has meant that we more than doubled the number of rooms available in William Creek from ~30 to 70 beds. We are also improving the style of accommodation and services. We have installed access to potable water and underground power. By building our solar generation capacity, we have managed to reduce the eight diesel generators to one. We are increasingly adopting the philosophy of ecological sustainability wherever possible, reflecting our values and those of our visiting tourists.

The very large injection of tourists into our business was also very important for the local economy, providing jobs for local people. The Australian Government also built a bitumen airstrip, replacing the dirt one. This was also critical. It allowed larger, high-performance aircraft and jets to land and also limited to the damage to aircraft generally, encouraging more visitors. At the same time, we upgraded the refuelling system to ensure we could adequately service the increasing number of aircraft landing. Importantly even in the dry periods, we have an increasing number of tourists wanting to experience outback Australia and visit the vast dryness of Kati Thanda-Lake Eyre. We see more opportunities to cover the vast outback distances in our aircraft and take visitors to other magnificent places in the Lake Eyre Basin.

The future

Ultimately, we rely on the rivers, mostly coming from Queensland, to deliver us a flood and Kati Thanda-Lake Eyre with water. One thing is certain: if the flow of water stopped or there was even less water coming, there would be a danger that it would not reach Lake Eyre. This would devastate our business. It would also affect employment in all local South Australian towns, including Port Augusta, Coober Pedy, Marree and Oodnadatta, as well as Queensland communities.

Australians want to learn and understand more of their land and the outback is a magnet for this. Lake Eyre in flood brings the wonder of our natural environment to the Australian general public. And it improves our economy enormously, and most of all it is sustainable. We can continue to expand our business and the opportunity for Australians and international visitors to come and see the outback and its wonders. Encouragingly, more and more Australians are embracing and understanding the outback and the majesty of Kati Thanda-Lake Eyre. We in the hospitality and tourism industry will continue to grow and improve our ability to cater for the needs of this ever expanding tourism market. Most importantly, we are not affecting the rivers and the lake. Any development upstream of the water resources by irrigation or mining will have a devastating impact on our livelihood. I passionately believe that we can look after this place and also make a living, contributing not only to long-term environmental but also to economic sustainability.

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14

When our rivers ran dry – 30 years of water resource development in the Murray–Darling Basin

Ed Fessey

Introduction

The lower Balonne River floodplain begins where the Balonne River splits into its main streams and braided channels (Fig. 14.1). Water then flows south-east into the Ramsar-listed Narran Lake and to the west, down the Culgoa, Birrie and Bokhara Rivers to the Darling River. There are ~1600 km of main river channels in this Lower Balonne system. Most of the floodplain of the Condamine–Balonne catchment is in the Lower Balonne, the largest in the Murray–Darling Basin (Kingsford *et al.* 2004). This floodplain was once excellent for cattle

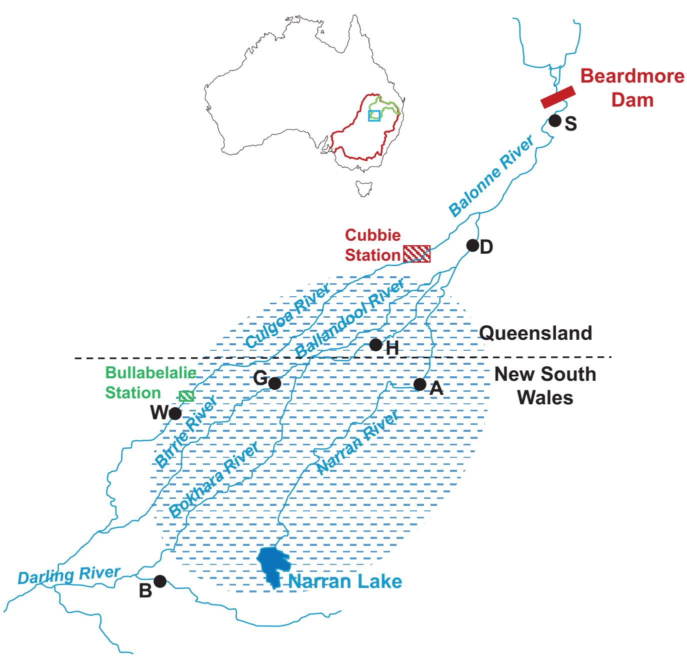

Fig. 14.1. The Lower Balonne system, shown in the inset (square), within the Condamine–Balonne catchment of the Murray–Darling Basin in south-eastern Australia. The Lower Balonne system crosses the Queensland and New South Wales border (dashed line) and diverges down four different rivers, one of which supplies the Ramsar-listed Narran Lake system. There are also urban centres (filled circles, A – Angeldool, B – Brewarrina, D – Dirranbandi, G – Goodooga, H – Hebel, S – St George, W – Weilmoringle), Beardmore Dam (government-built dam), Cubbie Station, a major irrigation property, and our Bullabellalie Station affected by reductions in flow.

and sheep production, benefiting from the widespread and variable floods and a reasonably reliable annual rainfall of 350–450 mm. The flooding was essential, providing the soil moisture for pasture growth, which lasted for up to two years. For example, native millet (*Panicum decompositum*) produces dry matter yields of up to 5 t/ha after a flood (Queensland Department of Primary Industries and Fisheries 2007).

The river system

The flow of the Balonne River is incredibly variable, with an average flow at St George of ~1.2 million ML/year before it was developed. More than 51% of this annual water volume between 1920 and 2013 was in just 20% of years. In the other 80% of years, the average flow was about half the average volume, with 30% of the total volume passing St George in this period occurring in just five events: 1950, 1956, 1976, 1983 and 2011. The highest annual flow at St George was 800% greater than the average annual flow, considerably more variable than the River Murray.

Before water resource development upstream of our property of Bullabellalie (Fig. 14.1), floods came and went, extending our pasture growth through the dry times. The scale of our productivity went up with increasing volume, height and duration of flooding, which was also dependent on antecedent conditions and upstream catchment conditions. Even when we did not have rainfall, the floods came and benefited us. For example, heavy local rainfall (200–300 mm over two days) ~160 km upstream in 1981 produced a small flood on our station, Bullabellalie. This event was critical for us, allowing my family to retain 250 core breeding cows for another three months, until it rained. Without the flood, we would have incurred an opportunity cost of about $250 000. This would have included selling cows onto a depressed market and the cost of later needing to replace them. Floods mean money to many of us who produce livestock from the floodplains of rivers (see Chapter 11).

It is not just the people of the floodplains who benefit from the rivers. The local towns of Dirranbandi, Hebel, Angledool, Goodooga, Weilmoringle and Brewarrina (Fig. 14.1) have also prospered since 1860, with the production from the healthy rivers and floodplains of the Lower Balonne. This all changed with irrigation development upstream of the Lower Balonne in the Condamine–Balonne catchment of the Murray–Darling Basin.

The age of development

The Condamine–Balonne river catchment was the last major river in the Murray–Darling Basin to be developed for its water resources (Kingsford 2000a; Thoms 2003; Kingsford 2004) and the environmental and social consequences are all too apparent. Development started in the Lower Balonne when the first broad-scale irrigated cotton was grown in 1972, after Beardmore Dam at St George was finished, storing 81 000 ML (Fig. 14.1). This was beginning of the end for the health of the rivers, starting the first major reduction in the volume, extent and duration of the flooding in the Lower Balonne system. Initially, the irrigation scheme struggled, as farmers tried different crops and experimented with which seasons to plant in. Agronomy, technology and skills improved, particularly for the cultivation of irrigated cotton. There was a strong social drive, backed by the mantra to diversify, which beckoned struggling grazing enterprises. Concerted water resource development began in the 1980s, increasing through the 1990s, before reaching its full potential in 2001 when ~1.2 million ML of private storage was built, just upstream of the Lower Balonne floodplain (see Chapter 15). The staggering scale and rate of development culminated in enough private storage to take all of the average annual flow in the river system (CSIRO 2008a).

The accelerating irrigation development was fuelled by a boom in floods, relatively low development costs, few legislative barriers (see Chapter 21) and little cost for water, as well as excellent returns on investments in irrigated cotton. The local economies of St George, Dirranbandi and Hebel flourished, as new businesses and professions rushed into the area to service the development boom. Much of the boom by large-scale developers was probably funded by offsetting their development costs against business interests elsewhere.

Federal and state politicians from both major parties and their agencies jumped on the bandwagon, supporting this wealth creation and apparent economic success story. They brushed aside the complaints of downstream floodplain graziers or states and ignored caution about long-term impacts. Downstream communities in New South Wales were bitterly opposed, pointing out the inevitable consequences that were all too apparent on other river systems in the Murray–Darling Basin (Kingsford 2000b; see Chapter 16). The communities of Hebel and Dirranbandi also divided along these lines. Before long, the damage was all too apparent. The reliable low and medium floods disappeared, sucked into large storages (Fig. 14.2), and the rivers seldom broke their banks to flood. There was no longer enough

Fig. 14.2. Cubbie Station lies upstream of the Lower Balonne floodplain and has storage capacity to hold more than 500 000 ML of river water in large off-river storages, predominantly to irrigate cotton. This has decreased flooding downstream, incurring significant impacts on downstream communities (photo, R. T. Kingsford).

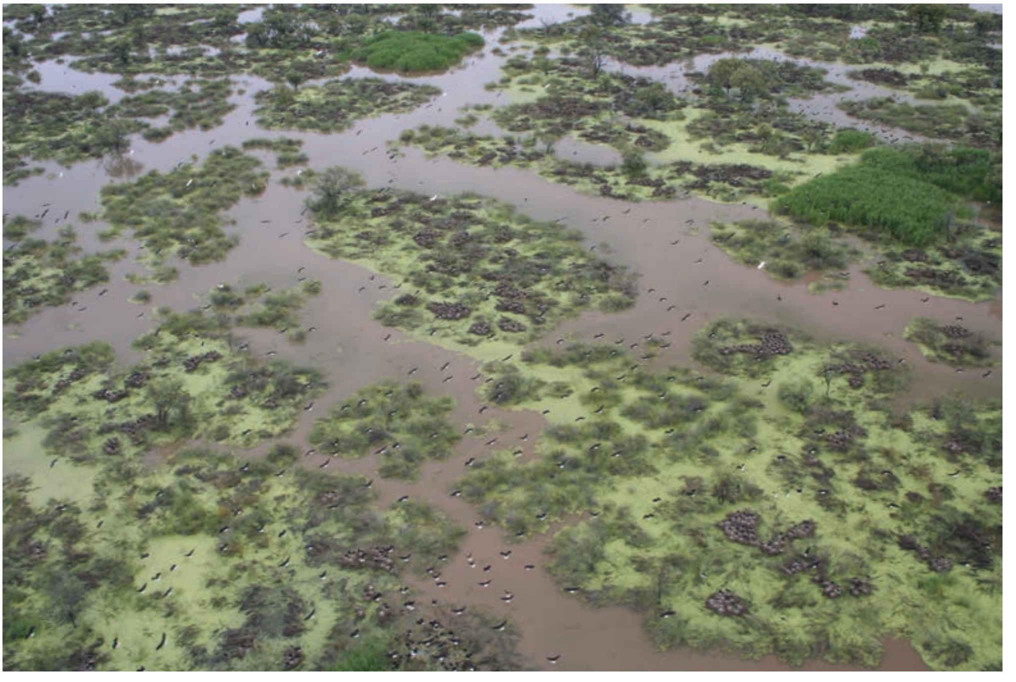

Fig. 14.3. Floodplains of the Narran Lake system, an internationally listed Ramsar site, like all floodplains on the Lower Balonne, rely on river flows from upstream, triggering widespread flooding and breeding of colonial waterbirds. Diversions of flows upstream to irrigation development have reduced the frequency of breeding events and degraded floodplain health (photo, R. T. Kingsford).

water to reach the end of the Lower Balonne system, except in extremely large floods. The social and economic impacts were real and harmful, even affecting the reliability of essential river flows for livestock and homesteads (stock and domestic flows). Downstream graziers and communities at Goodooga and Weilmoringle were particularly stressed (Fig. 14.1).

The speed of development and lack of government transparency were overwhelming (Tan 2000). Grazing communities were slow to respond, struggling to build cogent arguments and evidence that would convince legislators and bureaucrats (see Chapter 15). These grazing communities had a deep understanding of the complexity of the flows in the river which did not match the simplification and jargon of water management. Their pleas fell on deaf ears, possibly because of the complexity of explaining changes to flows in such a variable system and a perception by some government officers that the grazing industry belonged to the Stone Age. The scale and depth of impact that irrigation brought to all who lived on the Lower Balonne floodplain, including the irrigation communities, was all too apparent with the Millennium Drought.

No water flowed into internationally important Narran Lake (Fig. 14.3) for over a thousand days, defying the history books and exceeding the longest previous dry spell by about 400 days. The lakes system was renowned for its spectacular colonies of breeding birds, but even these were severely affected by the effects of water resource development

(Brandis *et al.* 2011). This was not natural, but all too explainable. Three flows at St George would have reached the lake, but were diverted for irrigation. In a natural system, the floods of 2004 and 2008 would have inundated substantial areas of the floodplain. There was widespread death of large areas of flood-dependent vegetation, including coolibah (*Eucalyptus coolabah*) and lignum (*Duma florulenta*).

Development also profoundly affected irrigation communities, after the set-up phase. The build-up phase was over, no longer demanding significant employment input. Exacerbating this, improved crop varieties reduced the need for as many chemical sprays and the need to employ people to weed the cotton (cotton chippers) or bale cotton when round-bale cotton harvesters arrived. Production of cotton per hectare doubled over 15 years, while employment numbers significantly decreased. The employment bonanza of the previous decade disappeared. Some irrigation businesses went into receivership, with Cubbie Station accumulating debts of about $300 million in 2013 (Locke 2013).

The legislative battle

In the 1990s, serious high-level national discussions reverberated about the levels of unsustainable development across the Murray–Darling Basin, particularly in the Lower Balonne system. The policy-makers and legislators had failed to constrain the level and speed of development. There was little consideration of the evidence backed by rigorous science for likely environmental impacts in the Lower Balonne. The implementation of policy and licensing left much to be desired (see Chapter 21), with little consideration about downstream impacts on communities or floodplain environments (Kingsford 2000a).

From the early 1960s, water harvesting licences were given out, mainly to landholders, mostly graziers, wishing to grow fodder for livestock. These licences triggered the boom in water resource development, largely unconstrained by policy. Limits to take water from the rivers were largely only constrained by the size of the pumps, available storage capacity and the water in the river. The Queensland water legislation did not define floodplains as part of the rivers (Gibbs 2009) – a catastrophic loophole for the river and its dependent communities. The rivers flowed reasonably frequently, providing further unrealistic expectations of reliability to the irrigation industry. Finally, recognising the rapidity of development in the early 1990s, the Queensland Government introduced a Water Allocation Management Plan (WAMP), following similar processes across the Murray–Darling Basin. There was also a cap on diversions across the Murray–Darling Basin, agreed by all the states in 1995, but Queensland managed to delay implementation for another five years, allowing further development in the Condamine–Balonne, affecting the Lower Balonne system and our livelihoods.

The volume of water that private water storages (Fig. 14.2) could capture grew by 500%. The WAMP process was discarded in favour of a new planning framework, the Water Resource Plan, implemented through a Resource Operations Plan. Large irrigators lobbied for more development, arguing this was possible using overland flow. This new policy position for overland flow was invented even though unknown for any other part of the Murray–Darling Basin. The concept was simple. The irrigation industry argued that because its members had developed large parts of the floodplain for their private storages and crops, the rivers could no longer flow onto these parts. The irrigation community argued and then calculated what volumes of water were forgone, if there was a natural floodplain. They successfully convinced a compliant Queensland Government that this volume then needed to be added to their water harvesting licences. If any semblance of equity existed, the same argument should have been applied to the downstream floodplains on graziers' stations, whose water was taken by the irrigation developments upstream. The overland flow concept excluded all other rights to water on the floodplain. Once again, the lobbying power was effective; a 'loop hole' was identified. The Queensland water agency allowed further take from the river to a voracious irrigation industry. It did not help that more than half of the wetlands in the Condamine–Balonne catchment were in New South Wales (Kingsford *et al.* 2004), a considerably smaller proportion of the catchment, with most of water coming from Queensland. In 2004, the Lower Balonne Water Resource Plan was passed into law (Queensland Government 2004), the first year that the full impacts of development affected a flood.

The Murray–Darling Basin Plan was introduced in 2012 (Murray–Darling Basin Authority 2012), with a commitment to review the state of the science in the Darling Basin (Murray–Darling Basin Authority 2016c). Under the Basin Plan, there was a commitment to return 390 GL/year, from current diversions in the Darling River catchments, including the Condamine–Balonne, to the river environment. In late 2016, the Murray–Darling Basin Authority proposed that this volume of environmental water be decreased to 320 GL/year, with a reduction from 142 GL/year to 100 GL/year in the Condamine–Balonne catchment (Murray–Darling Basin Authority 2016a). This reduction in environmental flow meant that the Australian Government would not buy back water from the irrigation industry and, in so doing, reduce the socio-economic impact on the Queensland town of Dirranbandi. The transparency of the science and the hydrological modelling had improved, but the modelling during periods of low flows was extremely unreliable.

