CULTURAL FLOWS

FIELD STUDIES
FINAL REPORT

NATIONAL
CULTURAL FLOWS
RESEARCH PROJECT

For First Nations People, water is a sacred source of life. The natural flow of water sustains aquatic ecosystems that are central to our spirituality, our social and cultural economy and wellbeing. The rivers are the veins of Country, carrying water to sustain all parts of our sacred landscape. The wetlands are the kidneys, filtering the water as it passes through the land.

First Nations Peoples have rights and a moral obligation to care for water under their law and customs. These obligations connect across communities and language groups, extending to downstream communities, throughout catchments and over connected aquifer and groundwater systems.

The project partners acknowledge all of the Traditional Owners across Australia who care for the waterways that sustain our Country. We pay deepest respects to their Ancestors and Elders who have protected and maintained water resources for thousands of years, and passed on the knowledge, stories and lessons through the generations.

We acknowledge the nations of Murray Lower Darling Rivers Indigenous Nations and Northern Basin Aboriginal Nations who continue to fight for their inherent right to water, and who had a pivotal role in creating and directing the National Cultural Flows Research Project.

We thank the Murrawarri and Nari Nari Nations who worked tirelessly as part of the research team to develop the cultural flows assessment approaches for this project.

This report has been prepared by Rural Solutions South Australia for the Cultural Flows Planning and Research Committee as part of the National Cultural Flows Research Project, developed by and for First Nations with the aim of helping to embed First Nations' water allocations in Australia's water management framework. Funding for the Research Project has been generously provided by the Murray Darling Basin Authority, the Commonwealth Environmental Water Office, the National Water Initiative, and the Department of Families, Housing, Community Services and Indigenous Affairs. Report authored by Dr John Mackenzie, Dr Rhonda Butcher, Dr Chris Gippel, Peter Cottingham, Rowena Brown, Klynton Wanganeen, Thomas Kloeden and Tamarind Meara.

Cover photo: Arthur Mostead – Gurra Gurra Creek near Berri SA, courtesy of Murray-Darling Basin Authority. Artwork 'Cultural flows' by Luke Penrith. Cover graphic design by Mazart Design Studio.

Key Acronyms and Abbreviations

CEWH – Commonwealth Environment Water Holder

ET - Evapotranspiration

FPIC – Free, Prior and Informed Consent

IP – Intellectual Property

IPA – Indigenous Protected Area

KEQ – Key Evaluation Questions

MDBA – Murray-Darling Basin Authority

MERI – Monitoring, Evaluation, Reporting and Implementation

MLDRIN - Murray Lower Darling Rivers Indigenous Nations

MNDWI - Modified Normalised Difference Water Index

NAILSMA - North Australian Indigenous Land and Sea Management Alliance

NBAN - Northern Basin Aboriginal Nations

NEP – Nation Engagement Plan

NNTC – National Native Title Council

NSW – New South Wales

PAR - Participatory Action Research

PBC – Prescribed Body Corporate

RSSA – Rural Solutions SA

SMART - Specific, Measurable, Achievable, Resourced and Time-bound

WOfS - Water Observations from Space

EXECUTIVE SUMMARY

This document summarises the research findings of the National Cultural Flows Research Project. It is supported by a series of accompanying research reports that provide more detail on methodology and field research results. It is intended to demonstrate the state of current practice in cultural flow assessment for a researcher, practitioner and Aboriginal Nation perspective, based on the outcomes of the three-year research project.

Cultural flows are defined in The Echuca Declaration (MLDRIN 2010) as ”water entitlements that are legally and beneficially owned by Indigenous Nations of a sufficient and adequate quantity and quality to improve the spiritual, cultural, environmental, social and economic conditions of those Nations. This is our inherent right.”

The National Cultural Flows Research Project (“the Project”) is a national research project driven by and for Aboriginal people. It was undertaken to provide rigorous and defensible knowledge on Aboriginal water interests for the benefit of Aboriginal people. The project aimed to secure a future where Aboriginal water allocations are embedded within Australia's water planning and management regimes, delivering cultural, spiritual, social, environmental and economic benefit to communities in the Murray-Darling Basin and beyond (NNTC 2014).

Significant challenges have been identified that have impeded the creation of cultural flow allocations in the Murray-Darling Basin and other catchments around Australia, including the challenge of determining Aboriginal water interests in water quantities or resource management terms.

Over three years, a team of technical experts worked in collaboration with representatives from the two case study nations - Nari Nari and Murrawarri (“Research Partners”) to develop and implement methods to describe and measure Aboriginal cultural water uses and values in quantifiable water volumes. Using established ecological and socio-cultural monitoring techniques, the Research Partners were able to demonstrate the cultural, ecological, social, and well-being outcomes of participation in a cultural flow planning process.

This report provides a summary of the key findings arising from this work, including the research approach and monitoring methodology developed for an intended cultural flow trial and a comparison of the capacity for cultural and environmental flows to meet Aboriginal cultural flow objectives. While the intended cultural flow trial was not conducted due to a natural flood event, the research draws upon the evidence and experience gained from the project to inform a Cultural Flows Guide for national application.

The research reported herein has been informed by a commitment to best practice in Aboriginal research and engagement. This includes: a strictly upheld requirement of Free, Prior and Informed Consent for all Research Partners; intellectual property protection; capacity building; and the purposeful pursuit of research outcomes that explicitly benefit Aboriginal people in response to needs identified by Aboriginal people (NNTC 2014). This included the recognition that the Research Committee, Project Team, Research Partners and Authorised Knowledge Holders are equal partners in the research process.

Most importantly, this report has informed the development of a Cultural Flows Guide (“the Guide"). The Guide was developed based on the lessons learnt in the planning and implementation process applied for an intended cultural flow. The Guide provides the steps for planning, implementation and assessment of a cultural flow.

The Guide is designed to prepare communities and water planning agencies to implement cultural flows at watering places across Australia. It is intended to support Aboriginal Nations wishing to undertake watering for cultural outcomes, and provides an accessible and flexible process for the inclusion of cultural flows within existing water planning and management regulations.

The findings from the research include the following:

- This report presents the methodology used to **successfully quantify the water requirements to meet Aboriginal cultural flow needs** at two case study watering places. The method applied has been used to inform a nationally consistent approach that can be adapted to diverse catchments and communities.

- This report demonstrates how **planning for cultural flows is essential for enabling Aboriginal water management**. Cultural flow planning creates legitimacy for Aboriginal water management objectives that are otherwise absent or marginalised in or by the existing process.

- In the comparison between intended cultural and environmental flows, this report shows how **the outcomes from cultural flows most valued by Aboriginal people are dependent upon autonomy and access to a dedicated cultural flow allocation**. These benefits cannot be achieved through an environmental flow allocation, even where Aboriginal people have played a determining role in the planning and management of an environmental flow allocation.

- This research has confirmed **the need to prioritise Traditional Aboriginal Knowledge in the ecological characterisation research** nationally. Traditional Aboriginal Knowledge has clear value to the management of water resources generally.