The impacts

About 50% of the water that once went to the environment in the Condamine–Balonne is now diverted, categorised at a very high to extremely high level of development, ranked third-highest out of 18 catchments in the Murray–Darling Basin (CSIRO 2008b). Much of this water would have inundated the vast floodplain of the Lower Balonne river system of more than 1.4 million ha (Kingsford *et al.* 2004). By 2008, only 5% of the flow reached the Darling River and there was widespread evidence of damage to the floodplain. There was such concern within government circles about the long-term impacts that a review of the science was commissioned, chaired by well-known freshwater scientist, Professor Peter Cullen (Cullen *et al.* 2003). The irrigators seized on a comment in the review that the floodplain was currently in good condition, avoiding mentioning the subsequent warning that impacts take time to show up. Professor Cullen later remarked that 'by the time they get the science right, the patient will be dead' (Senate Standing Committee on Rural and Regional Affairs and Transport 2006). The irrigation industry cleverly used highly selective scientific results and strong political influence to once again derail a planning process in search of sustainability.

The federal Water Minister in the Liberal National Party Government, the Honourable Malcolm Turnbull, visited Bullabellalie in 2005, acknowledging the serious impacts of water planning in the Lower Balonne system. There were widespread triple bottom line impacts to social, economic and environmental values (see Chapter 15). Vegetation dependent on the floods continues to die across large expanses of the floodplain. New South Wales and Queensland have gazetted national parks on either side of the border, largely reliant on floods from the Culgoa River; there will be inevitable long-term consequences for these national parks – a case of the powerlessness of the environment arm of governments. Floods of most sizes, the prime drivers of productive grazing, are gone except for occasional large floods. Irrigation development upstream of the Lower Balonne floodplain has cost each floodplain grazing enterprise on average of ~20% of their production (Murray–Darling Basin Authority 2016b).

The Northern Basin Review of the Murray–Darling Basin was completed in 2016 (Murray–Darling Basin Authority 2016c) with the recommendation to reduce the amount of water to be returned to the environment by 70 GL year (Murray–Darling Basin Authority 2016a). It is unlikely that there will be any real environmental improvement for the Lower Balonne floodplain, especially in terms of the key elements of reducing the interval between flows and increasing the duration and extent of flows, particularly in the low flow years. Intervals between flows show no improvement. The internationally important Narran Lakes system (Fig. 14.3) will continue to decline in environmental value.

Development of irrigation has already had a significant impact on the finances of graziers, with the recommended flows under the Northern Basin Review only projected to improve production by 6%, compared to the 20% impact. Other socio-economic impacts were not measured, including the lost environmental productivity of the floodplain and the increased cost of providing alternative water supplies for downstream communities (see Chapter 15).

The future

The development horse has bolted, leaving a fractured and broken floodplain community on the Lower Balonne system, with significant social, economic and environmental consequences. There was some opportunity to rehabilitate some of the floodplain, through the Murray–Darling Basin Plan. Its main aims were to identify fair, efficient and sustainable use of the water across the Murray–Darling Basin rivers, including the Lower Balonne system. This was a major breakthrough but implementation for sustainability seems largely unreachable. Since 2012, the process of implementation has increasingly moved away from transparent and rigorous decision-making, with increased politicisation reflected in the recommendations of the Murray–Darling Basin Authority to reduce the environmental portion in the Condamine–Balonne by ~30% (Murray–Darling Basin Authority 2016c). My hope is that rigorous assessment of floodplain inundation could identify the watering requirements for these floodplains and the Narran Lakes system (Figs 14.1 and 14.3), setting a pathway for some environmental and economic recovery of the Lower Balonne floodplain.

Further, whatever the final amount of water to be returned to the environment, actual delivery depends on significant coordination and goodwill. Inflows into the Condamine–Balonne are declining due to unmeasured interceptions affecting the volume of water to the Lower Balonne floodplain. The Northern Basin Review identified poor compliance in the management of water, particularly in relation to low flows, publicly exhibited to the Brewarrina communities by the Murray–Darling Basin Authority in September 2015 at a Northern Basin Community consultation meeting. We need to improve measurement of water diversions and their regulation. With the significant concessions given to the irrigation industry and poor compliance, reduction in flows to the environment will continue to undermine sustainability and further reduce flows into Menindee Lakes on the Darling and eventually into the River Murray. Without marked improvement in flow recovery and its implementation, the Basin Plan will fail, leading to ongoing uncertainty and ongoing reform. Political will that ensures transparent coordination is essential.

The lessons from the development of the Lower Balonne floodplain are simple. Small irrigation development leads to big irrigation development, as increased lobbying by irrigation industries allows more and more water to be developed. We need strong leadership, not beholden to sectorial interests, able to bring people of the Lower Balonne together and provide transparent outcomes that encourage greater and innovative irrigation production with less water. The environment needs more water and those of us who traditionally relied on natural floods need this water. Without this, the natural systems and people who rely on floodplain environments have little chance in the centuries ahead to recover the health and productivity of these magnificent river systems. The often quoted lines of Dorothea Mackellar that Australia is a land of '… droughts and flooding rains' has fostered perceptions that both occur in equal measure. They don't. The intervals between these floods have increased a lot in the Condamine–Balonne. Our developed systems need a base flow of water, through different climate scenarios. We need adaptive management. We need to ensure we reduce the lengths of the dry intervals between flows and increase longitudinal and lateral connectivity. And we need intergovernmental commitment and coordination to make sure this happens. Finally, we cannot afford to lose any more environmental water.

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15

A river and a livelihood – all but lost in a decade

Pop Petersen

Introduction

I am passionate about the Culgoa River in the northern part of the Murray–Darling Basin, where we lived. For 27 years we managed Brenda Station, a 66 400 ha sheep and cattle property, straddling the Queensland and New South Wales border. The Culgoa River runs through the property for 52 km; it not only supplied drinking water from its main channel, but its floods also sustained our livestock and our livelihoods. In the 1983 flood, the highest since 1890, we had 43 200 ha (74% of the property at the time) flooded for 13 weeks, producing amazingly productive pastures. Such large floods are rare but smaller floods regularly came, inundating different amounts of the property, excellent for our livestock breeding and production. Floodplain graziers, such as us, depend on these floods. When reliability of these floods went, we hurt economically, along with our environment.

The Culgoa River is one of four rivers, including the Birrie, Bokhara and Narran Rivers, which spread out, forming the Lower Balonne floodplain in the northern part of the Murray–Darling Basin (see Chapter 14). They connect, forming a network of more than 1.4 million hectares of floodplain (Kingsford *et al.* 2004). They receive their water from upstream, from the Condamine and Balonne Rivers (see Chapter 14; Fig. 15.1). The Narran River fills the Ramsar-listed Narran Lakes and then overflows down a creek into the Bokhara River to eventually reach the Barwon River. Periodic flooding used to sustain a vibrant sheep and cattle industry, dry land farming and the environment. The floods brought economic benefits usually lasting three years. For example, we estimated that the 1995 flood provided about $36.1 million in income from cattle, sheep and dry land farming for the 236 properties on the Lower Balonne floodplain in New South Wales. This productive floodplain and its people were irrevocably damaged by the development of water resources upstream – a story that needs to be told by those affected.

The development phase

The rivers and their flooding patterns were altered forever by upstream development of the rivers. Beardmore Dam, built in 1972 on the Condamine River (Fig. 15.1), marked the beginning of a rapid expansion in irrigation upstream in Queensland. This took many of the floods that we needed for our income. The pace of this development picked up in 1995 when off stream water storages were built to capture river water amounting to 90 000 ML and increasing another 15 times to 1 500 000 ML by 2003. The policy of the Queensland Government continued to promote water resource development, which contributed to increased diversions by irrigators (see Chapter 21). They even converted the amount of

Fig. 15.1. Flows from upstream in the Condamine–Balonne catchment flow down the Condamine River at St George where flows are confined to a large channel before the river fans out into a deltaic system with the four rivers of the Lower Balonne. Much of the irrigation development, that has catastrophically altered the Lower Balonne, is near St George and downstream on the Condamine-Balonne, but upstream of much of the Lower Balonne floodplain (photo, R. T. Kingsford).

overland flow on the floodplains of irrigation properties into a volume of water extracted. This development occurred despite an embargo in 1992, on the issuing of water harvesting licences. Access to this overland flow, our economic lifeblood and essential for the environment, was at no cost to the irrigation industry apart from their infrastructure and taking the water from the river. The water was free. Initially, there were also no limitations on the volume of water that could be diverted: if the pump was large enough and the water was there, it could be diverted into storage. All this water resource development occurred without a single environmental impact study.

The largest irrigation property is Cubbie Station on the Culgoa River, with a licensed storage capacity of 538 800 ML (Sydney Morning Herald 2009), about the same as Sydney Harbour. It has the capacity to take most of a flood. In 2004, Cubbie Station filled its storages to 25% capacity and the flood destined to reach Brenda Station stopped. Our water problems started when Cubbie Weir was built in 1986. It holds back water and moves it into a diversion channel, which is about three times larger than the main channel of the Culgoa River. Our records showed that before 1986, flows of 1000 ML/day for six days (i.e. 6000 ML) reached Brenda Station. In 1989, the height of Cubbie Weir was increased and now flows of 12 000 ML no longer reach the New South Wales and Queensland border, 30 km upstream of Brenda Station homestead. Even our guaranteed supply of stock and domestic flow did not reach us for the second flood in a row in July 2005.

The impacts

Brenda Station is an official recording station for the Bureau of Meteorology for river heights and rainfall. There were 110 floods from 1905 to 2005 at Brenda Station, averaging one about every 11 months. The homestead was never out of water between 1890 and 1992. In 1993, we were without water for 10 months and another four months in 2003. These were drought years, but the river still reached Brenda Station during the worst drought of 1943–47. Average annual rainfall for 2001–05 was 295 mm compared to 173 mm for 1943–47. The river often used to run continuously for a year before water resource development.

This development reduced river flows at the end of the Culgoa River by 58% (CSIRO 2008). The environmental effects were tragic and depressing. We had hundreds of dying or dead river gums (*Eucalyptus camaldulensis*), coolibah (*E. coolabah*) and river cooba (*Acacia stenophylla*), and thousands of hectares of dead lignum (*Duma florulenta*) (Fig. 15.2b). The latter provided nesting habitat for bird life and was very important food for livestock. At the same time, terrestrial plants such as rolypoly (*Sclerolaena muricata*) invaded the floodplain. Six fish species in this system are endangered. Waterbird numbers have declined. In 1996 the New South Wales and Queensland governments gazetted the Culgoa National Park, an 80 000 ha area to protect river red gums, coolibah and lignum communities dependent on flooding. These areas will continue to degrade over the coming decades.

Transferring our wealth upstream

After 1999, we did not get even a low flood for over six and a half years, and seven years for a moderate flood. Before 2004, a river flow peaking at 65 000 ML/day, at Jack Taylor Weir at St George, produced a moderate flood, inundating 24 000 ha on Brenda Station (e.g. 1994). Contrastingly, the 2004 flow peak of 66 802 ML/day, a major flood at St George, did not flood a single hectare of Brenda Station, nor anywhere south of the Queensland border. Our income was transferred upstream, as we lost production from livestock and dryland farming, a loss estimated to be $568 735 in 2004. Carrying capacity for sheep and cattle respectively decreased by 30% and 45%. The Queensland Department of Natural Resources offered no explanation when we met them. Instead, the Queensland water agency continued to allow diversion of water for irrigation in 2005, when people downstream on the Culgoa and Birrie Rivers had to cart water for essential domestic supply.

The extent and frequency of flooding decreased. We even had to build four off-river storages to supply our livestock with drinking water, without any financial assistance, for a service that the river used to provide for free. We also had to pipe water to parts of Brenda Station previously supplied with flood waters. Next, we had to fence off large sections of the river because livestock could cross the river, which had been a natural barrier. These real costs were incurred by many along these rivers and yet never recognised in any socio-economic analyses, until relatively recently during the Northern Basin Review (Murray–Darling Basin Authority 2016b). Further, the land lost value because reduced flooding decreased productivity (Fig. 15.2). For example, nearby Balgi Station had its land rates reduced by 30% in 2003. The properties became harder to sell. Upstream development with the irrigation simply shifted the wealth from a huge area of landholders to a small area of irrigators.

Fig. 15.2. The impact on our livelihood was catastrophic with declining productivity of the land and devastation of the environment as the floods stopped coming. This shows (a) the incredible response of floodplain vegetation after the 1983 flood, before upstream development of the river and (b) the results of upstream water resource development in 2004, taking the floods which we relied on and killing these long-lived trees on the floodplain (photos, P. Petersen).

Consultation

There was no discussion about developments, authorised by the Queensland Government, with downstream communities or even the Government of New South Wales. The entire Queensland water allocation management planning process was consistently weighted heavily towards the irrigation industry. Considerable concern mounted during the late 1990s and 2000s about the inequities of the planning process (Tan 2000; see Chapter 21). In 1999–2000, the Queensland Government developed a Water Allocation Management Plan. There was consensus among stakeholders about the plan, recommending cutbacks and restrictions. The irrigation industry objected to the modelling and planning began again with considerable national and state controversy. This was the catalyst for the Premier of Queensland, the Honourable Peter Beatty, to commission an enquiry headed by freshwater ecologist Professor Peter Cullen.

There were four terms of reference for review: (1) the hydrological modelling by the Queensland Department of Natural Resources for the Condamine–Balonne Basin; (2) the current ecological condition of the Lower Balonne river system, including its floodplains and wetlands; (3) the current relevant scientific information in order to propose an ecological definition of the health of the working river applicable to the Lower Balonne context; and (4) the range of likely future ecological conditions and trends in the health of the Lower Balonne river system, including its floodplains and wetlands (Cullen *et al.* 2003). The scientific report concluded that the time lag was too short to clearly demonstrate impact, but 'there will be significant long-term degradation of the Lower Balonne Floodplain and of the Narran Lakes in particular once the system experiences the water extraction that is possible with the present infrastructure' (Cullen *et al.* 2003). Further, the report concluded that the full impacts would not necessarily be fully obvious even in 40 years, given high flow variability. The report was substantially ignored because it was equivocal in the short term, with different sides choosing sections from the report that supported their positions.

Water resource planning started again, requiring a Community Reference Group of 22 members, including 12 members, with the Chair from the irrigation industry and only four from New South Wales, of which three were floodplain graziers, including myself, and the other a councillor from Brewarrina. The remaining members were from local councils and management groups in Queensland. No one provided input from the New South Wales Government. Concerns of floodplain graziers downstream about the river and floodplain were largely neglected when the Queensland Government legislated the plan in August 2005.

Nothing addressed the problem of downstream impacts or reduced extraction. There was only one small concession. If, after a dry period, there was a flood with a peak of 60 000 ML/day, which would flood a smaller downstream area than a natural flood peaking at 20 000 ML/day (i.e. before development), there would be a 10% reduction in diversions for up to a maximum period of five days. Further, this water was only 'borrowed', allowing it to be taken in the future for irrigation. In 2004, this concession would have only have delivered a meagre 4902 ML (a 10% increase), divided between four rivers.

Sadly, the New South Wales Government was missing in action, meekly accepting the inevitable consequences for the downstream river and its floodplain. The planning processes remained largely parochial. The Queensland Government showed further contempt for transparency and equity by appointing a local irrigator as the facilitator to the newly formed ministerial advisory council, charged with implementing the water resource plan and the resource operation plans. There were inevitable beneficiaries from the licensing of overland flows. Our consistent requests for an independent facilitator were ignored.

We would like to see the complete abolition of overland flow allocations. We want an annual volumetric cap placed on all water harvesting, replacing the current practice of filling up irrigation storages with flows above a threshold, regardless of how many times the river flows. We want pumps to be metered and diversions policed. Water has been pumped illegally from stock and domestic flow, but no one has ever been convicted of any offence. Flows must be allowed to run right through the rivers before water extractions are permitted. There also needs to be improved communication between the Queensland water agency and landholders downstream. No repayment of water by downstream users should be made to irrigators. Flows are marginally increased under the Murray–Darling Basin Plan, but long-term consequences and damage remain. The recommendations of the Northern Basin Review continue to reinforce the inequities, with the irrigation industry largely convincing the Murray–Darling Basin Authority that the 390 GL of water to be returned to the environment under the Murray–Darling Basin Plan should be cut by ~30% in the Condamine–Balonne (Murray–Darling Basin Authority 2016a).

Conclusion

We have always wanted a fair share of the water that was once ours. We relied on the natural flooding of the floodplains for grazing and watering our livestock and for our domestic needs (Fig. 15.2). The consequences of upstream irrigation development will continue to have major economic and environmental impacts. My husband and I lived on the Culgoa River for 27 years and watched with great sadness the continuing devastation of the river environment. It remains a disgrace that irrigation on our river could take so much water to the detriment of people and the environment downstream. It may be legal, but it remains morally wrong. We fought a losing battle against the wealthy and politically connected. We hold the Queensland Government responsible for the socio-economic and environmental mess. They simply allowed development to occur, oblivious to the downstream impacts, already obvious in many parts of the Murray–Darling Basin. The effects of this development were disastrous, economically, environmentally and emotionally.

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16

Making a living from the Macquarie Marshes – coping with decisions upstream

Garry Hall

Introduction

I live in the Macquarie Marshes, supplied by the highly regulated Macquarie River, in the northern part of the Murray–Darling Basin. The Macquarie Marshes are an incredible ecosystem that supports spectacular biodiversity that is highly dependent on the floods (Fig. 16.1). The large Burrendong and Windamere dams control the flows in the river, from ~260 km directly to the south-east, upstream of our cattle property in the Macquarie Marshes. These dams have captured the flows that we relied on for making our living and diverted this predominantly upstream of the Macquarie Marshes to irrigated agriculture. Plants in the Macquarie Marshes mainly grow in spring and summer, providing a high protein diet for our cattle. We rely primarily on the water in the Macquarie River because its floods produce our productive pastures of aquatic plants, such as water couch (*Paspalum distichum*). This growth translates into an economic equation, critical for our livelihood. Land that is flooded can support four times more cattle than land not flooded; the more flooded land, we have the higher our income and, conversely, the less flooded land, the more our profitability declines (Fig. 16.2). We breed our cattle in the Macquarie Marshes and then sell male progeny (weighing 400–450 kg) to feedlots, where they are fattened for the markets.

Living in the Marshes

The Macquarie River floods the Macquarie Marshes, through its various creeks and streams, before flowing through to the Barwon–Darling River. The floods usually come in the winter and spring, inundating our country and sustaining our livestock through the summer. The Marshes are less than 200 000 ha, with ~90% of this area privately owned. The grazing properties cover 2000–30 000 ha and, as well as supporting many different vegetation communities, are also where many of the large breeding colonies of waterbirds breed (e.g. straw-necked ibises (*Threskiornis spinicollis*), intermediate egrets (*Ardea intermedia*) and rufous night herons (*Nycticorax caledonicus*)), when there is enough flooding (Kingsford and Auld 2005; Bino *et al.* 2014). These breeding colonies, augmented by colonies on the nearby Macquarie Marshes Nature Reserve, comprised the major criterion for the Macquarie Marshes becoming listed as a wetland of international importance under the Ramsar Convention.

The Macquarie Marshes are much smaller than they used to be, before the dams were built (Kingsford and Thomas 1995; Ren *et al.* 2010). They started to decline when the Burrendong Dam was completed in 1967. This was when decisions were made upstream by

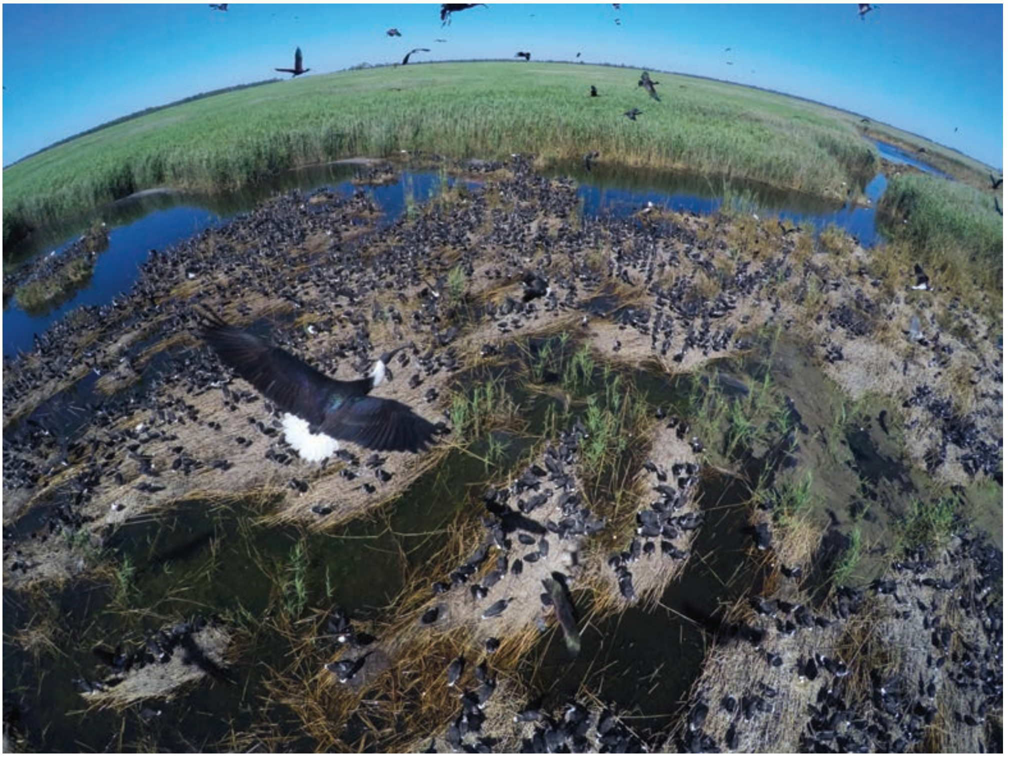

Fig. 16.1. The magnificent Macquarie Marshes in flood, an amazing natural ecosystem extending in all directions and supporting spectacular biodiversity, including waterbirds which breed in large numbers, such as these straw-necked ibises and different vegetation communities (photo, N. Moir).

governments oblivious to the long-term ecological and social consequences on the Marshes. The environmental and economic impacts on Marsh graziers increased in the 1970s and 1980s, before reaching a high level and remaining at this level in the late 1980s, when irrigation development peaked. The annual average flow of the Macquarie was estimated to be 470 000 ML, but the New South Wales government still issued 898 793 ML in licences, including the environmental allocation (Johnson 2005). This meant that, in average years, irrigation licence holders could only be expected to receive ~51% of their allocation. The impact on our livelihoods, and other graziers in the Marshes, was dramatic (Fig. 16.2). The social structure of the community altered considerably in the 1990s, as many landholders no longer had sufficient income to remain viable, given the size of their properties. Some properties were amalgamated and others were run by absentee land owners. This meant fewer people fighting for the marshes and the viability of our livelihoods.

Less frequent and less extensive flooding meant that the Marshes got progressively drier (Thomas *et al.* 2011). They became more difficult to flood as the dry periods got longer, increasing the times between floods (CSIRO 2008). The Macquarie Marshes were often wet and occasionally dry, but now they are often dry and occasionally wet. Their flooding and drying patterns have switched. This has had a huge impact on the plants that grow in the

Fig. 16.2. Most (~90%) of the Macquarie Marshes is privately owned with most used for grazing cattle production. Floods are critical for productivity, increasing income and supporting the social community but these have declined with the building of Burrendong Dam upstream, which allows diversion of much of the Macquarie River's flow to irrigation (photo, D. Herasimtschuck).

frequently flooded parts of the wetland. These were the areas that we and other graziers relied on for our productivity and sustainability, but they are no longer productive because the country does not flood or floods less often (Figs 16.1 and 16.2). These changes have had a major social, economic and environmental impact on our lives. The floods that shaped the Marshes have changed. We still get the occasional big floods and small floods, but the medium floods are either captured in the large dams or diverted upstream for irrigation. These dependable medium floods provided much of the productive vegetation for our cattle (Fig. 16.2).

These impacts on our livelihoods and the Macquarie Marshes environment have sometimes produced acrimonious debate within the agricultural industry (Kingsford 1999), although the science is clear. At various times the landholders in the Macquarie Marshes have been accused of further degrading the wetland by overgrazing. Some even argue that this is the main cause of environmental decline, contrary to scientific evidence and our local experience. Cattle were grazed in the Macquarie Marshes from the 1850s (Fig. 16.2), but the system only began to degrade significantly in the late 1980s. There are areas in the Macquarie Marshes Nature Reserve, now more than 20 years without grazing, where the floodplain vegetation has been destroyed and there are large areas of river red gum hundreds of years old that have died (Catelotti *et al.* 2015).

In 2012, we thought that the future for the Macquarie Marshes looked brighter for the first time in nearly four decades, with the implementation of the Murray–Darling Basin Plan

(Murray–Darling Basin Authority 2012). At the very least, we hoped that increasing environmental flow water to the Macquarie Marshes would halt the long-term environmental and economic decline. The Murray–Darling Basin Plan established the Commonwealth Environmental Water Holder, with a role to purchase water and manage environmental water in the Macquarie River. In addition, the New South Wales Government also purchased environmental water and managed environmental flows. There is now more than 300 000 ML of environmental flow held in environmental licences for the Macquarie River when all the upstream dams are full. In 2016, the Murray–Darling Basin Authority reviewed the Basin Plan target of returning 390 GL/year of water from irrigation and other efficiency measures to the environment (Murray–Darling Basin Authority 2016b), concluding that this measure should be reduced by 70 GL. For the Macquarie River, there was an absurd conclusion that the system had too much environmental water (12 000 ML/year, (Murray–Darling Basin Authority 2016a), raising the prospect that environmental water bought by governments would be sold back to the irrigation industry. This decision flies in the face of recent rapidly accumulating peer-reviewed science about the state of the Marshes (Thomas *et al.* 2011; Bino *et al.* 2015; Catelotti *et al.* 2015), which received no reference in the Northern Basin Review (Murray–Darling Basin Authority 2016b). Just as problematic, this assessment focused primarily on socio-economic assessments of the irrigation industry, largely ignoring the impacts of reduced flooding on floodplain graziers (Murray–Darling Basin Authority 2016c).

Our community

Hard-won gains in improved environmental outcomes did not happen by accident. Our dedicated local community, individuals in government, non-government organisations and scientists have forced major policy and management changes. In particular, it became clear that the Macquarie Marshes Nature Reserve was affected by the changes to flooding regimes and so we landholders of the Macquarie Marshes worked closely with the New South Wales National Parks and Wildlife Service to fight for the Marshes.

I have been involved in the water debate all my life. The Macquarie Marshes Environmental Landholders Association has provided a strong voice, particularly through the Mclelland, Fisher and Jones families and other community members. We are entering a new phase, with generational change, but new challenges still constantly appear. We are fortunate because our elders are lending their experience to our energetic youth. There is always another fight for our Macquarie Marshes, forced by another potential, subtle change in water policy. Decisions continue to be largely made upstream, with major ramifications for our Marshes and livelihoods. This is a never-ending struggle in the Macquarie River. In 2017 there will be a review of the water sharing plan, with the Commonwealth long-term environmental watering plan under development; both are critical for the sustainability of the Macquarie Marshes.

Conclusion

We are the custodians of the wonderful Macquarie Marshes, which not only sustain us and our livelihoods but also have an incredible biodiversity. We have learnt much about government decision-making, environmental degradation, partnerships and how to influence decisions to improve the sustainability of the Macquarie Marshes. It is clear that diverting water for irrigation started slowly in the Macquarie River but then rapidly developed, with devastating consequences for the Marshes and our livelihoods. This decision was made predominantly by the New South Wales Government and its water agency in particular, influenced by landholders wishing to diversify into irrigation and often supported by local government. The large dams were the cause and continue to affect the river and its sustainability. Landholders in the Macquarie Marshes have had to cope with this upstream decision and its consequences. We have come together and demanded change, sustained by our passion for the sustainability of our river, the Macquarie Marshes and our livelihoods. We who live in the Macquarie Marshes have learnt much and can teach others. When people talk about 'a little bit of irrigation', this can mean a small pump of a few centimetres, but the pumps can then increase to metres in diameter. Once they start, they won't stop. Be careful who you trust. Be wary of consultants and experts that can be bought. Don't leave anything to hearsay; collect all the current data you can now before development starts. But also remember that there are equally many to be trusted who are primarily committed to public good ideals and environmental sustainability.

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17

'Once more into the breach, dear friends …' – the ongoing battle for the Cooper

Bob Morrish

Introduction

Kati Thanda-Lake Eyre, the immense ephemeral salt lake at the heart of this dry continent, continues to haunt and fascinate the Australian consciousness. The lake itself is the dominant feature within a huge network of smaller fresh and saltwater lakes, swamps and sand dunes of the north-east deserts of South Australia and a vast expanse of channels, floodplains, swamps, dunes and ephemeral lakes of the fabled Channel Country of Queensland (Fig. 17.1). The whole region responds with spectacular growth and beauty in the rare seasons of extensive flooding sufficient to reach and fill Lake Eyre, as memorably documented by the late and much lamented ABC film crew, Paul Lockyer, Gary Ticehurst and John Bean

Fig. 17.1. The spectacular Channel Country of the Lake Eyre Basin rivers floods and drives a boom in numbers of animals, plants and other organisms as well providing a livelihood to many pastoralists who are committed to protecting this magnificent river system (photo, R.T. Kingsford).

(Lockyer 2012). As any resident of the region knows, these big floods are the exception rather than the rule. The region endures extremely dry conditions for much of its existence. The occasional life-giving flows of the rivers towards Lake Eyre are absolutely vital to survival in this uncompromisingly harsh though beautiful environment. Any threat to the integrity of these flows must be viewed with alarm.

Such a threat continues to loom large. The Liberal National Party Government in Queensland (2012–15), under Premier Campbell Newman, dismantled Wild River protections for the Channel Country and altered water legislation, allowing oil and gas resources companies and irrigation access to the Channel Country's water resources, wetlands and floodplains (see Chapters 20–22). The Lake Eyre Basin has become another battleground for two great competing drives of modern civilization: the drive for growth which has already devastated the Earth's ecosystems and biodiversity, versus the desire to respect, conserve and wisely use those remnants of natural beauty and biodiversity still left in our diminished world.

Seventeen years ago, people of Cooper Creek, with the scientific and conservation communities, successfully fought a battle to protect the 'Cooper' from the damaging effects of a proposed large-scale cotton irrigation development (see Chapter 7). The Newman Government's intention to open up the Channel Country rivers to irrigation, and to unconventional oil and gas development and the destructive effects of hydraulic fracturing ('fracking'), now means the earlier battle must be fought again, this time on the wider front, encompassing the three major rivers of Lake Eyre: the Cooper, the Diamantina and the Georgina Rivers. Hence the title of this chapter, 'Once more into the breach', evoking Shakespeare's portrayal of Henry V's rallying speech to the English outside the walls of Harfleur (Bate and Rasmussen 2007). I provide a brief history of the first battle for the Cooper, highlighting the critical role of politics in the struggle to protect the rivers of the Lake Eyre Basin.

Proposed Currareva irrigation development

On 25 September 1995, a consortium of four people from the Macquarie River, which supplies the Macquarie Marshes, a New South Wales wetland which had already incurred great social and environmental costs (see Chapter 16), announced their intention to develop a large irrigated cotton farm on the Currareva property, on the floodplain of Cooper Creek, ~12 km from Windorah (Fig. 17.2). The development, by what was known as the Currareva Partnership, was outlined in their Initial Advice Statement, proposing the growing of 3000 ha of cotton, with an annual harvest of 47 000 ML of water from the Cooper: 42 000 ML of new licence applications and 5000 ML of existing licences registered to the property. Less than 10% of Currareva's existing licence allocation had ever been used, by a previous owner to irrigate a small (50 ha) stock fodder crop. The major portion of the existing licence allocations remained as 'sleepers', largely unused (see Chapter 20), until the Macquarie Valley consortium proposed to fully activate them. Other proposed infrastructure included the necessary large water harvesting pumps, a large diversion channel (700 m long and 9 m deep) to a pump station and 25 000 ML of shallow storage (ring tanks) on the floodplain (over 5 km^2, 4.5 m deep). Their proposal foreshadowed possible future extensions of the project to horticulture and aquaculture, accompanied by additional demand for water.

Fig. 17.2. The Currareva waterhole, part of Cooper Creek near the town of Windorah, was to be the proposed site for a massive irrigation development involving the pumping of water into large dams or ring tanks to irrigate cotton (photo, R. T. Kingsford).

To achieve reliability of water supply from the highly variable flows of the Cooper, the consortium also proposed to take water at very low flows: 400 ML/day from flows of only 1400 ML/day (29% of the flow) and reaching maximum pumping capacity of 920 ML/day at flows of only 8000 ML/day (11.5% of the flow). It became immediately obvious to the people of the Cooper that such an extraction regime would destroy the connectivity, afforded by low flows to downstream drought refuge waterholes.

Cooper's Creek Protection Group

People from the Cooper and Diamantina Channel Country, and indeed all who formed the audience at the public meeting which introduced the irrigation proposal, were horrified at the prospect of destruction of their beloved Cooper by relentless water demand and by the toxic chemical pollution associated with irrigated agriculture. The Barcoo Shire Council relied on the Mayfield waterhole, immediately downstream from Currareva waterhole, for the Windorah town water supply and was understandably concerned. The local community immediately formed the Cooper's Creek Protection Group, with members comprising Traditional Owners, workers, station managers, pastoralists, town residents, local business owners and people with an interest in or connection with the Channel Country and the Lake Eyre region. Its goal became the preservation of the ecological integrity and biodiversity of the Cooper system's rivers, wetlands and landscapes, recognising that the region's human communities and sustainable industries depended on the maintenance of this integrity. Since its inception, the group has actively promoted a policy against irrigation, intensive agriculture

Table 17.1. Descriptive statistics of Cooper Creek annual flows in GL (= 1000 megalitres), mean, median, standard deviation, coefficient of variation (Coeff. var.) and coefficient of skew (Coeff. skew) at the Currareva and Nappa Merrie gauges, showing the extremely high variability and skew.