- This research has shown that **the methods for cultural flow planning are available, and can be drawn and adapted to a range of tools associated with water management** from both Aboriginal and non-Aboriginal contexts. These include the Aboriginal Water Assessment process and other tools and methods adapted from participatory environmental monitoring.

- Aboriginal people around the Country will **have to be resourced appropriately to participate in planning and implementation, including via dedicated capacity building investment, to facilitate the implementation of cultural flow management**. This investment will have direct, measurable benefits on the quality of life of Aboriginal people and outcomes achieved.

- Ongoing cultural flow research presents an important opportunity to work with Aboriginal Research Partners across the country to **identify ways that these tools can be adapted and shared to further contribute to an ongoing national cultural flows dialogue**.

Based on the findings of the research, the authors present the following conclusions:

1. The findings of this component are a proof of concept and can be used to support further research and development for providing culturally appropriate resources and programs to build capacity in Aboriginal communities to advocate for cultural flow allocations.

2. The findings of this component are an evidence base which can support the development and implementation of cultural flows, as defined in the Echuca Declaration and developed through the National Cultural Flows Research Project, and support Aboriginal Nations to advocate to governments the need to improve the inclusion and protection of Aboriginal values and interests in water.

3. There is a need for further investigation into mechanisms (such as grant programs and funding arrangements) that can be established to enable Aboriginal groups to invest in water and associated infrastructure to access water for cultural purposes.

TABLE OF CONTENTS

TABLE OF FIGURES

TABLE OF TABLES

1 INTRODUCTION TO THE PROJECT

The National Cultural Flows Research Project ("the Project") is a national research project driven by and for Aboriginal people. The project aim was to secure a future where Aboriginal water allocations are embedded within Australia's water planning and management regimes, delivering cultural, spiritual, social, environmental and economic benefit to communities in the Murray-Darling Basin and beyond (NNTC 2014).

The purpose of the Project was to provide rigorous and defendable knowledge on Aboriginal water interests for the benefit of Aboriginal people. The project included a range of scientific research methodologies and generations of cultural knowledge to:

1. Provide Australia with a greater understanding of Aboriginal values relating to water and other natural resources.

2. Provide Aboriginal people with information to ensure that Aboriginal water requirements and preferences can be reflected in water planning and management policy.

3. Inform the development of new governance approaches to water management that incorporate aspects of Aboriginal governance and capacity building.

While the focus of the project was on the Murray-Darling Basin, the Project trialed an approach with Aboriginal Research Partners at two case study watering places (Toogimbie Wetlands and Gooraman Swamp) with the aim of establishing the evidence base for a methodology that could be implemented by and for the benefit of Aboriginal people across Australia (NNTC 2014). It involved developing and applying a cultural flow planning methodology for potential national application. The findings of this work will also inform a subsequent stage of the Project (Component Five) which will seek to recommend policy, legal and institutional changes that will enable the implementation of Cultural Flows for the economic, social and cultural benefit of Aboriginal Nations.

Oversight of the Project was provided by the National Cultural Flows Planning and Research Committee ("the Research committee"). The Research Committee represents its member organisations: Murray Lower Darling Rivers Indigenous Nations (MLDRIN); Northern Basin Aboriginal Nations (NBAN) and the Northern Australia Land and Sea Management Alliance (NAILSMA) along with representatives from the office of Commonwealth Environmental Water Holder (CEWH), Murray-Darling Basin Authority (MDBA), National Native Title Council (NNTC) and nominated state government agencies (NNTC 2014).

Established in March 2011, the Research Committee has an ongoing role to ensure that the NCFRP research meets the needs of Aboriginal people and organisations, is conducted with the Free, Prior and Informed Consent (FPIC) of Aboriginal participants and has regard to Aboriginal decision-making processes.

Throughout the research process, the Project Team worked in close collaboration with nominated representatives from the two case study nations - Nari Nari and Murrawarri ("Research Partners") and selected individuals who had spiritual, cultural and/or ecological knowledge of the case study site ("Authorised Knowledge Holders").

1.1 Project background

> *"Across Australia, water is governed through a complex system of laws and policies that largely fail to meet the needs of Aboriginal communities. While some mechanisms are in place to consider cultural values in water management, they fall short of the legally and beneficially owned water entitlements that are needed to improve the spiritual, cultural, environmental, social and economic conditions for Aboriginal people. Securing Aboriginal water rights in Australia is the primary purpose of the National Cultural Flows Research Project*." (Rigney and Anderson 2017, p. 19).

1.1.1 Water rights and native title

Historically, Aboriginal peoples' rights to water have largely been excluded from Australia's complex water planning and management regimes. Although the *Native Title Act 1993* (Cwth) includes water rights as a part of Native Title rights, only rights to use water for domestic and personal purposes have been recognised by the courts (Jackson et al. 2009). Whilst the *Native Title Act 1993* gives prescribed body corporates (PBCs) and claimants some procedural rights concerning the development on land and water where native title may exist, no exclusive rights to water for PBCs have been established.

1.1.2 National Water Initiative

In 2004, the National Water Initiative (NWI) was the first instance in which Aboriginal rights to water had been formally recognised in national water policy (COAG 2004). Specifically, sections 52 to 54 of the NWI require Aboriginal participation in water planning, and require catchment-based water allocation plans to incorporate Aboriginal social, spiritual and customary objectives, and strategies for achieving these objectives (COAG 2004). However, no national guidelines were created to ensure the inclusion of Aboriginal rights or interests in water reform, and the inclusion of Aboriginal interests in water plans was found to be uneven and rare (NWC 2009; NWC 2011, p. 44-6).

The National Water Commission, having completed a desktop review of Aboriginal involvement in water planning across the country, found that while approaches are variable across Australia, most governments have made advances in recognising the need to address Aboriginal water issues (NWC 2014). The report also noted that progress is being made on engaging Aboriginal people in water planning and management processes. However, the review also found that challenges remain and little progress has been observed in the allocation or licensing of water for Aboriginal social, economic, spiritual or cultural purposes. The 2014 report highlighted that:

> *"Indigenous Australians have managed their lands and waters sustainably for thousands of generations. Through their spiritual, cultural and customary connections to the landscape, they have acquired a deep knowledge and understanding of Australia's water systems. Incorporating this knowledge into Australia's water management approaches represents an opportunity for all governments to recognise Indigenous water issues and improve the sustainable management of our water systems."* (NWC 2014, p. 2).