Gauge[a]	Annual flow (GL)			Coeff. var.	Coeff. skew
	Mean	Median	Std. dev.		
Currareva	3150	1690	4260	1.35	3.08
Nappa Merrie	1430	240	2890	2.02	3.37

[a] https://water-monitoring.information.qld.gov.au and McMahon *et al.* (2008) , Currareva records 1939–1988 (incomplete), Nappa Merrie records 1949–2005 (incomplete)

and any activities threatening the integrity of landscapes, rivers, wetlands and biodiversity of the Cooper in particular and the Lake Eyre system.

Basic hydrology

People of the Cooper intuitively recognised the intimate dependence of the system's ecology on water flows. A fundamental understanding of the Cooper system required some knowledge of annual flow statistics (Table 17.1), available from the only two gauges for the Cooper's downstream reaches in Queensland, Currareva and Nappa Merrie, with the Nappa Merrie data supplemented for the years 1970–2005 by data from the Cullymurra gauge in South Australia, a short distance downstream. Nappa Merrie is the site of the famous Burke and Wills Dig Tree, ~400 km downstream from Currareva, the other gauge.

It was immediately obvious that there were high transmission losses between Currareva and Nappa Merrie and very high annual variability of flow, as well as very high skew introduced into mean values by extreme rare events, such as the 1974 flood period (Table 17.1). If the 1974 event was excluded from the data, the mean annual flow at Currareva would be reduced by ~500 GL or 500 000 ML. For such skewed data, the median is a much better indicator of central tendency. High transmission losses reflect the extreme aridity of the environment and the geographic scale of the system, distributing flow into extensive areas of channels, floodplains and wetlands which receive the flow and effectively prevent much of it from continuing downstream. Three large ungauged tributary systems (Kyabra Creek, Wilson River and Warri Creek) also contribute flow between Currareva and Nappa Merrie and so the measured transmission loss underestimates true loss. The proposed annual demand identified for irrigation for Currareva (47 000 ML), amounted to 19.8% of the median flow at Nappa Merrie and 2.8% of the median flow at Currareva, substantially more than estimates using means.

Water volumes measured in megalitres (ML) tend to lack concrete reference to most people, except irrigators and hydrologists. We needed to make the potential impact more meaningful. A useful basis for comparison was to imagine an 'idealised' waterhole 60 m wide across the water surface, 5 m unvarying depth and 40 m wide across the bed (bank slope of 1 in 2). Such a waterhole would need to be 4 km long to store 1000 ML. Even such a waterhole 1 km long (holding 250 ML of water) would be a significant drought refuge. The proposed annual irrigation water demand at Currareva would have filled such a waterhole 188 km long. Even more alarming was the evidence from the Murray–Darling Basin that irrigation, once established, would lead to an ever-increasing water demand (see Chapters 14–16). The people of the Cooper needed no further evidence to convince them of the extreme threat posed by the Currareva irrigation proposal.

The Cooper alliance

Early in the campaign to protect the Cooper, a strong alliance developed between the Cooper's Creek Protection Group, the Australian Conservation Foundation, the Queensland Conservation Council and the Australian ecological science community. The alliance received strong support from people of the other Channel Country rivers, all the way to Lake Eyre, and from old ringers, drovers, outback station people generally, bush poets and songwriters, as well as disgruntled residents of cotton irrigation areas (e.g. Bourke, Narromine, Goondiwindi and Dalby), Macquarie Marshes Environmental Landholders' Association, Paroo River Association, tourism operators and tourists. There was widespread interest and support from the Australian public and strong media interest from ABC Radio and TV, from ethnic broadcaster 2WEB Bourke, from some commercial radio and TV stations, and from some of the major print media.

The pro-irrigation lobby

Forces actively promoting the proposed Currareva development comprised the four Currareva partners, the Queensland Cotton Industry Policy Council, the Queensland Irrigators' Council, and a small group of irrigation aspirants from upstream subcatchments. Interestingly, the peak cotton industry body, the Australian Cotton Foundation, remained neutral in the debate. It was generally assumed that they did not welcome the additional negative publicity likely to be generated by the Cooper cotton proposal while the Australian Cotton Foundation was attempting to promote a 'cleaner' image for the cotton industry. Recognising the unwillingness of the Australian Cotton Foundation to enter the debate, the Cooper's Creek Protection Group decided to focus negative publicity on irrigation broadly, rather than on cotton, avoiding any publicity battle with the well-resourced Cotton Foundation.

Department of Natural Resources

The Currareva proposal and development application triggered the first Water Management Plan (now called a Water Resource Plan) in Queensland. This required stakeholder consultation, under the *Water Act 1989*. This was achieved by setting up a 'Cooper Creek Advisory Panel', including individuals from the Cooper's Creek Protection Group, South Australian Department of Environment and Natural Resources, the South Australian Arid Areas Water Resources Commission, the Queensland Department of Natural Resources, the Queensland Department of Environment, the Barcoo Shire Council, the Conservation Council of South Australia, the Queensland Conservation Council, as well as the Currareva proponents and their allies from the Queensland Irrigators' Council and the Queensland Cotton Industry Policy Council. The process was conducted by the Queensland Department of Natural Resources. Hydrological modelling of Cooper flows was done by an expert group within the Queensland Department of Natural Resources.

The Minister for Natural Resources (National Party), Howard Hobbs, refused repeated calls from the Cooper's Creek Protection Group, the conservation bodies and the Environment Department for ecological science input. It became obvious that Minister Hobbs and the National Party Government openly favoured extending irrigation development to the Cooper. It was also clearly apparent that a powerful subsection of departmental culture at the time endorsed the minister's views.

Windorah scientific workshop

The Cooper alliance's strategic response to the minister's obdurate stance on ecological input was to organise what may well have been the first scientific meeting ever held in a small outback town – the Windorah Scientific Workshop: An Ecological Perspective on Cooper's Creek, 3–6 September 1996. Over 100 people attended, including conservationists, interstate bureaucrats, natural resource managers, local community, pastoralists and, of course, scientists who presented papers from a range of disciplines focusing on aquatic and arid zone ecology (Angela Arthington, Stuart Blanch, Stuart Bunn, Peter Davies, Martin Denny, Richard Kingsford, Jerry Maroulis, Grant McTainsh, Mike Olsen, Jim Puckridge, Julian Reid, Brian Roberts and Brian Timms).

The workshop made an important recommendation in an open letter to the Queensland Government, supported by a summary of ecological considerations. The recommendation stated that no irrigation or other large-scale water extraction should be allowed for the Cooper or other Lake Eyre Basin rivers, given the aridity of these desert systems, their very high flow variability, the role of rivers and wetlands of the Lake Eyre system in sustaining biodiversity through periods of boom and bust, and the degradation already evident from irrigation development in the semi-arid Murray–Darling Basin. This recommendation and abstracts of papers were published (Noonan 1996).

The recommendation was also endorsed by scientific bodies: the Australian Society for Limnology, the Institute for Wildlife Research (University of Sydney), and the 5th International Ecological Conference, Perth, September 1996. Later in September 1996, 127 horsemen and horsewomen from the Channel Country staged a mounted rally, supporting the workshop recommendation and protesting the government's intransigent attitude. The workshop and the rally attracted widespread media interest, which reflected poorly on the government's stance on the issue.

The politics of protection

The National Party Government partially capitulated to the combined forces opposing the Currareva project, shortly after September 1996 announcing that it would not allow cotton irrigation on the Cooper. However, its duplicity was revealed in its Draft Water Management Plan of April 1998, which proposed 22 500 ML of new water harvesting licences, as well as a suggestion to force the activation of 'sleeper' licences on the Cooper – the two largest of which amounted to 10 000 ML, split between Currareva and its neighbouring property Hammond Downs (see Chapter 20). The Queensland Department of Natural Resources and the minister were clearly pursuing a development agenda. The department's hydrological modelling indicated significant downstream effects, low flows being particularly vulnerable to proposed low-threshold extraction conditions.

Had it not been for a change of government after the state parliamentary election of 1998, the Draft Water Management Plan would have been adopted and an irrigation industry would have been established on the Cooper. From 1998 to 2012 (14 years), the Labor Government in Queensland reversed the direction chosen by the National Party and implemented several important legislative instruments for protection of the Channel Country rivers. The Minister for Natural Resources, Rod Welford, introduced the new Water Management Plan for the Cooper in September 1999, ruling out any new irrigation development or water harvesting, and preserving natural flows almost in their entirety. Existing entitlements (e.g. town water supplies, riparian stock and domestic rights) remained.

Subsequent Ministers for Natural Resources, Stephen Robertson, Kate Jones and Vicki Darling, confirmed and strengthened these levels of protection. This direction was slightly altered with the development of a Water Resource Plan for the Georgina–Diamantina system, which allowed 10 000 ML irrigation entitlement (see Chapter 20). This resulted primarily from local pressure to allow for diversification and the support of the water agency, a common theme in the promotion of irrigation development. Otherwise the Georgina–Diamantina Water Management Plan conformed to the 10-year review, which strengthened protection in the Cooper system, with important new controls of overland flow water available under the revised *Water Act 2000*.

In 2011, the greatest level of protection was achieved when the Cooper, Diamantina and Georgina Rivers were declared Wild Rivers under the *Wild Rivers Act 2005* (see Chapters 20–22). Wild River declarations were important legislative instruments which could coordinate and trigger protections for declared rivers and specific areas within an array of other legislation, potentially affecting sustainability, including the *Water Act 2000* and its Water Resource Plans, the *Sustainable Planning Act 2009*, the *Environmental Protection Act 1994*, and the *Mineral Resources Act 1989* (see Chapters 20 and 21). Much of the regulation within the *Wild Rivers Act 2005* and Wild River declarations controlling mining and petroleum resource activity was coordinated through corresponding provisions of the *Environmental Protection Act 1994*. Importantly, the Wild Rivers legislation locked in regulatory controls over water take in the Water Resource Plans. The *Wild Rivers Act 2005* and declarations afforded stronger levels of protection according to ecological sensitivity of the river, wetland and floodplain environments in particular areas than other legislation: High Preservation and Special Floodplain Management Areas (see Chapter 20). These regulations controlled or prohibited potentially damaging developments such as intensive agriculture, intensive animal husbandry (feedlots) and, most importantly, mining in the designated areas. They did not impede traditional pastoralism or other industries such as tourism.

The coordinated protections afforded under the *Wild Rivers Act 2005* were not achievable under piecemeal application of instruments, available under other legislation. Sadly, the state election of 2012 heralded the end of these protections, when the Liberal National Party (2012–15) of Premier Newman, Deputy Premier Seeney and Minister for Natural Resources and Mines, the Honourable Andrew Cripps, introduced a raft of legislative changes repealing the *Wild Rivers Act 2005* and declarations (see Chapters 20 and 21), amending the *Water Act 2000* to give unlimited water to mining and petroleum exploration and production as a statutory right, and severely curtailing democratic rights to object to mining and resource industry activities. The Western Rivers Advisory Panel, set up by Minister Cripps, was largely a sham, with local stakeholders such as the Cooper's Creek Protection Group, conservation organisations and South Australian interests denied representation. However, even this panel, containing some pro-development people, advised in favour of strong protection for the rivers of the Lake Eyre Basin (Western Rivers Advisory Panel 2013), particularly protection from unconventional gas extraction (CSG and shale gas). This advice was ignored by Minister Cripps and his Cabinet colleagues when they unleashed their unabashedly pro-mining (petroleum resource development) legislative agenda. The unfortunate consequence is that currently the rivers, wetlands, floodplains and all landscapes, water resources and ecosystems that make up the Lake Eyre Basin are facing their greatest threat ever. This is the threat of shale gas development involving the process of hydraulic fracturing.

Conclusion

While important protective instruments, such as the Wild River declarations, can be overturned at will by growth-obsessed governments, the future of our natural environment is fragile. Meanwhile, it is vitally necessary to continue the battle:

> In peace, there's nothing so becomes a man
> As modest stillness and humility,
> But when the blast of war blows in our ears,
> Then imitate the action of the tiger;
> Stiffen the sinews, conjure up the blood,
> Disguise fair nature with hard-favoured rage;
> Then lend the eye a terrible aspect;'

Shakespeare, *Henry V*, Act 3, Sc.1, lines 3–9

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18

River and wetland health in the Lake Eyre Basin – an economic perspective

Mark Morrison

Introduction

Many of the world's natural resources form part of the economic sphere, and rivers and wetlands are no exception. For example, considerable amounts of the world's water resources are diverted for irrigated agriculture, providing economic value through production of food and fibre. Many mining developments also use water resources in their production. There are also social, economic and environmental costs of such developments which are often not well accounted for; these are described as externalities and can be a cause of market failure.

Economists include the environment in economic assessments by deriving monetary values. This requires estimation of values for changes in environmental quality, which is often a difficult challenge as natural resources are typically not traded in markets but many policy decisions are influenced by economic values. Rivers and wetlands and their dependent biodiversity have values which need to be measured to provide an open and transparent recognition of the impacts of economic development activities. For example, a key question for the Lake Eyre Basin rivers is to identify the costs and benefits of irrigation or mining developments, two of the highest profile potentially deleterious developments affecting the rivers. There are no economic valuations of the rivers and wetlands in the Lake Eyre Basin, but there is increasing understanding of the importance of identifying the economic value of changes to environment quality in developed rivers. Consequently, I use current understanding of the economic values of the environment for the developed nearby Murray–Darling Basin to illustrate the magnitude of likely values in the Lake Eyre Basin.

Economic values of the environment

There are two types of economic values for the environment: use and non-use values (Morrison and Hatton-MacDonald 2010). First, use value comes from using a good (e.g. water) either directly or indirectly. For example, direct use includes recreation by locals and tourists to the river (see Chapter 13), and amenity value from living near an environment in good condition. Direct use also includes commercial fishing and grazing livestock on the rivers and floodplains of the Lake Eyre Basin (Fig. 18.1; see Chapters 10 and 11). Indirect use values reflect the indirect benefits to people from environmental quality. This might include the organisms in the environment. For example, waterbirds may help control locust plagues; trees provide shade for livestock; and wetlands improve water quality. These direct and indirect use values are often called ecosystem service values.

Fig. 18.1. There are many direct economic benefits from the rivers of the Lake Eyre Basin, including pastoralism and increasingly tourism, with visitors keen to experience the wonder of the outback rivers such as the Thomson River near Longreach (photo, A. Emmott).

Non-use values are different from direct or indirect use of the resource. For example, many people live a long way from the Lake Eyre Basin but they still care about its long-term sustainability, even if they never visit it. For example, people in Brisbane or Sydney may be willing to pay to maintain its quality. This type of value is called an existence or non-use value (Pearce and Markandya 1989). Non-use values occur for several reasons. People might simply value existence; care about it for their children or grandchildren; care that others have the opportunity to experience its environment; or feel it is their stewardship or spiritual responsibility to look after the Lake Eyre Basin. This was indicated during the proposed development of Cooper Creek in 1995 (see Chapter 17), when there was a groundswell of concern from communities around Australia about the potential impact on the values of the Lake Eyre Channel Country (see Chapter 7). These non-use values are likely to dominate any economic value assessment because the people living away from such a remote region dominate the numbers who gain their direct use value from the region.

Together, these use and non-use values make up total economic value. It is possible to identify the total use value for the Lake Eyre Basin rivers and wetlands. We could measure how much income is derived for all of the pastoralists who derive an income from the floods of the Lake Eyre Basin. We could also conceivably measure the impact of tourism from the

Lake Eyre Basin rivers, though neither of these valuation exercises has previously been done. Contrastingly, it is only possible to identify a change in non-use value. Thus economists calculate the total use but their estimate of non-use value focuses on how value changes with a new resource use option. Economists cannot calculate the total use and non-use value of a wetland or river.

Measuring the economic value of the environment

How does an economist estimate the economic values of the wetlands and rivers of the Lake Eyre Basin? There are three broad sets of approaches. First, market-based techniques can be used to estimate economic values for direct and indirect uses of the environment. This includes the productivity approach, which estimates change in economic value. For example, it would be possible to measure the loss of economic value of flooding for grazing in the Channel Country of the Lake Eyre Basin, if irrigation diverted water from the Thomson River upstream. Further, in the group of market-based techniques, replacement or damage costs can be used to estimate values where there is a loss of an ecosystem service and there is a need to develop an alternative to replace the service. For example, destruction or degradation of a wetland may remove its ecosystem service of purifying water or tourist value, requiring a replacement water source. This may require establishing a new water treatment plant or treating water to a higher level of quality where the cost of replacement indicates the value of the resource. This approach could be used in the context of rehabilitating the pollution effects of the Lady Annie Mine (see Chapter 19). Another example is the reductions in flows to the lower River Murray, which required governments to spend more than $2.4 billion, including a desalination plant for Adelaide that was highly reliant on the River Murray for its water supply (Kingsford *et al.* 2011).

The second set of approaches is the revealed preference techniques. These use information from related markets to estimate values. One commonly used technique is the travel cost approach for estimating recreational use values. For example, we can tell something about the recreation value people have for a destination such as a wetland by how much they would spend in getting to their location in terms of travel cost and time. People are clearly prepared to spend a lot of money visiting Lake Eyre (see Chapter 13). We know that as the cost goes up, people tend to visit less often and consequently it would be expected that there may be proportionally less visitation for people further away. This relationship allows estimation of a demand curve for identifying recreation value. A second revealed preference technique is hedonic pricing, which involves using property prices to identify environmental values. An expectation is that house prices change with environmental quality; this technique separates the change in economic value due to changes in environmental quality from the characteristics of the house or community. This informs about the amenity value of the local environment. For example, if there were a decline in the vegetation of the Channel Country along the Diamantina River, this might affect property values.

Finally, there are stated preference techniques, with contingent valuation and choice modelling, the two most widely used. Contingent valuation involves estimating non-market values through directly questioning respondents about their willingness to pay for specific

Table 18.1. Example of choice modelling, comparing different features of river health from the River Murray (based on MacDonald *et al.* 2011). Respondents could be asked to choose one of the three options (A, B, C), assuming this was their only choice.

Features	Maintain current (option A)	Improve quality of the River Murray and Coorong (option B)	Improve quality of the River Murray and Coorong (option C)
Waterbird breeding along the River Murray	Every 10 years	Every seven years	Every year
Native fish	10% of original population	20% of original population	40% of original population
Healthy riverside vegetation	50% of original area	60% of original area	60% of original area
Waterbird habitat in the Coorong	Poor quality	Good quality	Poor quality
Household cost ($/year for 10 years)	$0	$50	$250

options. Respondents are presented with a description of a change (e.g. a project to improve the quality of a wetland), and a question is asked to identify their willingness to pay for this change to occur. Respondents evaluate a single scenario, indicating whether they would vote in favour or against it, or how much they would be willing to pay to achieve the scenario. For example, would you vote in a referendum in favour of every householder in New South Wales paying $100 to restore the Macquarie Marshes, a wetland affected by water resource development (see Chapter 16)?

Choice modelling has become increasingly popular, particularly in Australia. In choice modelling, the goods and questions are described and asked differently to those in contingent valuation. In choice modelling, respondents evaluate several scenarios, defined using a fixed set of attributes which change across scenarios. For example, this may include changes to the area of native vegetation or number of native fish (Table 18.1). Respondents would then choose between alternatives described, using these features and a household cost. Before making such a choice, they would also receive information about the environmental condition of the river, based on the latest current understanding, what has led to any decline, and what options are available to improve environmental quality. These choices are repeated for individuals several times. The repeated choices provide insight into how respondents' choices change with different levels of the attributes and household cost. This provides a measure of how much respondents are willing to pay for each attribute. For example, if increasing the frequency of waterbird breeding by a year has the same effect on the probability of people choosing an option as reducing household costs by $20, this indicates that household willingness to pay to increase frequency of waterbird breeding by a year is on average $20.

Economic value of rivers and wetlands – the Murray–Darling Basin

Wetlands and rivers around the world have considerable economic value, as has been demonstrated using these methods (Brander *et al.* 2006). In Australia, there is also growing understanding of the economic value of wetlands and rivers of the Murray–Darling Basin (Table 18.2).

Table 18.2. Summary of estimates of the economic value of different ecological attributes of wetlands in the Murray–Darling Basin, based on what households are willing to pay (based on Morrison and Hatton-MacDonald 2010).

Ecological attributes	Description	Economic value (per household)	References
Native floodplain vegetation	Additional 1000 ha of healthy vegetation	$1–5	Whitten and Bennett 2001; Morrison and Bennett 2004; Hatton-MacDonald and Morrison 2005; Bennett *et al.* 2008b
	1% improvement in area of healthy vegetation	$2.20–5.70, apart from $13.72 for River Murray	Morrison and Bennett 2004; Rolfe *et al.* 2006; Bennett *et al.* 2008a
Native fish species and populations	Native fish species present 1% increase in native fish populations	$3.30–3.50 per species $0.50–5.10, apart from $15.40 for River Murray	Morrison and Bennett 2004 Whitten and Bennett 2001; Bennett *et al.* 2008a; Bennett *et al.* 2008b
Waterbird breeding	Willingness to pay to increase the frequency of colonial waterbird breeding in major wetlands in the Murray–Darling Basin	$14–34/year (increased frequency), apart from $65/year for River Murray	Morrison *et al.* 1999; Morrison 2002; Morrison *et al.* 2002
Waterbirds and other species	Habitat for endangered/protected/threatened species Number of waterbirds and other species with sustainable populations	$4.3–7.4 per species $3.9 per species	Morrison 1999; Whitten and Bennett 2001; Morrison 2002; Morrison *et al.* 2002; Morrison and Bennett 2004 Bennett *et al.* 2008a

Using the value estimates presented in Table 18.2, economic values for the different attributes of wetlands and rivers were identified for each of the 19 catchments of the Murray–Darling Basin (Table 18.3). These values were extrapolated across households in the state in which the catchment was predominantly located, except for the River Murray where estimates were for all states and territories.

These value estimates were then used to identify the economic benefits associated with the Murray–Darling Basin Plan (Centre for International Economics 2011). This involved collecting background information for each of the catchments in the Murray–Darling Basin about how much different ecological attributes were improved by the Murray–Darling Basin Plan, which included increasing water for the environment. The expected change in each ecological attribute was then multiplied by the household value for a unit change, in each of the attributes, and then by the number of households, after adjusting for non-respondents. The least conservative approach for aggregating economic value assumed that all households in the state where a catchment was located had the average sample value. Non-respondents to

Table 18.3. Estimates of economic values in dollars per household (present value, NA = not applicable) of four ecological attributes of the 19 catchments in the Murray–Darling Basin (Morrison and Hatton-MacDonald 2010).

Catchment	Ecological attribute			
	1% increase in native vegetation	1% increase in native fish populations	One-year increase in frequency of colonial waterbird breeding	Unit increase in number of waterbirds and other species present
Barwon–Darling	2.26	0.46	13.87	2.25
Border Rivers	2.19	0.46	NA	1.10
Campaspe	5.69	5.06	NA	3.89
Condamine–Balonne	2.63	0.46	13.87	1.10
Mt Lofty Ranges	5.69	5.06	NA	3.89
Goulburn–Broken	5.69	5.06	NA	3.89
Gwydir	2.19	0.46	13.87	1.10
Lachlan	2.19	0.46	13.87	1.10
Loddon–Avoca	5.69	5.06	NA	3.89
Macquarie–Castlereagh	2.19	0.46	33.08	1.10
Moonie	2.63	0.46	13.87	1.10
Murray	13.72	12.80	65.11	3.43
Murrumbidgee	2.26	0.46	13.87	2.25
Namoi	2.19	0.46	NA	1.10
Ovens	5.69	5.06	NA	3.89
Paroo	2.63	0.46	13.87	1.10
Snowy Mountains Scheme	NA	NA	NA	NA
Warrego	2.63	0.46	NA	1.10
Wimmera	2.19	0.46	NA	1.10

the survey were unlikely to have the same economic value as respondents and so adjustments were made for this (Morrison and Hatton-Macdonald 2010). Values were aggregated only for the Murray River, across Australian households in all states and territories. However, sensitivity analysis determined the effects of either fully or partly extrapolating values for these wetlands, to households outside their state. Most of the value estimates were for single-year payments. In the few cases where willingness to pay involved payment over more than one year, amounts in later years were discounted and summed. This allowed an estimation of non-use values across the Murray–Darling Basin and produced a range of non-use values for a unit change in each of the four attributes, after aggregation across households (Table 18.4).

Such estimates allowed policy-makers to consider the economic benefit for the environment, of providing more water (i.e. improving the rivers which were seriously degraded), across the 19 river catchments. Each value estimated the non-use value for the community of a unit change in the attribute, such as a 1% change in native fish populations.

Table 18.4. Estimated economic values ($) per household (present value, NA = not applicable) of improvements in four ecological attributes for each of 19 river catchments, across the Murray–Darling Basin (Morrison and Hatton-Macdonald 2010).

For all catchments apart from the River Murray, values (Table 18.3) were aggregated across all households in the state where the catchment was located (with an adjustment for non-respondents).

Catchment	Ecological attribute			
	1% increase in native vegetation	1% increase in native fish populations	1 year increase in frequency of colonial waterbird breeding	Unit increase in number of waterbirds and other species present
Barwon–Darling	$3 594 000	$667 000	$24 693 000	$3 578 000
Border Rivers	$2 437 000	$414 000	NA	$1 086 000
Campaspe	$3 363 000	$2 990 000	NA	$2 299 000
Condamine–Balonne	$2 926 000	$414 000	$15 337 000	$1 086 000
Mt Lofty Ranges	$1 494 000	$1 329 000	NA	$1 022 000
Goulburn–Broken	$5 019 000	$4 463 000	NA	$3 431 000
Gwydir	$3 482 000	$667 000	$24 693 000	$1 749 000
Lachlan	$3 482 000	$667 000	$24 693 000	$1 749 000
Loddon–Avoca	$3 363 000	$2 990 000	NA	$2 299 000
Macquarie-Castlereagh	$3 482 000	$667 000	$58 802 000	$1 749 000
Moonie	$1 961 000	$277 000	NA	$728 000
Murray[a]	$79 098 000	$73 794 000	$375 369 000	$12 203 000
Murrumbidgee	$3 594 000	$667 000	$24 693 000	$3 578 000
Namoi	$3 482 000	$667 000	NA	$1 749 000
Ovens	$3 363 000	$2 990 000	NA	$2 299 000
Paroo	$2 598 000	$414 000	$15 337 000	$1 086 000
Snowy Mountains Scheme	NA	NA	NA	NA
Warrego	$2 598 000	$414 000	NA	$1 086 000
Wimmera	$2 660 000	$509 000	NA	$1 336 000

[a] Values from Table 18.3 were aggregated across all Australian households (with an adjustment for non-respondents).

To make use of these value estimates in a cost–benefit analysis, changes in attributes needed to be estimated, along with changes in policy position. For example, if native fish populations in a catchment changed by 10%, due to improvements in fish habitat, then the estimate (Table 18.4) for the appropriate catchment needed to be multiplied by 10.

In addition, the recreation values in each catchment have economic value, which can be estimated where identifiable. General recreation was valued at $55.40 per trip; recreation at dams or lakes was valued at $35.98 per trip; recreational trips at wetlands ranged from $270.13 to $561.28 per trip; while fishing at dams or lakes was valued at $355.90 per trip.

To calculate the aggregate change in recreation value, the change in the total number of visits would need to be calculated and then multiplied by the appropriate value. Changes in recreation value can be added to the change in non-use values to calculate the change in total

Fig. 18.2. The Coorong, Lower Lakes and Murray Mouth are listed as a wetland of international importance with environmental values, with significant economic values (Tables 18.5 and 18.6).

economic value. Values for the Coorong wetland were estimated separately, given its significant economic value, with an improvement from poor to good quality estimated to deliver $4.3 billion in non-use value (MacDonald *et al.* 2011).

The Centre for International Economics (2011) subsequently estimated the economic value of environmental benefits from the Murray–Darling Basin Plan. In this cost–benefit analysis, values were included only for changes in native fish populations, the frequency of waterbird breeding and the state of the Coorong, Lower Lakes and Murray Mouth (Fig. 18.2) because of a lack of ecological response data for the other ecological attributes. Aggregate value estimates (net present benefit) were $3750 million for a 3000 GL/year reallocation, $4760 million for a 3500 GL/year reallocation, and $5430 million for a 4000 GL/year reallocation of irrigation water to the environment, excluding an improved Coorong, which increased the overall estimate to $9704 million. Improvement in the state of the Coorong (from poor to good) was expected to occur only for the 4000 GL/year reallocation. Sensitivity analyses were done, including using alternative value estimates (Van Bueren and Bennett 2004) and a meta-analysis (Rolfe and Brouwer 2011).

Overnight visitor numbers were respectively estimated to increase for different scenarios of returning annual environmental flows to the Murray–Darling Basin: 113 452 for 3000 GL/year, 133 463 for 3500 GL/year and 153 212 for 4000 GL/year. These changes in visitation were combined with value estimate of $585 per overnight trip to derive the aggregate change in recreation value. Other estimates were derived for changes in costs associated with salinity, flooding and dredging. As a result, it was possible to estimate the

Table 18.5. Increases in non-use and use values and decreases in irrigated agricultural economic values (NA = not available), for three scenarios of water returned to the environment, evaluated in the cost–benefit analysis for the Murray–Darling Basin Plan (Centre for International Economics 2011).

Economic value	Cost ($x million) of environmental flow scenarios			
		3000 GL	**3500 GL**	**4000 GL**
Non-use values	Values for changes in fish population and waterbird breeding	$3750	$4760	$5430
	Values for the Coorong	NA	NA	$4274
Use values	Recreation	$490	$562	$649
	Salinity	$91	$87	$84
	Cost of flooding	$2	$2	$2
	Cost of dredging	$13	$14	$14
Irrigated agriculture[a]	Lower estimate	$924	$1107	$1309
	Higher estimate	$4491	$5789	$7329

[a] Lower cost estimates resulted from assuming and elasticity of demand of -0.5 for water (i.e. more elastic, so reduced water availability had less effect on water prices) and there was no baseline growth in the real price of water. High cost estimates resulted from assuming that there was an elasticity of demand for water of -0.05 (i.e. more inelastic demand, so reduced water availability had an increased effect on water prices) and that the baseline real price of water grew by at ~8%/year.

increase in non-use and use values and decreases in economic value from irrigated agriculture, resulting from the redirection of water from irrigated agriculture to the environment of 3000–4000 GL/year (Table 18.5). The Australian Government agreed to return 2750 GL/year to the environment under the Murray–Darling Basin Plan, although this figure is recommended to be further reduced by 70 GL/year in the Darling River catchments (Murray–Darling Basin Authority 2016).

A 3000 GL/year increase in environmental flows substantially increased use and non-use values (over $3300 million), which exceeded the lower estimate for costs to irrigated agriculture (Table 18.5). Even when high costs to irrigation were used, use and non-use values were only $145 million less (Table 18.5). Similar results held for a 3500 GL/year reallocation, with an increased cost to irrigation, using the high estimate (Table 18.5). For the 4000 GL/year increase in environmental flows, including values from improvement of the Coorong and Lower Lakes, the use and non-use values substantially exceeded both the lower and higher irrigation cost estimates, by $9.1 billion and $3.1 billion respectively (Table 18.5).

This evaluation excluded various non-use values associated with improved environmental quality, including changes in vegetation, waterbirds and other organisms. It also excluded other use values. For example, the evaluation did not include the value of grazing to the livestock industry, resulting from increased flooding (Chapter 11). For example, 15 years of flooding added $6.8 million in gross profit to three grazing properties on the Paroo River (Arche Consulting 2010). There were also insufficient data to apply this more widely across the entire river basin.

Given considerable challenges in identifying the full range of environmental benefits for cost–benefit analysis of the Murray–Darling Basin Plan, CSIRO and researchers from several universities evaluated changes in ecosystem service values of the Murray–Darling Basin, with different scenarios of increased environmental flows for the Murray–Darling

Basin Plan (Prosser *et al.* 2012). This involved consideration of the return of 2800 GL/year of environmental water, less reallocation than previously modelled but close to the final provision in the Murray–Darling Basin Plan (2750 GL/year). They identified a wide range of ecosystem services benefiting from increased environmental flows (Table 18.6). Carbon sequestration was one of the large-valued ecosystem services (Table 18.6). Other values of erosion prevention and household salinity were smaller. There were also substantial changes to amenity value, with property prices near Barmah–Millewa Forest, the Lower Darling river system, the Mid-Murrumbidgee River Wetlands and Lake Alexandrina increasing overall by $353 million, due to increased river flows. Increased values for tourism were identified, with more flows along the River Murray adding $161 million/year (Table 18.6) to the present value of $490–649 million, previously calculated (Centre for International Economics 2011).

Substantial use values were either excluded or underestimated in the first cost–benefit analysis of the Murray–Darling Basin Plan (Centre for International Economics 2011), compared to the subsequent estimates (Prosser *et al.* 2012), which included values for carbon sequestration, changes in property prices and recreation (Table 18.6).

Neither study aggregated the individual value estimates produced across the Murray–Darling Basin. Using Prosser *et al.* 2012, this would have produced an estimated

Table 18.6. Estimates of economic value of ecosystem services in the Murray–Darling Basin in response to improved flows in the rivers with 2800 GL/year of water reallocated from irrigated agriculture to the environment (Prosser *et al.* 2012).