1.1.3 Aboriginal interest in water

A key demand from Aboriginal organisations around the country to ensure the protection of Aboriginal interests in water is for the allocation of Aboriginal-specific water entitlements, for cultural or commercial purposes. The 2002 report on Aboriginal onshore water rights produced by the Lingiari Foundation for the Aboriginal and Torres Strait Islander Commission found that one of the four points of convergence across multiple Aboriginal groups was their expectation of a right to "exercise their spiritual, cultural, social and economic rights through access to water for commercial use" (Lingiari Foundation 2002, p. 76). In that same year, the Boonamulla Statement was developed out of a two-day workshop on natural resource planning for representatives of Aboriginal communities in New South Wales (NSW) (NSW Aboriginal Land Council et al. 2002). The workshop was convened to prepare a statement about Aboriginal peoples' expectations of the NSW Government's planning process for water, catchment management and native vegetation. Included in the ten goals for resource management expressed in this statement was that:

> *"Access to water should be seen as a matter of social justice allowing Aboriginal communities priority access to the water market (i.e. through provision of allocation of water licences to Aboriginal people through an appropriate management structure such as a Trust)."* (NSW Aboriginal Land Council et al. 2002, page unknown).

This aspiration was re-iterated in MLDRIN's Response to the Living Murray Initiative (MLDRIN 2003). This submission, which represented agreement across ten Aboriginal Nations in the Murray-Darling Basin, included a recommendation that a water allocation be made available to each of these Nations to enable them to exercise their custodial responsibilities for river management. At the discretion of each Nation, it was proposed that the water could be used to increase environmental flows, or to help generate a more independent economic base for their people (MLDRIN 2003, p. 7).

1.1.4 Acknowledging cultural entitlements in water management

Currently, Australia's water policies require all levels of government to have regard to the recognition and protection of Aboriginal values in water resources management. However, there is insufficient rigorous and defendable information to enable jurisdictions to fulfil this requirement in a way which is meaningful for Aboriginal people. The creation of cultural flow entitlements is one way to acknowledge appropriately Aboriginal values and interests in water management, and protect those interests.

The limited attention to the establishment of cultural entitlements for Aboriginal people to date is linked to the assumption that Aboriginal interests in water are limited to the protection of cultural heritage or fulfilled by adequate environmental allocations (FPWEC 2011). This assumption, although consistently refuted in the position statements and submissions of Aboriginal groups and organisations around the country, has tended to prevent consideration of the economic interests that Aboriginal communities may have in developing water resources (Lingiari Foundation 2002; MLDRIN 2003; FPWEC 2011). It also diminishes the diverse suite of Aboriginal values in water, which can include social and well-being aspirations, ecological restoration activities, education, employment, economic interests, cultural renewal, land use planning and participation in research or monitoring.

1.1.5 Aboriginal values for water

The full range of values that Aboriginal people have for water are challenging to express in volumetric or other water management terms. As a consequence, these values are typically excluded from consideration in water allocation decision-making (Australian Parliament 2011, p. 81). Critically, the work undertaken here has attempted to address the gap between the accumulating knowledge and understanding of Aboriginal water-related values and practices, and the limited capacity for this knowledge to translate into substantive water planning or management initiatives for the protection and enhancement of these identified values.

This report provides an evidence base to demonstrate the range of environmental and social outcomes that can be attained through the establishment of an allocation for cultural purposes under a statutory water plan. It also shows that an adaptive management approach combining cultural, ecological and hydrological components can quantify the specific water requirements for a cultural flow.

> *"That spiritual connection is hard to explain under this system. Because the environmental system is about the ecology. This is about the spirit. So that's our religion to a certain extent. Part of our religion. That would be the equivalent of a church - kind of. That would be connected to other stories as well. That's why this research is important, because of what it can show."*
> – F. Hooper pers. comm. 2016 (Research Partner - Murrawarri)

1.1.6 Aboriginal cultural and spiritual connections with water

The inextricable connectivity between identity, spirituality and water gives Aboriginal people a unique role in water resource management. Aboriginal identity and the status of traditional ownership and custodianship should be recognised and reinforced throughout water management.

Recognition and respect of customary governance arrangements, including the cultural and spiritual dimensions of those arrangements, are vital to effective Aboriginal water management. To facilitate this, Indigenous culture and values must be identified and incorporated in natural resource planning and implementation, particularly with respect to the distinct connections maintained by Aboriginal people to those resources. Of these connections, it is the spiritual and cultural connections between water, and sacred places, and animals and plants that depend on water that is the most under-accounted in current water governance.

For Aboriginal Australia, water is a sacred and an elemental source and symbol of life (Langton 2006 cited in Jackson 2006), with the resources provided by aquatic ecosystems a pivotal part of spirituality and cultural economy (Weir et al. 2013). Australian Aboriginal communities have a moral imperative to care for surface and groundwater resources, as part of their commitment to looking after Country (Yu 2000; Goode 2003 cited in Syme et al. 2008) as evidenced by dreamtime stories and cultural and spiritual activities (Syme et al. 2008). These obligations connect across communities and language groups, extending to downstream communities, throughout catchments and over connected aquifer and groundwater systems. For water governance to meet the needs of Aboriginal people, it must capture the spiritual connection as well as the cultural responsibilities derived from these obligations.

The spiritual aspects of the relationship between Aboriginal people and water was reiterated by participants throughout the project. For example, the cultural significance of the watering place for the Murrawarri Research Partners was chosen specifically due to the presence of

Mundaguddah, the name that the Murrawarri give to the Rainbow Serpent. Murrawarri hydrological knowledge is connected to the Mundaguddah, and derives a spiritual dimension from this connection. The Mundaguddah travels across Murrawarri Country through the subterranean channels, thereby linking together a series of significant water places through Murrawarri Country and throughout the Murray-Darling system. In particular, the presence and movement of the Mundaguddah relies on sufficient quantities of water present at three key places: at an important waterhole in the Culgoa River, the Gerrara Springs and Gooraman Swamp. Each of these places has associated cultural practices, obligations and established cultural prohibitions linked to water availability, and Research Partners noted that all three water sites have been varyingly impacted by upstream development. Similarly, the aspirations for the use of cultural water in the management of the Toogimbie watering place by the Nari Nari reflected the importance of ongoing protection and preservation of Nari Nari significant sites. These sites, including artefact, burial sites and occupation sites, were not only significant due to their heritage values, but also due to the belief in the continuing spiritual presence of ancestors in the landscape. The plant and animal species targeted via cultural flow water were species that had totemic significance to the Nari Nari.

Once aquatic ecosystems are altered, degraded or lost from within a landscape, the particular cultural values associated with that system can also be permanently lost. Changed conditions of surface and groundwater systems due to historical water development has impacted on both environmental values instream and for the riparian ecology, and this has had a well-recognised impact on the cultural values of the Aboriginal community generally. What is less well recognised, is that there is also an associated significant loss of spiritual connection and sense of well-being. That is, the current water regime continues to have a negative impact on the spiritual and emotional life of the Traditional Owners in the community.

The lack of attention to the decline of spiritual values for Aboriginal people in water management is part of what cultural flows intend to address. Cultural flow planning can give credibility and legitimacy to spiritual values in the landscape connected to the water places, and allow participating Traditional Owners to demonstrate the importance of those cultural values, and have those values recognised in the instruments of water management through a potential future allocation of water.

1.2 Project objectives

The Project objectives, as originally designed by the Research Committee consisted of the following components (NNTC 2014):

1. Describe the Aboriginal cultural water values and needs across Australia (completed January 2014).

2. Develop and use methodologies to describe and measure the cultural water uses, values and needs of particular Australian Aboriginal communities.