Ecosystem service	Estimated value ($x million)	Description[a]
Carbon sequestration	126–1041	Present value
Erosion prevention	23.8	Present value
Reduced household costs from salinity	3.1	Annual
Reduced agricultural costs from salinity	29	Annual
Recreation benefits from reduced blackwater events	5–10	Annual
Reduction in acid sulphate soil	9.2	Annual
Reduction in costs of dredging the Murray Mouth	3.6	Annual
Increased property prices	311 (Coorong, Lower Lakes and Murray Mouth) 15.5 (Lower Darling river system) 1.3 (Barmah–Millewa Forest)	Present value
Tourism on the River Murray	161	Annual
Non-use values[b]	$7.7 billion (return of 2800 GL/year, including the Coorong) $3.4 billion (return of 2800 GL/year, excluding the Coorong) $3.9 billion scenario 3 (return of 2800 GL/year, with values for the Coorong adjusted by ecosystem state)	Present value

[a] 'Present value' refers to the current value of the future stream of benefits. 'Annual value' refers to the value of the benefits that will occur each year.
[b] Increased value from native vegetation, native fish populations and frequency of waterbird breeding, and improved quality of the Coorong.

total economic value of $6.2–11.5 billion, with the increased 2800 GL of environmental water each year. This contrasts with the aggregate value of $4.4 billion (Centre for International Economics 2011), estimated for return of 3000 GL of environmental water each year. The increased valuation relates to increased knowledge of the considerably increased economic benefits from improving or maintaining environmental quality, through water reallocations.

Implications for the Lake Eyre Basin

There are challenges in valuing river and wetland health in the Lake Eyre Basin, with no previous environmental valuation studies. There is also no policy need to improve degraded wetlands and rivers, such as in the Murray–Darling Basin. But the principles remain the same. It is critical to understand the real economic values to the community of use and non-use environmental values, such as those identified in the Murray–Darling Basin (Table 18.6). Relatively few people live within the Lake Eyre Basin and so there are limited direct or indirect use economic values, except for grazing (see Chapters 10 and 11) and tourism (Chapter 13). However, the Lake Eyre Basin is a unique and iconic system and so there are likely to be significant non-use values. Some understanding of the potential economic values can be gained through benefit-transfer from the Murray–Darling Basin. For a free-flowing river system such as in the Lake Eyre Basin, the decision will primarily be whether to allocate water resources from the environment, such as irrigation or mining (see Chapter 22), and should be made using a cost–benefit analysis.

There is high economic value from irrigation in the nearby Condamine ($457 million/year) and Border Rivers ($245 million/year) in the Queensland (Nguyen *et al.* 2012) part of the Murray–Darling Basin. This gross value cannot simply equal the value of irrigation. It does not take account of the change in the productivity of the land from use of irrigation, nor does it take into account environmental costs. It also does not adequately measure the downstream impact on other economic uses of water (see Chapters 14 and 15) and neither does it adequately include the costs of building and maintaining large public infrastructure, such as dams or the costs of regulating and managing the river for irrigation. These are all government subsidies for irrigation. Currently, the economic value of irrigation is low from the Lake Eyre Basin rivers because of the relatively small amounts of active irrigation and absence of a large dam.

The development of mining projects, including coal mines and coal seam gas (CSG) projects, could also affect the connectivity of wetlands and river flows (see Chapter 22), with other associated environmental costs, impacting on river health (see Chapter 19). Using Computable General Equilibrium (CGE) modelling, gross regional product was predicted to increase by about $470 million/year with the development of the CSG industry in north-west New South Wales (Williams *et al.* 2012) – an estimate which did not include environmental costs.

Given the current understanding of the environmental values and costs of the Murray–Darling Basin development, environmental costs from development of the Lake Eyre Basin rivers will also be substantial. Use values, such as grazing, are substantial but remain largely unquantified, while non-use values are likely to be considerable given its iconic status (see Chapter 7). There are also considerable recreation values, given the amount of tourism and the distances people are willing to travel (see Chapter 13). The costs to the environment will not be just the cost to Lake Eyre, but also the cost in the decline in river health in its unique rivers: Cooper Creek, and the Diamantina and Georgina Rivers. There are also likely to be impacts on cultural values, both Aboriginal (see Chapters 8 and 9) and European. Consequently, development of either irrigation or mining resources in the Lake Eyre Basin will probably come with considerable costs that need to be adequately accounted for, not just the economic values of outputs.

Conclusion

I have outlined the nature of economic values for the environment and how they can be estimated. Economic value estimates for improved river health have been estimated for the Murray–Darling Basin, where they are related to improved flows in a highly regulated river system. Apart from this, it has many similar environmental values to the Lake Eyre Basin, providing a useful comparison. The estimation of the benefits of returning water to the Murray–Darling Basin have shown there are considerable economic values for the environment of the Murray–Darling Basin, which would probably be similar for the Lake Eyre Basin. Non-use values dominated in the Murray–Darling Basin, but there were also substantial economic values resulting from ecosystems services, also known as direct and indirect use values. Given the relatively marginal value of intensive agriculture in the Lake Eyre Basin, and the lack of a major dam, the additional economic value from establishing irrigated agriculture would be unlikely to exceed the economic costs. Similarly, the economic value of additional coal or CSG mining developments, particularly given the downward trajectory of coal prices and gas prices, is unlikely to exceed the economic costs from reduced environmental quality where it affects the rivers of the Lake Eyre Basin.

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19
Mining and the Lake Eyre Basin environment – past, present and possible futures

Gavin M. Mudd

Introduction

The extraction of mineral and energy resources has a varied history across the Lake Eyre Basin, especially on its fringes, growing considerably since the 1960s. Given the recent mining and energy boom, especially coal, coal seam gas (CSG) and base metals, resource extraction will grow around and within the Lake Eyre Basin. This brings benefits in minerals, metals or energy resources and economic activity, but it also brings substantial environmental risks, if not managed well. This has always been the heart of the mining debate – balancing risks and benefits – ideally within the ecological resilience of the local, regional and global environment. Georgius Agricola, one of the earliest scholars of metal mining, recognised this in the 16th century in his treatise *De Re Metallica* (Agricola 1556, p. 8):

> [T]he strongest argument of the detractors is that the fields are devastated by mining operations … Also they argue that the woods and groves are cut down, for there is need of an endless amount of wood for timbers, machines, and the smelting of metals. And when the woods and groves are felled, then are exterminated the beasts and birds, very many of which furnish a pleasant and agreeable food for man. Further, when the ores are washed, the water which has been used poisons the brooks and streams, and either destroys the fish or drives them away. Therefore the inhabitants of these regions, on account of the devastation of their fields, woods, groves, brooks and rivers, find great difficulty in procuring the necessaries of life … Thus it is said, it is clear to all that there is greater detriment from mining than the value of the metals which the mining produces.

Agricola, a firm supporter of mining and its products for society, clearly understood the significant environmental and social risks. His warnings are just as relevant today to the management of the Lake Eyre Basin: balancing the benefits of economic development against the social and environmental risks. Sustainable management of the Lake Eyre Basin is at stake. I review the status of mineral and energy resources within and adjacent to the Lake Eyre Basin, key production trends, potential environmental impacts and risks, illustrated by case studies from important sectors or accidents. Finally, I consider the implications for the future sustainability of the Lake Eyre Basin.

Mineral and energy resources and the Lake Eyre Basin

Mining within and around the margins of the Lake Eyre Basin has focused mainly on petroleum, base metals (copper, lead and zinc) and some gold mining. These remain the commodities for future developments, along with substantial coal, CSG and, potentially, shale gas and tight gas projects (e.g. Geoscience Australia and Australian Bureau of Agricultural and Resource Economics 2010). Mineral deposits and energy resources are associated with the major geological provinces, including the Mount Isa Block and Galilee Basin, the Arckaringa Basin and Stuart Shelf, the Pedirka Basin and the Willyama (Broken Hill) Block (Fig. 19.1). Water remains one of the most critical resources, potentially constraining or affected by these developments (see Chapter 20). This includes changes to flood waters which periodically flow through the Lake Eyre Basin rivers and the underlying groundwater resources in the Great Artesian Basin (see Chapter 1).

There are substantial mineral and energy commodities available for production, compared to annual production in and around the Lake Eyre Basin (Table 19.1). For the

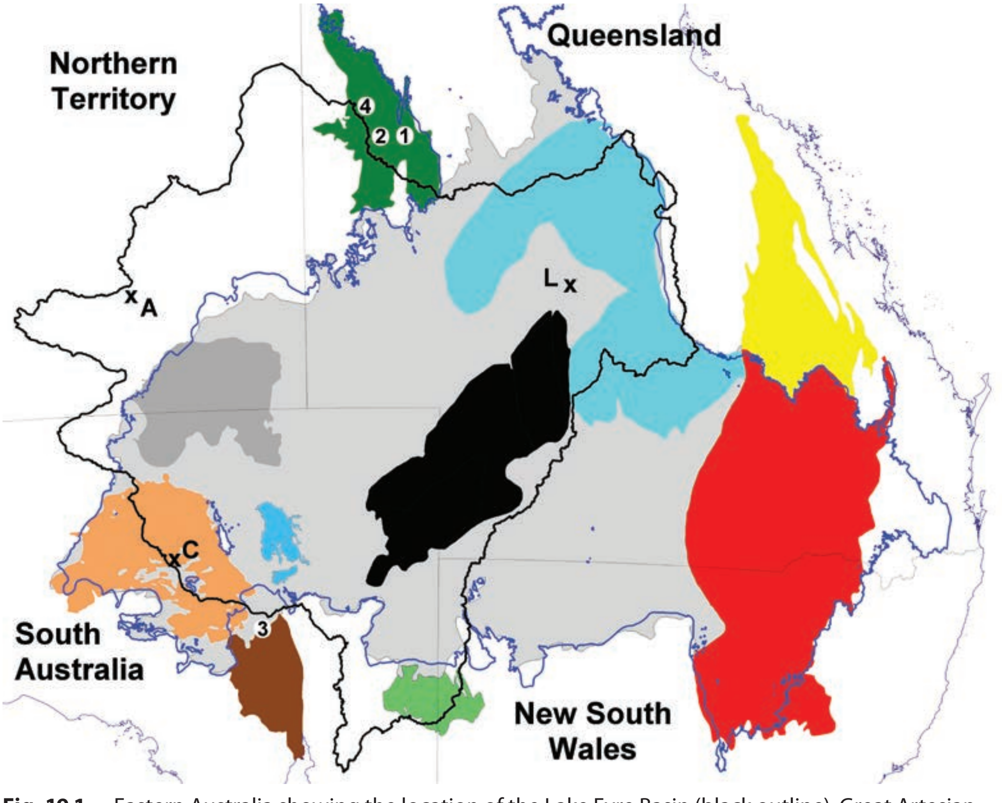

Fig. 19.1. Eastern Australia showing the location of the Lake Eyre Basin (black outline), Great Artesian Basin (blue outline), major geological basins or blocks (Ackaringa Basin (orange), Bowen Basin (yellow), Cooper Basin (black), Eromanga Basin (light grey), Galilee Basin (light blue), Mount Isa Block (dark green), Pedrika Basin (dark grey), Surat Basin (red), Willyama (Broken Hill) Block (light green), major towns (marked x, Alice Springs – A, Coober Pedy – C, Longreach – L, 2 – Mt Isa) and the locations of four case studies (filled circles, 1 – Mary Kathleen uranium mine; 2 – Mount Isa lead-zinc-silver-copper mining complex; 3 – Olympic Dam copper-uranium-gold-silver mining complex; 4 – Lady Annie copper mine).

Table 19.1. Volumes of available resources and production of mineral and energy commodities in 2013, within and adjacent to the Lake Eyre Basin, including the proportions relative to available Australian resources and annual production in parentheses.

Units include tonnes (t), thousand tonnes (kt), million tonnes (Mt), million litres (ML), and peta (10^{15}) joules (PJ) for energy.

Major geological province	Commodity	Available Resources	Production in 2013
Mount Isa Block	Copper (Cu)	16.11 Mt (11.6%)	248.4 kt (24.9%)
	Lead (Pb)	29.60 Mt (50.4%)	431.1 kt (60.6%)
	Zinc (Zn)	46.52 Mt (79.2%)	956.7 kt (62.8%)
	Gold (Au)	418.6 t (2.8%)	6.88 t (2.6%)
	Uranium oxide (U_3O_8)	103.9 kt (3.0%)	0
	Rare earth oxides (REOs)	0.90 Mt (1.5%)	0
	Iron (Fe) ore	328 Mt (0.2%)	0
Galilee Basin	Black coal	35 300 Mt (20.8%)	0
Arckaringa Basin	Brown coal	11 131 Mt (4.9%)	0
Eromanga Basin	Black coal	5941 Mt (3.5%)	0
Cooper-Eromanga Basin	Conventional gas	1906 PJ (1.7%)	109 PJ (4.9%)
	Liquefied petroleum gas (LPG)	503 ML (0.3%)	353 ML (3.2%)
	Condensate	5243 ML (1.7%)	250 ML (3.5%)
	Crude oil	16 014 ML (11.8%)	1916 ML (17.6%)
Leigh Creek Field	Black coal	546 Mt (0.3%)	3.2 Mt (0.5%)
Willyama (Broken Hill) Block	Copper (Cu)	0.47 Mt (0.3%)	4.0 kt (0.4%)
	Lead (Pb)	2.37 Mt (4.0%)	51.4 kt (7.2)
	Zinc (Zn)	3.09 Mt (5.3%)	64.2 kt (4.2%)
	Gold (Au)	30.5 t (0.2%)	2.05 t (0.8%)
	Uranium oxide (U_3O_8)	90.3 kt (2.6%)	~300 t (4.7%)
	Rare earth oxides (REOs)	0.05 Mt (0.1%)	0
	Iron (Fe) ore	1985 Mt (1.5%)	0
Stuart Shelf (and nearby)	Copper (Cu)	85.08 Mt (61.2%)	252.0 kt (25.2%)
	Lead (Pb)	0.21 Mt (0.4%)	0
	Zinc (Zn)	0.21 Mt (0.4%)	0
	Gold (Au)	3566.9 t (24.2%)	7.71 t (2.9%)
	Uranium oxide (U_3O_8)	2654 kt (77.0%)	4024 t (62.6%)
	Rare earth oxides (REOs)	52.67 Mt (90.5%)	0
	Iron (Fe) ore	586 Mt (0.4%)	0
Pedirka Basin (and nearby)	Copper (Cu)	0.35 Mt (0.3%)	0
	Lead (Pb)	0.026 Mt (0.04%)	0
	Zinc (Zn)	0.022 Mt (0.04%)	0
	Gold (Au)	3.2 t (0.02%)	0
	Uranium oxide (U_3O_8)	23.5 kt (0.4%)	0
	Rare earth oxides (REOs)	1.22 Mt (2.1%)	0

All mineral resources estimates compiled from company reporting; production data compiled from Australian Bureau of Resource and Energy Economics (2014); Geoscience Australia (2014); Mudd (2014); Office of the Chief Economist (2014); Australian Petroleum Production and Exploration Association (2015); United States Geological Survey (2015).

Fig. 19.2. Typical oil and gas production facility in the Cooper–Eromanga Basin of the Lake Eyre Basin, south of Innamincka (photo, R.T. Kingsford).

conventional petroleum industry in the Lake Eyre Basin, the Cooper–Eromanga Basin (Figs 19.1 and 19.2) continues to be a strategic national resource, making up ~12% of Australia's crude oil resources and represents almost one-fifth of Australian annual production (Table 19.1). Production of conventional gas is still relatively minor, compared to national production (under 2%; Table 19.1), but it remains a critical supply for the eastern gas market (~14.3%). There were no formally reported reserves of unconventional gas (CSG, shale gas and tight gas) in 2013 in the Lake Eyre Basin (specifically the Galilee, Cooper, Pedirka and Arckaringa Basins), but exploration licences are extensive across South Australia and Queensland (Queensland Department of Natural Resources and Mines 2015; Queensland Department of Natural Resources and Mines 2017). There is little coal production, apart from Leigh Creek field, north of Port Augusta in South Australia, just outside the Lake Eyre Basin, which closed in late 2015, but giant projects are under various stages of development in the Arckaringa, Galilee and Pedirka Basins. The Galilee Basin projects are the most advanced, such as Alpha and Kevin's Corner by the GVK Hancock Coal partnership led by Gina Rinehart, China First/Galilee led by Clive Palmer's Waratah Coal, and Carmichael led by India's Adani Mining Group. These massive projects will dwarf existing mines in the Bowen Basin or Hunter Valley if they proceed. One mine could potentially produce up to 60 Mt coal per year (e.g. the Alpha open pits will reach up to 6 km wide by ~24 km long, with about an equal area for infrastructure, tailings dams and overburden dumps).