3. Quantify water volumes to meet cultural values and needs (both Murrawarri and Nari Nari) and scientific assessment of a trial flow at Toogimbie Indigenous Protected Area (IPA) Wetlands.

4. Develop and implement a monitoring methodology of the ecological and socioeconomic, health and wellbeing outcomes of cultural flows and analyse how they compare with environmental flow outcomes.

5. Recommend policy, legal, and institutional changes that will enable the implementation of cultural flows.

6. Building the capacity of Aboriginal organisations to build support for cultural water provisions and to implement recommendations for improved local and national water management, planning, policies and laws.

1.2.1 Project scope

As part of a multidisciplinary Project Team, Rural Solutions SA (RSSA) was engaged to deliver Components Two, Three and Four of the Project. Key activities included:

- Development and implementation of key plans to inform project delivery.
- Development and application of a set of methodologies at two case study sites (referred to in this report from this point forward as watering places) that:
    - Determine the historical and contemporary cultural uses and values of water.
    - Provide an authoritative basis from which to determine volumetric requirements and develop indicators and baselines for measuring the impacts of cultural flows at the watering places.
- Quantification of water volumes and flow regimes required to meet the uses and values identified by each case study Nation, by:
    - Planning a trial flow at Toogimbie Wetlands.
    - Conducting hydrological modelling at Toogimbie Wetlands and Gooraman Swamp.
- Development and implementation of a monitoring methodology of the ecological and socio-economic outcomes of cultural flows, and analyse how they compare with environmental flow outcomes.
- Preparation of a Field Work Results and Findings Report
- Development of a Cultural Flows Guide (NCFRP 2017e; 2017f) for national application.

1.2.2 Research limitations

Key research limitations:

- Owing to a reduction in scope and case study watering places, from four to two, the development of a detailed national guide that was representative of the various contexts faced by Aboriginal people within the Murray-Darling Basin and/or across Australia was not possible. Instead the Project draws upon the evidence and experience gained from the two case study watering places (Toogimbie and Gooraman Swamp) to inform a proposed guide for national application.
- The two case study watering places (Toogimbie and Gooraman Swamp) were selected as a point of contrast and comparison of flows within a regulated and unregulated system. As a result of this determination, it was agreed that no flow trial would occur at Gooraman Swamp case study watering place as part of the Project. Rather, only cultural flow planning

activities were conducted. As a consequence, only limited conclusions can be drawn at this time.

- An unexpected limitation was the absence of a controlled flow trial as originally intended. Although a flow trial was planned for the Toogimbie watering place, in late 2016 a major natural flood event in the Murrumbidgee River occurred. This resulted in the adaptation of the project methodology from a controlled flow trial to assessing the role of a natural inundation event or flood. Consequently, conclusions drawn from the social and ecological monitoring results are based on monitoring of the pre- and post-flood event at one watering place - Toogimbie.

1.3 About this report

This report (NCFRP 2017d) represents the consolidation of Component Four of the Project by summarising the research, its approach and key findings, and using this as a basis for a proposed national guide for cultural flows. This report is informed by previous reports supplied as part of the Project including:

- The NCFRP Project Plan (NCFRP 2016a)
- The NCFRP Nation Engagement Strategy (NCFRP 2016b)
- Aboriginal Water Interests for Establishing Cultural Flows (NCFRP 2016c)
- Gooraman Swamp and Toogimbie Cultural Flow Monitoring and Evaluation Plans (NCFRP 2016d and NCFRP 2016e)
- Nari Nari and Murrawarri Nation Engagement Plans (NCFRP 2016f and NCFRP 2016g)
- Toogimbie Trial Flow Delivery Plan (NCFRP 2016h)
- Field Work Results and Findings Report (NCFRP 2017a)
- Toogimbie and Gooraman Swamp Ecological Characterisation Report (NCFRP 2017b)
- Hydrological and Hydraulic Modelling Report (NCFRP 2017c)

Final publications associated with Component 4 include the following:

- Cultural Flows: A Guide for Water Managers (NCFRP 2017e)
- Cultural Flows: A Guide for Community (NCFRP 2017f)

The structure of this report consists of:

- **Section 2** describes the cultural context of the two case study watering places, including Aboriginal values and aspirations for water identified in the research;
- **Section 3** explores the linkages between the aquatic ecosystem and Aboriginal values, including cultural linkages and Traditional Aboriginal Knowledge;
- **Section 4** demonstrates the steps in the formulation of a cultural flow trial methodology, including hydrological and hydraulic modelling;
- **Section 5** explains the outcomes from the research and presents the research key findings;

- **Section 6** examines the implications of the research findings for cultural flows generally, including the perspectives of Research Partners.

1.3.1 Terms and definitions

For the purpose of this report the following terms and definitions have been adopted:

- Authorised Knowledge Holder
  A person, normally a Traditional Owner, who has been provided cultural and/or traditional knowledge of a particular place or thing through customary law and is recognised by the Traditional Owner community to have the authority to speak on or share that particular knowledge where appropriate.

- Research Partners
  A Traditional Owner and/or community nominated participant who is recognised as speaking for Country. Individuals may be involved in any/all aspects of Cultural Flows..

- Traditional Aboriginal Knowledge (TAK)
  TAK includes the cultural traditions, values, beliefs, and worldviews of Aboriginal peoples as distinguished from Western scientific knowledge. Traditional Knowledge is based on direct experience, testing, observation of patterns over long periods of time, and teachings and recording in the collective memory through oral tradition, storytelling, ceremonies and songs. It is a holistic and inclusive form of knowledge (adapted from Dei 1993, p.105; Augustine n.d.).

- Watering place
  The physical location (site) to receive the cultural flow within Country. Within the context of this report, the watering place is a specific location within Country which has connections to, and importance for, contributing to water related cultural values. It may be a single aquatic ecosystem or a complex of ecosystems and or locations, noting that Nations do not partition Country in the same way as Western Science.

- Western Science
  The systematic study of the nature and behaviour of the material and physical universe originating in European enlightenment. This system of knowledge is based on repeated observation, experiment, and measurement, and the formulation of laws to describe these facts in general terms.

See Appendix 1 for a full list of terms and definitions.

1.4 Defining "Cultural Flows"

The proposed Cultural Flows Guide (NCFRP 2017e; 2017f) builds upon the definition of "cultural flows" that was endorsed by representatives from 31 Aboriginal Nations at a joint meeting of MLDRIN and NBAN. This agreement is formalised in The Echuca Declaration (MLDRIN 2010) as:

> *…."water entitlements that are legally and beneficially owned by the Indigenous Nations of a sufficient and adequate quantity and quality to improve the spiritual, cultural, environmental, social and economic conditions of those Nations. This is our inherent right."*

This definition identifies the core requirements of a cultural flow:

1. That the entitlement be **legally and beneficially owned by Aboriginal Nations**.

2. That the **use of the water be unrestricted** other than determined by those nations to **improve quality of life** for Aboriginal people.