Mines also produce metals in and around the Lake Eyre Basin, with the Mount Isa and Stuart Shelf (central South Australia) regions accounting for half of Australia's annual production of copper with nearly three-quarters of the nation's remaining copper resources, dominated by the Olympic Dam mine (78.7 Mt copper , Cu). The Mount Isa Block also has most of Australia's lead–zinc (Pb–Zn) resources (Table 19.1), dominated by the Mount Isa mining complex (20.3 Mt Pb, 32.5 Mt Zn). Most of Australia's uranium resources (uranium oxide, U_3O_8) are in central South Australia, dominated by Olympic Dam mine (2.5 Mt U_3O_8), with some uranium from the Mount Isa Block (albeit mostly refractory ores which effectively remain uneconomic). Relatively minor deposits of gold are also mined with other metals, contributing considerably to the economic viability of projects (e.g. Prominent Hill, Olympic Dam, Ernest Henry, Osborne; Table 19.1). Minor metals (silver, cobalt, molybdenum and the rare earth oxides), often found in copper deposits in or near the Lake Eyre Basin, also contribute to production.

There are also rare earth projects around the margins of the Lake Eyre Basin, particularly Olympic Dam (~52.5 Mt). Using 2013 prices for metals – copper $7572/t, uranium ~$95 000/t U_3O_8, gold $46 755/kg, silver $785.6/kg, rare earths (assuming a light-dominant rare earth mix) ~$30/kg (adapted from OCE 2014; United States Geological Survey 2015) – makes the rare earths at the Olympic Dam site worth about $1274 billion, more than the combined worth of copper, uranium, gold and silver ($1004 billion).

'Frontier' areas for mineral and energy exploration (e.g. the Pedirka, Arckaringa and southern Galilee basins) are portrayed as regions for significant hope of discovery and potential development, especially unconventional gas (either CSG, tight gas or underground coal gasification), and although there are some reported coal resources (e.g. Alpha, Carmichael), there are no formal estimates of gas reserves (as of 2013). There is also potential in these basins for underground coal gasification or coal-to-liquids projects, although these methods remain arguably uneconomic and are deeply controversial for their environmental impacts (e.g. Linc Energy near Chinchilla in Queensland). Other relatively minor commodities (e.g. mineral sands or potash) may also prove economically viable, if exploration is successful, though the balance between economic value and environmental and social risks and benefits remains largely untested.

Megatrends and their environmental implications

I now review the history and future for mining developments in the Lake Eyre Basin and immediate surrounds by examining the current understanding of base metal, petroleum and gas and rare earth mining.

Base metals

Australia's production of base metals (copper, lead and zinc) is increasing gradually, dominated by big projects around the margins of the Lake Eyre Basin (e.g. Mount Isa, Cannington, Olympic Dam and Century mines). Megatrends affecting modern mining include declining ore grades; increasing tailings' volumes; increasing use of megapits; increasing project scales; increasing waste rock movements; more environmental scrutiny during assessment and approvals; more stringent regulatory oversight (at least in theory); more complex ores (especially mineralogy) requiring increased grinding and use of processing technology; and more demanding expectations from local communities and interested

Fig. 19.3. Former open cut mine at the Mary Kathleen uranium project, showing active weathering (i.e. sulfide oxidation) of the side walls and the lack of any rehabilitation of the former pit where water quality remains poor (photo, G. M. Mudd).

stakeholders (e.g. investors, shareholders and non-government organisations) (e.g. Mudd 2009; Mudd 2010). As a result, managing and rehabilitating mine wastes is increasingly difficult using standard approaches. I examine these challenges for four mining case studies: Mary Kathleen, Mount Isa, Olympic Dam and Lady Annie. The first three are just outside the margins of the Lake Eyre Basin, but Lady Annie sits across the catchment boundary, with some infrastructure extending into the headwaters of the Lake Eyre Basin. The technical issues and environmental challenges posed by these projects are all symptomatic of the challenges facing the future of mining projects inside or around the Lake Eyre Basin.

Mary Kathleen uranium mine

The former Mary Kathleen uranium mine (Figs 19.1 and 19.3) operated over 1958–63 and 1976–82. It was rehabilitated during 1982–85, winning a national environmental excellence award in 1986 from Engineers Australia, based on three key claims: minimal seepage from the tailings dam; no acid mine drainage; and minimal risks of water quality affecting human health or grazing animals – but each claim has proven incorrect (Lottermoser *et al.* 2005; Lottermoser and Ashley 2008; Lottermoser 2011; Mudd 2014). Further rehabilitation is widely expected to be required, given the exposure of grazing cattle to heavy metals and radionuclides. A challenge, or opportunity, is that the tailings still contain a modest amount of rare earth oxides – opening up the possibility of reprocessing the tailings to extract these and potentially fund further site rehabilitation to a modern standard.

Mount Isa mining complex

The Mount Isa mining complex (Figs 19.1 and 19.4) is among the larger base metal mines in the world. Discovered in February 1923 and brought into production by 1931, it has produced considerable lead–zinc–silver and copper (Table 19.2). The grades of ore milled and remaining resources have declined for lead and silver but remain similar for zinc, while

Fig. 19.4. Mount Isa mining complex, one of the world's largest mines for production of base metals, showing the extent of industrial infrastructure, including the copper and lead smelters, and an open cut mine in the background (photo, R. T. Kingsford).

copper grades have also declined, even though steady until 2003 (Fig. 19.5). The Mount Isa field has had significant historical pollution problems with lead and heavy metals, particularly via airborne dispersion of smelter emissions and dusts. There are ongoing issues affecting public health, especially blood lead levels in children (Munksgaard *et al.* 2010; Taylor *et al.* 2010). Although the lead and copper smelters were to close in 2016, they were recently extended to ~2020, with expansion plans involving two major open cut mines (lead–zinc–silver and copper). These would require the relocation of all milling and smelting plants and

Table 19.2. Cumulative production (1931–2014) and available mineral resource (2014) from the Mount Isa field (updated from Mudd 2009).

Resources	Ore mass (Mt)	Metal	Ore grade	Metal mass
Cumulative production	218.7	Lead	5.4%	8.72 Mt
		Zinc	6.6%	9.88 Mt
		Silver	129 g/t	20.3 kt
	269.9	Copper[a]	3.2%	8.09 Mt
Available resource	704.3	Lead	3.0%	21.4 Mt
		Zinc	5.2%	36.7 Mt
		Silver	59 g/t	41.4 kt
	352.2	Copper	1.4%	4.87 Mt

[a] Includes at least 41.4 t silver

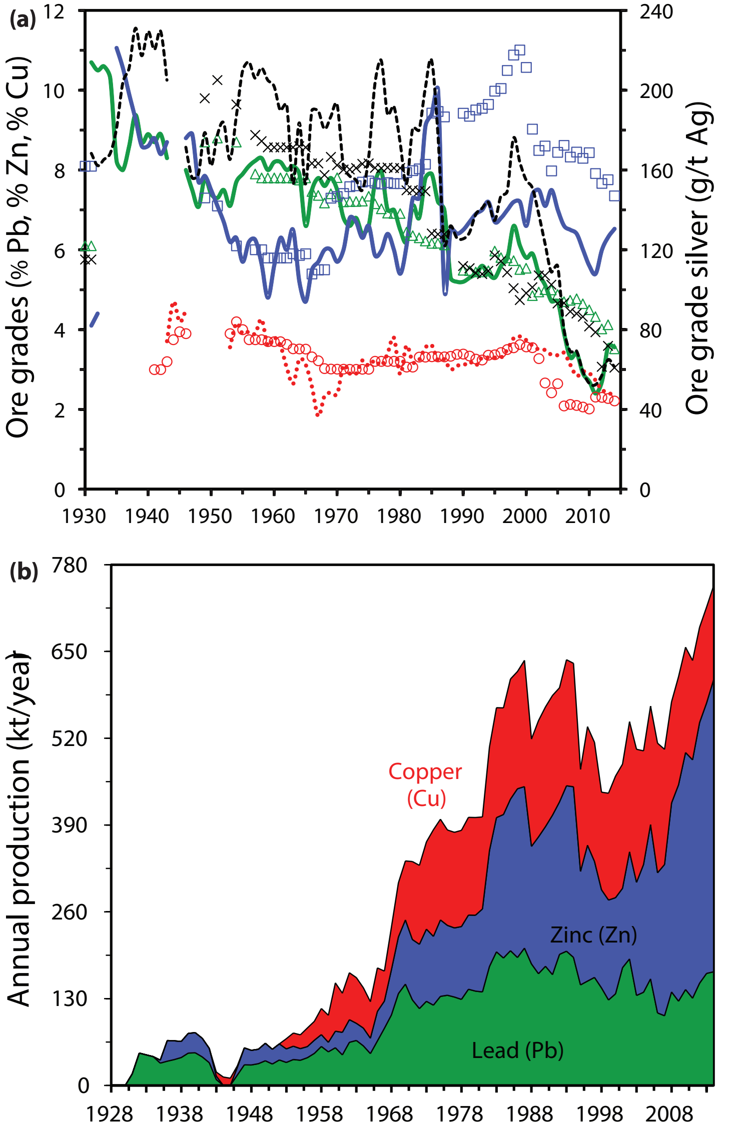

Fig. 19.5. Long-term annual trends (1931–2014) in (a) lead (% Pb) in ore milled (green line) or mineral resources (open green triangles); zinc (% Zn) in ore milled (blue line) or mineral resources (open blue squares); silver (g/t Ag) in ore milled (dashed black line) or mineral resources (diagonal black crosses); and copper (% Cu) in ore milled (dotted red line) or mineral resources (open red circles); and (b) production of lead, zinc and copper from the Mount Isa mining complex (data updated from Mudd 2009).

infrastructure. Plans are yet to be publicly released. Mount Isa still holds substantial mineral resources and could continue for decades. Potential environmental, health and social impacts could increase if the open cut developments proceed, without rigorous baseline assessments and environmental management. Risks to the flows and water quality of the Leichardt River provide significant lessons for the free-flowing rivers of the Lake Eyre Basin.

Fig. 19.6. Olympic Dam, near Roxby Downs in South Australia, is one of the largest copper, uranium, gold and silver projects in the world, and includes an underground mine, ore processing mill, copper smelter, refinery, hydrometallurgical facility and massive above-ground tailings dam (photo, B. Parkhurst).

Olympic Dam

The Olympic Dam (Figs 19.1 and 19.6) copper, uranium, gold and silver project is one of the larger base metal–uranium deposits in the world (Table 19.3), particularly including the potential value of rare earth oxides (Mudd *et al.* 2013; Weng *et al.* 2015). Despite considerable environmental and political controversy, production began in August 1988, with a large underground mine, flotation mill, copper smelter and refinery, and a copper and uranium hydrometallurgical plant. There were plans to develop a megapit, substantially increasing capacity (costing ~$25 billion), but the Fukushima nuclear accident, combined with low commodity prices, forced BHP Billiton to investigate more economical methods to expand the project and extract value. Despite the large quantity and economic value of rare earths (Tables 19.1 and 19.3), used in beneficial modern environmental and consumer technologies

Table 19.3. Olympic Dam cumulative production (1988–2014) and mineral resources (2014).

Data updated from Mudd (2009); Mudd (2014).

Resources	Ore mass (Mt)	Metal	Grade	Metal mass
Cumulative production	168.5	Copper	2.27%	3.53 Mt
		Uranium oxide	0.065%	~74.8 kt
		Gold	~0.6 g/t	54.2 t
		Silver	~6 g/t	494.5 t
Available resource	9550.0	Copper	0.81%	78.47 Mt
		Uranium oxide	0.026%	2498 kt
		Gold	0.29 g/t	2,975 t
		Silver	1.6 g/t	11 040 t
		Rare earth oxides[a]	~0.55%[a]	~52.5 Mt[a]
Available resource (gold only)	283.0	Gold	0.75 g/t	273 t

[a] Not Joint Ore Reserves Committee (JORC)-compliant and represents an estimate only (see Weng *et al.* 2015)

Table 19.4. Production, energy, water and greenhouse gas emissions for Olympic Dam (mean ± standard deviation, 2009–2013), based on each metal's proportional financial value, in parentheses, and average annual inputs divided by outputs.

Data updated from Mudd (2009); Mudd (2014).

Measure	Production	Water	Energy[a]	Greenhouse gases[b]
Copper (75.27%)	170 ± 39 kt/year	47.1 ± 5.5 kL/t	21.8 ± 4.6 GJ/t	3.8 ± 0.1 t CO_2/t
Uranium oxide (17.54%)	3650 ± 775 t/year	528 ± 43 kL/t	249 ± 39 GJ/t	44.0 ± 2.9 t CO_2/t
Gold (6.25%)	3.21 ± 0.66 t/year	271 ± 17 ML/t	125 ± 17 PJ/t	22.6 ± 1.1 kt CO_2/t
Silver (0.94%)	29.16 ± 6.05 t/year	4.4 ± 0.4 ML/t	2.0 ± 0.4 PJ/t	0.36 ± 0.006 kt CO_2/t
Average inputs/outputs[c]		11 100 ± 1750 ML/year	5.63 ± 0.93 PJ/year	951 ± 53 kt CO_2/year

[a] giga (10^9) joules (GJ)
[b] Greenhouse gas emissions are carbon dioxide (CO_2) equivalent.
[c] Average inputs divided by outputs refers to taking inputs (e.g. water) divided by outputs such as copper, based on the proportional financial value of that output (e.g. 75.27% of total input water is allocated to producing copper).

(Weng *et al.* 2013), these resources continue to be ignored for the more controversial and lower value uranium.

Olympic Dam has significant environmental costs in energy, water and greenhouse gas emissions (Table 19.4). Total energy, water consumption and greenhouse gas emissions have increased over time (Fig. 19.7). The overall efficiency of water and energy use and greenhouse gas emissions improved over the first decade of operations, but stabilised after ~2002. With respect to production of metals, the energy and greenhouse gas emissions intensities per tonne of metal (e.g. GJ/t Cu, t CO_2/t U_3O_8) are gradually increasing, due to declining, albeit variable ore grades, while water use remains stable. Major accidents can increase environmental costs significantly. For example, the October 2009 Clark Shaft failure limited production from the underground mine for several months until mid-2010. This reduced total energy and water needs but still drove up environmental metrics in 2009–10, despite reduced activity (Fig. 19.7b). As ore grades decline, significant pressure will drive up energy–water–greenhouse gas metrics, with fewer metals produced from lower grade ore for the same inputs and outputs. Although the former Western Mining Corporation used to report such data regularly in corporate sustainability reports, these data are increasingly difficult to obtain. Transparency and good public reporting on environmental performance are essential for assessing long-term environmental and socio-economic costs and benefits of the major Olympic Dam mining project.

Lady Annie copper mine

In early 2009, there was a very large environmental accident at the Lady Annie copper mine, ~200 km north-west of Mount Isa (Fig. 19.1). While the open cut mines are just outside the Lake Eyre Basin, the main processing infrastructure was just inside, consisting of a heap leach which uses acid solutions passing through piles (or heaps) of copper ore to dissolve and

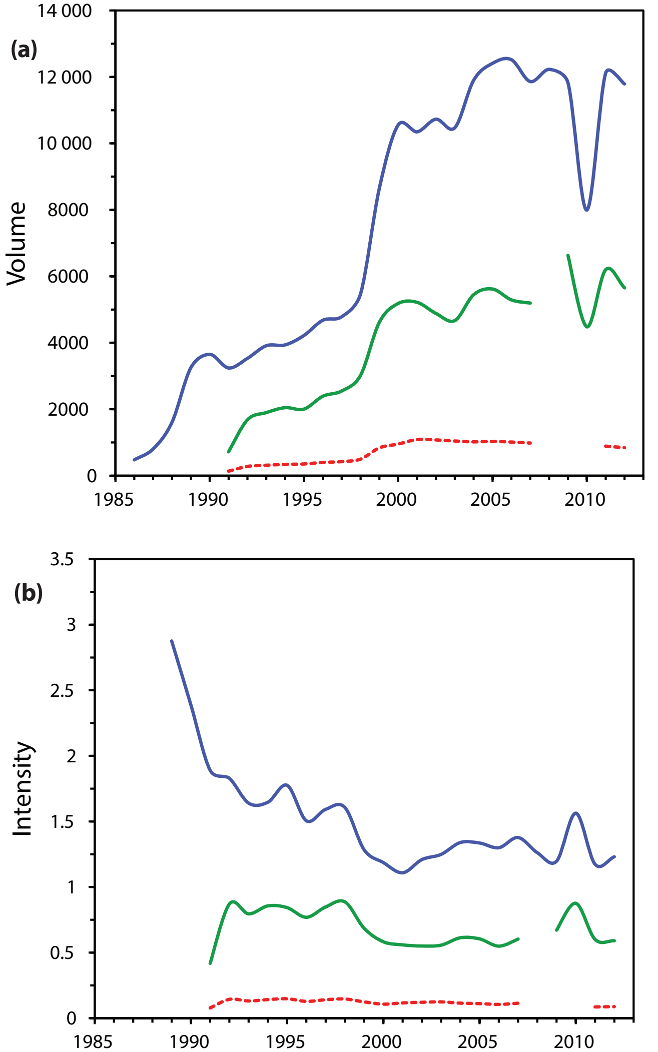

Fig. 19.7. (a) Annual water consumption (ML/year, blue line), energy use (TJ/year, green line) and greenhouse gas emissions (kt CO_2/year, dashed red line) for Olympic Dam (1985–2013; gaps due to lack of reporting); (b) water consumption (kL/t of ore, blue line), energy use (GJ/t of ore, green line) and greenhouse gas emissions (t CO_2/t of ore, dashed red line) (data updated from Mudd 2014).

extract the copper to be purified in a chemical refinery. Commercial operations started in October 2007, at the height of the mining boom. By late 2008, global metals prices had crashed, due to the evolving global financial crisis, and the project became uneconomic, followed by bankruptcy placement for the operating company (CopperCo). Unfortunately, cumulative rainfall was high in early 2009, producing considerable local flooding onsite. This eventually caused a structural failure of the solution ponds, sending highly acidic and metal-rich solutions into Saga and Inca Creeks, part of the headwaters for the Buckley River, one of the Lake Eyre Basin's major western river systems.