This definition reflects the needs of Aboriginal communities to have their interests and rights in water given the commensurate status and security of legally enforceable tenure granted to other consumptive water users, rather than being defined on the basis of environmental or cultural heritage requirements. As the Echuca Declaration (MLDRIN, 2010) confirmed,

> *"Cultural flows are water rights we hold in our own name and are not held in trust by Government AND provide us with enough clean water to improve all parts of our lives…Our lives will be improved by cultural flows if: the rivers and creeks get a proper amount of water at the right times; the health of our spirit, body and mind is improved and strengthened – the land, water and people are one; if our Country is healthy enough that we can look after and use our Country according to our culture….; recognition by all Australians that this is our Country and that we need to be listened to when we talk about our Country…We are the only ones who can decide if our Country and our lives have improved."*

Further discussion on the general distinctions between cultural and environmental water is presented in Section 3. This draws on the literature to support the case for the inclusion of cultural management of water for cultural outcomes highlighting the essential linkages between culture and water and the distinctions between cultural and environmental outcomes.

2. CULTURAL CONTEXT

2.1 Case study selection

In November 2015, two (2) case study watering places (sites) were selected and confirmed by the Research Committee for the Project - Toogimbie Wetlands near Hay and Gooraman Swamp near Weilmoringle in New South Wales (NSW). The two case study watering places were selected as a point of contrast and comparison of flows within a regulated and unregulated system. The cultural significance and context of the two case study watering places is discussed below.

2.2 Toogimbie Wetlands

> *"Toogimbie Vision Statement: The Land will be protected, and its Cultural and Natural values enhanced, creating a quality environment for present and future generations."*
>
> *– Nari Nari Tribal Council 2012, p. 4)*

The Toogimbie Wetlands is situated on the broad floodplain of the lowland Murrumbidgee River (uppermost area of the Lowbidgee floodplain) downstream from the rural town of Hay, in western NSW. It is a former pastoral property dating from the introduction of farming to the region in the late 1800s (DEWR 2007). In March 2004, the Toogimbie IPA was formally declared, and has since been continually owned and managed by the Nari Nari Tribal Council. Toogimbie Station covers approximately 7,000 hectares, of which 4,600 hectares is the declared IPA conservation area. The remaining lands are leased for agricultural purposes. The site is managed by the Nari Nari Tribal Council through culturally informed land management practices to promote environmental restoration of the largely degraded site, whilst ensuring the protection and enhancement of the local Aboriginal culture and history.

2.2.1 Landform and climate

The Toogimbie Wetlands (Figure 1) landscape includes flat former pasture lands contrasting with eucalypt-lined creeks and waterways, and a nearby floodplain. Particularly important to the Nari Nari people is Toogimbie's wetlands, which are home to iconic species and traditional medicines. These wetlands are in the northern section of the site located adjacent to the Murrumbidgee River, and comprise approximately 2000 hectares. The climate is made up of temperature extremes in summer and winter, but relatively consistent rainfall patterns (e.g. monthly winter-spring rainfall of approximately 31 to 35 mm, summer-autumn monthly rainfall of approximately 26 to 30 mm; source: Australian Government BOM 2017). The natural flow pattern of the river is for high flows in winter and spring fed by upland areas that include the Australia Alps, followed by low flows in summer and autumn. However, upstream water storage and flow regulation means that overbank flows that would sustain important river, floodplain and wetland flora and fauna are now of reduced frequency and duration (MDBA 2012a, b).

Figure 1: Toogimbie House Wetland during a controlled water event (2016). Image J. Woods.

2.2.2 Values: Spiritual, Cultural and Ecological

The Hay area was once part of a major Aboriginal trade route and large social and cultural network (DEWR 2007). Much of the cultural history of the local Aboriginal people was disrupted by European settlement. Toogimbie Wetlands and IPA activities seek to preserve important assets such as protecting scarred trees, campsites and burial mounds, as well as helping to reconnect the people to their land. Toogimbie Wetlands represents both a visual and spiritual link between the health of the land, its water systems and its people (Figure 2).

Figure 2: Surveying one of the many culturally significant sites at Toogimbie Wetlands. Image Nari Nari Tribal Council.

The IPA centred upon the wetland as a site of cultural significance for contemporary Nari Nari cultural practice and the transmission of inter-generational knowledge, through environmental restoration, wetland rehabilitation and Aboriginal land management (Nari Nari Tribal Council 2012). This environmental restoration is not intended to restore the Toogimbie wetland itself to a pre-development condition, but to manage the landscape in order to re-establish species and conditions of cultural and conservation significance at a whole of landscape scale. In this way, the site is managed mainly for conservation through purposeful intervention. Work conducted on the IPA over the past decade demonstrates the significance of a culturally-defined ecosystem for the preservation of both regional biodiversity and cultural identity. Toogimbie has a critical role in landscape scale conservation by protecting key ecological assets, including species and habitats, in an area that has undergone substantial modification.

Toogimbie's lignum wetlands along the Murrumbidgee River are part of the region's first lignum floodplains to be set aside for conservation purposes (DEWR 2007). These freshwater seasonal wetlands support many local plants and animals. A 2002 fauna survey (Pennay et al. 2002) found 86 different fauna species including 55 bird, 18 mammal, 11 reptile and 2 frog species. Tree and shrub species include River Red Gum, Black Box and smaller species such as Boree or Weeping Myall, River Cooba, Dillon Bush and Nitre Goosefoot (DEWR 2007) (Figure 3).

Figure 3: Aquatic plant management at Toogimbie Wetlands. Image Nari Nari Tribal Council.

These natural and cultural values are further specified in the IPA Plan of Management as (Nari Nari Tribal Council 2012):

- Significant nesting and breeding area for wetland birds.
- Shrubland and plains country managed for noxious and feral species.
- Riparian zones, stream bank areas and the Murrumbidgee River – habitat for native aquatic fauna and mammal species.
- Future potential of wetland to attract regional threatened species.
- Maintenance of bush medicine and food sources for generations to come.
- Refuge for wildlife in a developed landscape (farmland, irrigation, river regulation).
- Sense of ownership, pride and connection to Country.
- Physical reconnection to culture and Country.
- Location of significant sites, including burial sites and occupation sites.
- Socio-economic potential for community.
- Traditional harvest (Fish/hunt/gather foods and medicine).
- Cultural knowledge, stories, experience as a community.

Although these values are not expressed specifically in relation to water, there is an implicit relationship between the fulfilment of these management goals and access to water. The availability of an appropriate cultural flow allocation has been the limiting factor of efforts on the Toogimbie site to re-establish vegetation and biodiversity for environmental and cultural benefit.

2.2.3 Water access and management

The Murrumbidgee River is the second largest river in the Murray-Darling Basin and is home to more than 25 per cent of the Murray-Darling Basin's population. Land use is dominated by dryland grazing and cereal based cropping, which account for more than 75 per cent of land use in the Murrumbidgee River Valley. An additional 5 per cent of the catchment is irrigated, producing rice, grapes, citrus, vegetables and other crops and livestock (CEWO 2014). The Murrumbidgee catchment also includes the Ramsar listed site of Fivebough and Tuckerbill Swamps, and two wetlands of national importance - the Mid-Murrumbidgee Wetlands and the Lowbidgee Floodplain (Environment Australia 2001, NSW OEH 2014).

Cultural, environmental and irrigation assets within the Murrumbidgee system can be watered by releases from Blowering and Burrinjuck dams, but water delivery is constrained to in-channel flows that inundate the main river channel and low lying wetlands and creek systems with commence-to-flow thresholds occurring below bankfull height (MDBA 2012a; CEWO 2014). Low-lying wetland assets include the Mid-Murrumbidgee wetlands, and areas of the Yanco-Billabong Creek system and Old Man Creek system. Pumping water directly to wetlands is possible in some cases, including at Toogimbie Station.

Water infrastructure on Toogimbie Station (Figure 4) has allowed the Nari Nari Tribal Council to water the wetlands in a way that emulates the historical flood regime prior to upstream development. Key to the restoration of the Toogimbie Wetlands has been the Nari Nari's access to a 2150 ML Cultural Access Licence (CAL) from the NSW Department of Primary Industries. A CAL is one of the two types of Aboriginal specific-purpose licences for Aboriginal people available under the NSW Water Management Act. It is one of only two such licences that have been granted under the Act. In this instance, the on-site pumping and channel infrastructure complements the enclosing effect of a series of levees that establishes four 'cells' on the wetlands, three of which can currently be watered annually. The water available under the CAL has been used over the past decade to flood the wetland for the purpose of culturally-informed wetland rehabilitation, since the grant of the license in 2005.

Figure 4: Installation of infrastructure to manage flows across the wetland. Image Nari Nari Tribal Council.

Initial discussions with the Nari Nari Tribal Council during the inception meeting identified key areas of concern around the use of the CAL. These licences are only available to Aboriginal persons or Aboriginal communities and provide water for personal, domestic and communal use including manufacture of traditional artefacts, watering of domestic gardens, hunting, fishing and gathering, recreational, cultural and ceremonial purposes. The conditions of these licenses explicitly prohibit their use for economic gain, despite the high transaction and delivery costs associated with accessing the water. Cultural access licenses do not have the same guarantee of property right as other entitlements, and the licenses must be renewed annually. Additionally, the availability of cultural flows is subject to demand by neighbouring irrigators. This means that it is typically only available in the winter, which is suboptimal for wetland restoration and plant growth. The license does not permit carry-over, which limits the ability to retain water for a larger flood event and encourages watering every year, which may not emulate the historical and pre-development wet-dry cycle.

2.2.4 Land Management practices

Management practices at Toogimbie Wetlands are in line with World Conservation Union Category IV - Habitat / Species Management Area, managed mainly for conservation through purposeful intervention. Toogimbie Wetlands also demonstrates the characteristics of a culturally-defined ecosystem within the Category IV classification, given the associations between the cultural management strategy and the regional biodiversity. Toogimbie has a critical role in landscape scale conservation by protecting key ecological assets, including species and habitats, in an area that has undergone substantial modification (Figure 5).

Figure 5: J. Woods (Research Partner) collecting native vegetation seeds for redistribution at Toogimbie Wetlands. Image Nari Nari Tribal Council.

2.2.5 Aspirations

Water is vital to the rehabilitation of the wetlands, and the Aboriginal land management practices on the site are conducted as part of the fulfilment and demonstration of broader social arrangements and cultural practices. Knowledge of water stories and cultural history varies amongst the Research Partners, however there is a deep commitment to and understanding of the way in which culture is enacted and re-enacted as practice through the rehabilitation and other land management practices on Country. As Nari Nari Research Partners express it:

> *"Cultural practice always happens when people are on Country."*
> *– J. Woods, pers. comm. 2016 (Research Partner –Nari Nari Tribal Council)*
>
> *"What we're doing here is unique. And we want to share that – with non-Aboriginal people too. To be able to say, this is where we've got to, this is who we are, this is what we do. The Nari Nari has been like a training centre or a training hub. Have a look at the young people who come through here, they've all been trained on this Country…. When we teach, we teach what we know about the landscape and about the culture, then it's up to them whether they want to go on to study science or other things. We've been successful – a lot of boys and girls have come through our system. Some have gone on to National Parks jobs, CMA jobs, water jobs…. People have told us that there's opportunities for tourism, and getting people to come by from the road, but for me it's always been about the training. This is a place you can train and learn, and feel good about that."*
> – J. Woods pers. comm. 2016 (Research Partner - Nari Nari Tribal Council)

The site is managed using culturally informed land management practices to promote environmental restoration of the largely degraded site, whilst ensuring the protection and enhancement of the local Aboriginal culture and history. Community leadership and participation in re-habilitating the system to a healthy riparian and floodplain environment plays a significant role in re-engagement of the community to Country, contributing to community wellbeing and reconnection to Country for the Nari Nari. In this way, the management aspirations reflect the significance of Toogimbie as a site of cultural regeneration and as a place of education, learning, well-being and capacity.

Centrally, the Nari Nari Tribal Council have identified their vision and long-term aspirations for the Toogimbie Wetlands site, in the IPA Plan of Management (Nari Nari Tribal Council 2012, p. 4):

> *"The Tribal Lands will be a place of pride for Aboriginal people. The land will be protected, its cultural and natural values enhanced, creating a quality environment for present and future generations."*

Within this broader vision, aspirations directly attributable to a cultural flow were identified as:

- Sustaining and protecting the site as an educational facility for intergenerational transfer of cultural knowledge and practice and as an exemplary demonstration site of Aboriginal management of Country. In the longer term, these outcomes were linked to long-term sustainability of management interventions, to cultural regeneration, to the emergence of new community leaders and to improved community governance.

- Enhancing the site as a significant nesting and breeding area for wetland birds of cultural significance, especially the Black Swan. Birds of cultural and iconic significance to the Nari Nari do not have the same priority for environmental outcomes, and are not likely to be targeted in environmental flow conditions or events.

- Restoration and maintenance of vegetation with bush medicine, craft, ceremony artefacts and food sources. Specifically identified vegetation includes the native grasses such as White Top and Wallaby Grass (associated with food, weaving and habitat for hunting grounds), Common Nardoo (traditional food source), Old Man Weed (traditional medicine species), Cumbungi (artefact construction and food source), common reed (weaving, construction, ceremony and food source). These vegetation outcomes are linked directly to re-establishing traditional harvest activity of the site, to enable sharing of cultural knowledge, stories and experiences as a community.

- Establishing Refuge for wildlife in a highly developed and modified landscape (farmland, irrigation, river regulation), including threatened species such as the Southern Bell Frog, but also animals of historical and cultural importance such as Kangaroo, Emu and Koala.

- Supporting cultural management of the Toogimbie site as it contributes to the ongoing protection and preservation of Nari Nari significant sites, including artefact, burial sites and occupation sites, connected to the belief in the continuing spiritual presence of ancestors in the landscape.