At least 447 ML of mining waste water was accidentally released into the Saga and Inca Creeks in the headwaters of the Buckley River, one of the Lake Eyre Basin's western rivers, during two periods in early 2009 (Queensland Department of Environment and Heritage Protection 2012). It severely degraded water quality, biodiversity and pastoral grazing, as well as recreational and traditional values for the streams (Taylor and Little 2013). In particular, the downstream river became highly acidic and rich in heavy metals. This killed fish and had severe impacts on other biodiversity and cattle. It even dissolved star pickets used in fencing. The mining company was convicted of serious environmental harm and fined half a million dollars, with the additional responsibility and costs of remediation and engineering costs of almost $11 million (Queensland Department of Environment and Heritage Protection 2012). The mining company had been explicitly alerted to this risk by the regulator before the accident. There was only a modest 'rehabilitation' bond held for the project, inadequate for the environmental and economic cost of the accident. This serious flaw in the environmental regulatory system for mining remains unresolved throughout Australia: rehabilitation bonds do not currently cover the costs of accidents. The Lady Annie case stands as a rare but stark example of the challenges in achieving strong environmental protection from the risks of mining impacts in the Lake Eyre Basin and Australia.

Petroleum and gas

The Cooper–Eromanga Basin is an important oil and gas field for Australia, supplying gas to eastern Australia as well as a critical source of crude oil. Primary operations are centred around Moomba in north-eastern South Australia in the Lake Eyre Basin, operated by Santos, with smaller companies recently developing modest size oil fields (or wells) (Fig. 19.2).

Australia's crude oil production, with 17.6% from the Cooper–Eromanga Basin, peaked at 34.0 GL in 2000, but has rapidly dropped to 12.6 GL in 2014 (Fig. 19.8). Conventional

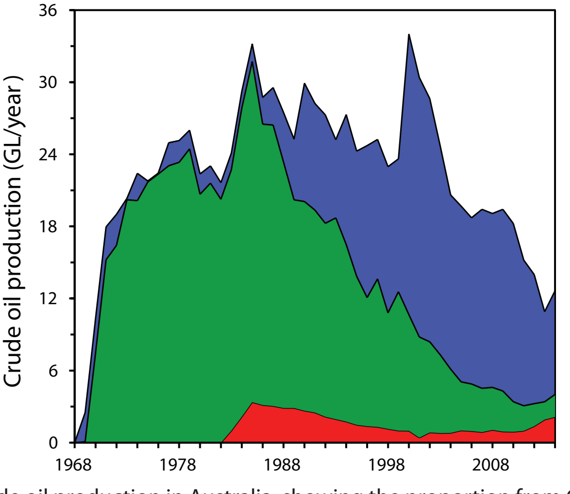

Fig. 19.8. Annual crude oil production in Australia, showing the proportion from Cooper–Eromanga Basin (red) of Queensland and South Australia, relative to the Gippsland Basin (green) and the rest of Australia (blue) (data from Australian Petroleum Production and Exploration Association (2015); GL – billion litres).

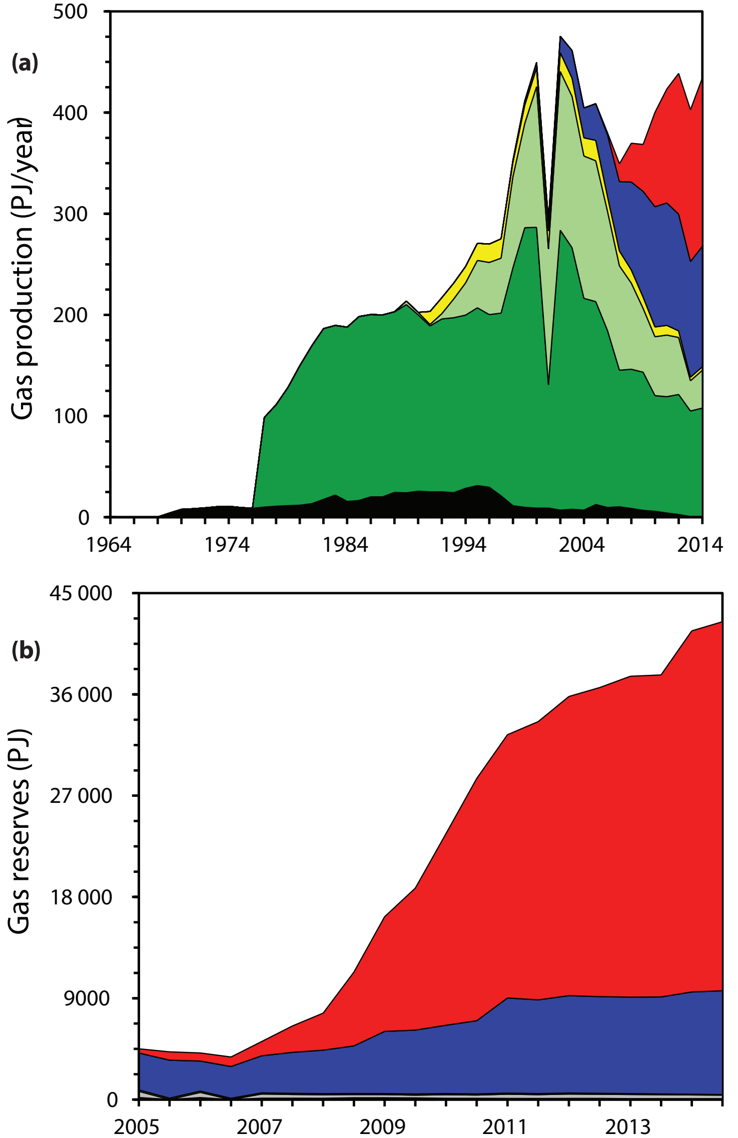

Fig. 19.9. (a) Annual conventional gas production in the Bowen–Surat Basin (black), Cooper–Eromanga Basin (South Australia, dark green; Queensland, light green) and Denison Basin (yellow) and CSG in the Surat (red) and Bowen (blue) basins; (b) six-monthly reporting of Queensland reserves of conventional gas in the Bowen–Surat Basin, Cooper–Eromanga and Denison basins (grey and black) and CSG in the Surat (red) and Bowen (blue) basins (equivalent data unavailable for South Australia) (data combined from Queensland Department of Natural Resources and Mines, 2004–2014; Australian Petroleum Production and Exploration Association 2015).

gas from the Cooper–Eromanga Basin in South Australia and Queensland peaked in 2002, leading to a significant increase in production of unconventional gas from CSG fields (Fig. 19.9). This explains why the Queensland Government has increasingly supported CSG as a major gas supply (Queensland Department of Natural Resources and Mines 2015), rather than investigating other technologies that might reduce gas demand – such as switching electricity and domestic heating or cooking away from gas to more sustainable technologies such as solar thermal electricity or solar hot water.

The recent trends in conventional and CSG reserves in Queensland (Fig. 19.9) show a downward trend for conventional gas and a relatively modest total of 474 PJ at the end of 2013. In addition, Santos, Beach Energy and Drillsearch all report 1570 PJ of gas in their SA operations in the Cooper-Eromanga Basin (current gas production is 109 PJ/year; Table 19.1). There has been extraordinary growth in CSG reserves in the Surat and Bowen Basins in Queensland, with the Surat Basin rising from 374 PJ in December 2004 to 32 795 PJ in June 2014. This makes CSG reserves comparable in scale to those off the northern coast of Australia (e.g. the Carnarvon, Browse and Bonaparte basins), underpinning three major liquefied natural gas export projects on Curtis Island near Gladstone in Queensland. While there are no formally reported CSG or shale gas reserves within the Lake Eyre Basin yet (as of 2013), companies are exploring the Galilee and other basins. Given the extensive exploration licences issued by the Queensland Government (e.g. Western Rivers Alliance 2016), there is a good probability that the CSG history from the Bowen and Surat Basins could be repeated inside the Lake Eyre Basin (especially the Galilee Basin), leading to new frontiers for CSG and potentially shale gas developments and associated environmental risks for the Lake Eyre Basin.

Coal seam gas (CSG) in Queensland

The CSG industry remains highly controversial, with major environmental, economic and social risks and impacts. This relates to its exploration and development, which can have impacts on groundwater levels (i.e. heads or pressures) and groundwater quality (especially, salts, metals, organics and radionuclides), as well as the potentially greater release of methane to the environment due to groundwater impacts (Drinkwater *et al.* 2014). CSG is produced underground, where it is trapped in coal seams. To release this gas, wells need to be established, sometimes close to each other (~0.6–1 km), involving a platform and a road and pipe network to service the well and take away the gas and water produced (Fig. 19.10). To extract the gas from deep underground, groundwater invariably needs to be extracted first to reduce water pressure and allow the flow of the gas to a well from where it is extracted. This groundwater needs to be stored or managed above ground. Average groundwater extraction produced for the past 10 years (2004–2014) is respectively 50.0 and 121.6 ML/PJ for CSG in the Bowen and Surat basins. Water extraction is higher in the earlier phase of CSG development and then declines over time (Drinkwater 2015).

Occasionally where the coal has low permeability, water with small quantities of sand and a wide array of chemicals (e.g. various salts, heavy metals, organics and biocides, depending on the biogeochemistry involved) is injected under extremely high pressure to hydrologically fracture and control the behaviour of the coal and allow the gas to escape to a nearby well – a process commonly known as 'fracking'. This water also needs to be removed and managed (e.g. treated, discharged to surface water and sold to local users such as farmers), but invariably contains residual contamination from the complex mix of chemicals. There are inevitable environmental and social risks in these developments, which remain poorly

Fig. 19.10. The patchwork of CSG wells near Chinchilla in Queensland, showing the potential network of roads and cleared platforms that may serious affect river flows of the Lake Eyre Basin if established in the Channel Country (photo, R. T. Kingsford).

studied and quantified. These include effects on groundwater (water level declines and pollution), fugitive emissions (especially methane and volatile hydrocarbons), surface water (methane gas bubbling, and treated waters discharged to rivers), land values, infrastructure (pipelines, roads, ponds and process plants), social impacts, economic issues (especially availability and cost of labour), greenhouse gas footprint and climate change risks (Drinkwater *et al.* 2014).

Existing domestic CSG projects in Queensland were approved under petroleum legislation, with no traditional environmental impact assessment (EIA) process. There were no systematic baseline studies before development to track environmental impacts on groundwater, surface water, flow paths, air quality, water quality, health or demographics. Furthermore, monitoring is historically minimal, with key aspects such as methane still missing in statutory requirements. The domestic CSG projects meet domestic supply obligations but increasingly compete with large CSG export projects, which have undergone normal EIA approvals. Considerable difficulties remain for adequate scientific assessment of environmental and public health impacts from CSG operations (Drinkwater 2015). For the Lake Eyre Basin and its potential CSG developments, there is a need to clearly identify potential impacts on the rivers, groundwater and socio-economic values.

Shale gas

The rise of unconventional gas extraction from shales, as well as hydrocarbon liquids used to manufacture some petroleum products, has been substantial in the United States (Rao 2012).

Although some call the emergence of shale gas an ‘energy revolution’ or even a ‘game changer’, critiqued by Hughes (2013), potential environmental and public health impacts make it highly controversial (e.g. Jackson *et al.* 2013; Small *et al.* 2014). This also uses hydraulic fracturing (‘fracking’) of the shale to increase permeability and allow water, gas and petroleum liquids to flow from where they are trapped. Given the vast size of shale rocks across continental platforms, such as the Marcellus Shale in the eastern United States, this represents an enormous energy resource. The hydrocarbon liquids produced by shale gas activities attract the oil price, and this value is deducted from the costs of gas extraction. A high oil price makes gas cheaper to produce, although the recent decline in the oil price has reduced this effective subsidy and now makes some shale gas operations marginally economic to uneconomic. There are significant environmental and health risks and potential impacts, although there are relatively few scientific studies (Drinkwater *et al.* 2014).

First, shale gas and fracking may increase methane (and possibly other contamination) into shallow groundwater resources, sometimes important for drinking water. The most infamous example is the lighting of methane from a kitchen tap in Colorado, burning continuously due to the high methane content of the water (popularised by the documentary movie *Gaslands* by Josh Fox). The two common ways which could explain this outcome are either faulty construction of wells, allowing methane to migrate along this pathway to shallow (less than 100 m) groundwater (Osborn *et al.* 2011; Jackson *et al.* 2013) or fracking causing connection of vertical fractures between shale gas and overlying groundwater systems. This is not widely accepted for deep shales (2–3 km) but may be a problem for shallow shale gas operations. Second, some chemicals used in fracking are highly toxic, such as biocides used to control unwanted bacterial growth, which can seal the fracture and reduce permeability. These chemicals have seldom been subjected to rigorous environmental risk assessments for use in fracking. This is especially relevant for CSG, which is often much shallower, 0.5–1 km, than shale gas. Third, there are increased risks of seismic activity (i.e. earthquakes) from fracking, often relating to low intensity but increased frequency, although this may be more related to deep injection of wastewaters (Small *et al.* 2014). Fourth, concerns over or competition for water and land between gas companies and agriculture can be significant (Drinkwater *et al.* 2014). Fifth, increases in air pollution, especially volatile hydrocarbons and noise, could explain impacts raised by local communities near shale gas activities, although still poorly understood (Drinkwater *et al.* 2014). Sixth, formation waters extracted from shale gas operations are often saline and may be rich in hydrocarbons and/or heavy metals, including sometimes radioactive elements such as radium or uranium (Barbot *et al.* 2013), leading to major wastewater management issues. Finally, discussion about the relative merits of investment in renewable energy, compared to shale gas development, is seldom debated. Shale gas production remains a deeply contentious industry. Despite high profile claims of a potential shale gas bonanza in the Arckaringa Basin (Fig. 19.1), there remain no reported shale gas reserves yet in or near the Lake Eyre Basin.

Rare earths

The rare earth group of elements, often called rare earth oxides, their typical form in nature, are increasingly critical for a range of modern technologies. They are essential for computers, renewable energy, phosphors, consumer electronics, speciality alloys and chemicals as well as various military technologies. There are light rare earth oxides such as lanthanum and cerium, or heavy rare earth oxides such as dysprosium, terbium and neodymium. The heavy ones are much higher value, but are also found in low concentrations in rare earth deposits. The main minerals hosting rare earths, such as monazite or bastnäsite, often have a widely variable mixture of light and heavy rare earth oxides and constituent elements. Most of the world's deposits are dominated by light rare earth oxides (Weng *et al.* 2015).

This makes rare earth mining projects inherently difficult, with each deposit needing a unique approach for separation of different rare earth oxides to saleable products, along with substantial chemical and energy inputs. Rare earth mining often includes substantial thorium and some uranium, resulting in radioactive wastes following processing and refining of rare earths. If the refinery and various gaseous, liquid and solid wastes are poorly managed, this can lead to significant risks for workers and the surrounding environment and communities. This explains concerns raised by Malaysian and Chinese communities about these impacts from their historic or current rare earth mining projects and refineries. If a project proposes to extract and sell the thorium and/or uranium, this also raises significant public concerns given that both are nuclear source materials and subject to international treaties for nuclear power or weapons.

Conclusion

The Lake Eyre Basin has extensive mineral and energy resources, some critical for Australia's energy supplies or export-focused metal industries. The mining and petroleum industries have grown substantially in recent decades, with considerable opportunity to expand. The gradual depletion of conventional petroleum is driving a switch to unconventional sources, including CSG and shale gas. These mining and petroleum projects may have profound impacts on water resources and their associated natural resources (see Chapters 20 and 21). They may affect groundwater, surface water and flood flows across the landscape, as well as altering water quality. Mining developments in the Lake Eyre Basin are commonly growing in size and generating more waste. The cost–benefit analyses for such developments are rarely comprehensive, seldom including economic values of the environment (see Chapter 18). If the experience of the United States or even CSG in Queensland is repeated and the dreams of petroleum geologists come to fruition, developments of CSG and shale gas will impose considerable risks to the Lake Eyre Basin and its unique water resources, ecosystems and cultural heritage. There is an increasing environmental assessment burden, requiring extensive monitoring followed by rehabilitation, sometimes already poorly managed at potentially great public cost (e.g. Lady Annie mine). As Agricola (1556) acknowledged, mining can bring economic and material benefits, but it also comes with environmental, social and economic risks. This remains the heart of the sustainability debate for the mineral and energy sectors operating in or around the Lake Eyre Basin.

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