Restoration of the ecology of the site has significant socio-economic potential for the community, with a cultural water allocation contributing directly to achievement of economic independence through enterprise development and water trading. This type of economic activity is consistent

with cultural responsibility and contributes to the sense of ownership, pride and connection to Country (for example, establishing cultural tourism activities, including use of the site for science and research tourism). Employment, training and education outcomes are linked to cultural management of the wetland, which in turn contributes to the maintenance and regeneration of cultural knowledge and practice.

2.3 Gooraman Swamp

> *"Gooroman, bordered by red sandhills, was at the time covered with two metres of clear water, full of fish and alive with birds…..I'd like to see them days come back again…. But never again…."*
> – R. Campbell pers. comm. (cited in Creamer 1985)

Gooraman Swamp is located on Murrawarri Country on the floodplain of the Culgoa River (ngarntu) in northern NSW, approximately 20 km southwest of the Culgoa National Park and adjacent to Weilmoringle or Wayilmarrangkal (Murrawarri for Oldman Saltbush) (Figure 6). The Culgoa River is a branch of the Ballone River that rises in southern Queensland. The river flows in a southwesterly direction for approximately 490 km from downstream of St George in southern Queensland to its confluence with the Darling River in NSW, between Bourke and Brewarrina.

2.3.1 Landform and climate

The regional climate is semi-arid, with an average annual rainfall of approximately 410 mm (Bureau of Meteorology data, unpublished), and typified by cool winters and hot summers. The rainfall pattern is that of a summer-rainfall region, with highest mean rainfall in January-February and lowest rainfall in winter-spring.

Gooraman Swamp and the nearby Weilmoringle township are situated within the western district of the Darling Riverine Plains Bioregion. Combined they cover an area of 3,500 hectares. The bioregion is characterised by extensive floodplains of 10 major rivers: the Barwon-Darling, Culgoa, Birrie, Bokhara, Narran, Gwydir, Namoi, Castlereagh, Macquarie and Bogan. It has been estimated that 10 to 20% of the native vegetation in the Western Division has been cleared for agriculture, which is less such disturbance than other parts of the bioregion (NPWS 2002, 2003). The area surrounding Weilmoringle is comprised of Northern Riverine Woodlands, which is a habitat type that includes River Red Gum Woodlands along river frontages and extensive Coolibah–Black Box Woodlands on the floodplains of the Culgoa River. As noted by the NPWS (2002, 2003) and Hunter (2005), the Riverine Woodlands on the Culgoa River floodplain (particularly in the nearby Culgoa National Park) are the largest and least disturbed area of contiguous Coolibah Woodland left in NSW.

Gooraman Swamp is a deflation basin perched on the floodplain of the Culgoa River. The local vegetation consists of River Red Gum and Black Box Woodland within and at the margins of the wetland, interspersed with Coolibah. Gooraman Swamp is approximately 28 hectares in size and has a volume of approximately 320 ML at a full supply level (FSL, 125.6 m AHD) (Figure 6).

Figure 6: Gooraman Swamp (2016).

2.3.2 Values: Spiritual, Cultural and Ecological

purtu nguwa ngana	***Give us rain***
mayi ngara thulukala	***The ground is like dust***
wala yural thanu ngana	***We have done you no wrong***
purtu nguwa ngana	***Give us rain***
manu nguwa ngana	***Give us bread***

The Murrawarri have lived and celebrated the land at W*ayilmarrangkal* through dance, song corroborees and dreaming stories. Declared an IPA in July 2011, *wayilmarrangkal* contains a number of significant cultural sites, including modified trees, campsites, ceremonial and spiritual places.

> *…"For the Murrawarri the Culgoa is the most important place, we have to make sure we take care of the river. The swamp [Gooraman] has a very high spiritual, physical and environmental value but the river has also a social value, as soon as that water is over the weir, everyone is down there fishing and swimming. It is a connection that has never been broken. Without water in the river there is no water for the swamp or the Mundaguddah."*
>
> – F. Hooper pers. comm. 2017 (Research Partner - Murrawarri)

The cultural significance of the watering place for the Murrawarri is connected to the *Mundaguddah*, the name that the Murrawarri give to the Rainbow Serpent (Creamer 1985, p. 7). The *Mundaguddah* travels across Murrawarri Country through the subterranean channels, thereby linking together a series of significant water places through this Country and throughout the

Murray-Darling system. The presence and movement of the *Mundaguddah* relies on sufficient quantities of water present at key places: an important waterhole in the Culgoa River (*ngarntu)*, the Gerara Springs and Gooraman Swamp (Figure 7).

Each of these places has associated cultural practices, obligations and established cultural prohibitions linked to water availability, and Research Partners noted that all three water places have been varyingly impacted by upstream development. Gooraman Swamp is the home of the *Mundaguddah* (Creamer 1985, pp. 6-8):

> *"It is believed that the Mundaguddah used to travel 80 kilometres to Gerara Station which has a permanent water spring that never goes dry. When the floodwaters come up at Weilmoringle, the Spring at Gerara Station changes its natural clear colour of water to a dirty brown colour. This is how many of the Aboriginal people living at Gerara Station knew that the Culgoa River was in flood. How the Mundaguddah used to travel from Weilmoringle to Gerara Station is unknown, but it is believed that there must be a tunnel leading right through, big enough for the Mundaguddah to travel to and from each place. The Mundaguddah has never been seen, but many of the Aboriginal people still talk about it today and believe its legend is true."*
>
> – J. Byno, pers. comm. (cited in Creamer 1985, p.11)

Figure 7: Gerara Spring (2016). During times of flood, the water within the spring rises and changes colour.

2.3.3 Cultural obligations and responsibilities

Murrawarri Research Partners have cultural obligations to maintain the ecological health of the place. In particular, there is a responsibility to maintain the health of the River Red Gums, as spirit trees, which represent the continuing presence of the ancestors in the landscape and establish means of communication with those ancestors (Creamer 1985). There is a deep spiritual significance to the health of the River Red Gums at Gooraman Swamp.

…" The River Red Gum species is the most important / highest [cultural] value, there is no value higher for us [the Murrawarri].. That's our chuch, that's our connection back to the ancestors.. That's how we talk to ancestors through those trees. Every time we walked into those spirit trees the wind would blow up.. that's the old fellas talking to us, up in the sky camp talking to us..For us there is no other importance, the other value which we can't even try to explain. So that water has the same significance. It is like someone going to chruch and speaking to god. That is why Gooraman swamp is so significant to us."

– F. Hooper, pers. comm. 2017 (Research Partner – Murrawarri)

Further, a wide range of ecological and cultural values at the site would be re-established and protected as a consequence of the restoration of Gooraman Swamp to its historical flow patterns (Figure 8). For example, having water in Gooraman Swamp was the key driver of the return of migratory birds, and to assist in the proliferation of bushfood species, including iconic fauna species relied upon for hunting and the availability of plant species for medicine and cultural practice.

Figure 8: Culgoa River upstream from the Mundaguddah waterhole at Weilmoringle (2016).

2.3.4 Water access and management

> *"Water, is a perennial problem at Weilmoringle…European demands for sheep and cattle were much greater than the Murrawarri's need for survival……As far back as 1885 there was an enquiry into the conservation of water in the Culgoa River."* (Gill 1996, p.85).

Restoration of the historical water regime at Gooraman Swamp is vital to the resumption of traditional land management at this place. The appropriate conditions for seed gathering, the re-establishment of fire management techniques and the reduction in weed species were all

connected to getting water to the Swamp at the appropriate time and duration. Traditional land management by Research Partners on their own Country was seen as integral to improved cultural esteem and identity benefits that are connected to the fulfilment of cultural management, and this is consistent with the experience of cultural management of Country around Australia. Cultural management of Country is linked to the long-term aspirational goals of Murrawarri Research Partners, who articulated strong connections between the health of the water places, access and availability of those places for cultural practice, and the intergenerational exchange of knowledge. In this case, increased cultural management includes the obligations to downstream communities to maintain the home and protect the spirit of the *Mundaguddah*. The lack of capacity to fulfil those obligations under the current water regime has had an impact on the spiritual and emotional life of the Research Partners in the community.

2.3.5 Aspirations

"To get water in the river – that's why I wanted to link both Gooraman Swamp and the Mundaguddah water hole, because there is a correlation. There's a connection there from the Mundaguddah waterhole to the Gooraman Swamp, and that's of cultural significance. And that's the difference between the environmental flow and the cultural flow. Because [getting water to Gooraman Swamp] is fulfilling our cultural purposes. If we look at the two, some of it will overlap. So for example, the Mundaguddah waterhole and Gerrara Springs will fall into the environmental flow category. Because if you get in the Culgoa, down to Weilmoringle, and you fill that waterhole up, and you have enough water flowing down the system, then there are a number of waterholes, the connection to this place here. [Gooraman Swamp] is his home. The connection then allows him to travel. It's the same – there are all different names for him all through the Murray. There's a common connection."

– F. Hooper, pers. comm. 2016 (Research Partner – Murrawarri)

A cultural flow was seen as crucial to the restoration of that historical water regime, including the patterns of flooding and the wet/dry cycle associated with significant off-river places such as Gooraman Swamp. It was recognised by all Murrawarri partners that the changed conditions of the river due to upstream development was having a negative impact on both environmental

"First be last and last be first… What is going to keep me alive first, what is going to keep my spirit alive. So at Gooraman, by looking after the resources [water] and in return it looks after us.. Like the birds and stuff.. need to look after the spirit and resources first, it will look after us.. It [water] is not just a natural resource, it is the number one resource."

– P. Sullivan, pers. comm. 2017 (Research Partner – Murrawarri)

"People would walk for miles upstream just to see the water come down the river. The connection between water and wellbeing is so important."

– J. Byno, pers. comm. 2017 (Resarch Partner – Murrawarri)

"I think water is the most important thing.. We cant survive without water.. and having access to that spiritual water that we have really strong ties to, like at Gooraman and Weilmoringle, I think we need to get back to being able to show that to people, and we can't do that without having water there and I think this is the most important step forward for us as first nations people in controlling the most imporant resources that we have on our land [water]."

– S. Hooper, pers. comm. 2017 (Research Partner –Murrawarri)

values instream and for the riparian ecology, and that this in turn had a cultural and social impact on the community. The Murrawarri aspirations for water management at Gooraman Swamp relate primarily to correcting the negative impacts of the current flow regime, and specifically those impacts on culturally significant sites, processes and practices derived from the historical flow regime of the Culgoa River (*ngarntu)*. In the absence of a cultural flow allocation, water delivery to Gooraman Swamp based on overbank flows from the Culgoa River (*ngarntu*) during flood events is entirely dependent on diversion and storage of flood flows upstream of Weilmoringle (*wayilmarrangkal)*.

3. CULTURAL KNOWLEDGE AND LINKAGES

It is an indisputable fact that a fundamental and essential connection exists between Aboriginal Australians and water in the landscape (Bandler 1995). In the driest continent on Earth the natural variability of aquatic ecosystems dictates the natural resources available, to both present and past generations. The wetting and drying patterns influence movement through, and connection to, Country. Characteristics of different aquatic ecosystems have had a strong influence on traditional activities (e.g. Bandler 1995, Powell et al. 2015, Bayliss and Ligtermoet 2017), development of technologies and use of techniques (e.g. fish traps., Kelly 2014, Rose et al. 2016).

It is therefore crucial to link the culture aspects of aquatic ecosystems to the key element – water. The following section provides an overview of the current literature discussing this crucial link.

> *"Water is life….to everything and everybody."*
> – J. Byno, pers. comm. 2017 (Research Partner - Murrawarri)

3.1 Linkages: Aquatic ecosystem and Aboriginal uses, values and benefits

3.1.1 Connecting culture to water

> *"Indigenous people were very much a part of the ecology of aquatic ecosystems and their effects may have been profound. Despite this, their role in influencing these ecosystems has largely been ignored by contemporary freshwater ecologists and managers."* (Humphries 2007, p. 106).

Australian aquatic ecosystem are diverse reflecting an extreme level of variability in terms of their hydrological regime, geomorphological features and response to a harsh, often arid climate. Aquatic ecosystems range from estuarine and marine systems including mangroves, estuaries, coastal lagoons, intertidal saltmarshes, to permanently flowing and episodic rivers and streams, vast floodplain systems, localised groundwater dependent systems such as mound springs, large fresh and saline lakes, swamps and wetlands. Globally, cultural and other social values of aquatic ecosystems exhibit a strong specificity (certainly regional and often local) that characterises them and adds a new dimension to their diversity (Ramsar Convention 2002). This is very evident in the variability in how water is valued in Australian communities (e.g. Gibbs 2006; Rolfe & Windle 2003 cited in Gorman 2013a; Weir et al. 2013).

Aquatic ecosystems are amongst the most threatened in the world, with significant losses and degradation continuing to occur (e.g. Dudgeon et al. 2006; Finlayson et al. 2013; Davidson 2014; Dudgeon 2014). The loss of aquatic ecosystems and associated loss of traditional activities in many parts of Australia has led to a perceived decrease in the importance of aquatic ecosystems as a direct resource base for Aboriginal communities (Finn & Jackson 2011). What is not well recognised is that there is also an associated significant loss of spiritual connection and sense of well-being. Once aquatic ecosystems are degraded or removed completely from a landscape the particular cultural values associated with that system can be permanently lost, often within a generation.

3.1.2 Traditional Aboriginal Knowledge (TAK) and water management

In Australia water is a sacred and an elemental source and symbol of life (Langton 2006 cited in Jackson 2006), with the resources provided by aquatic ecosystems a pivotal part of cultural economy (Weir et al. 2013). This is as true for current generations as it was for past generations. It is important to acknowledge that TAK is not 'past' knowledge, rather it is continuing knowledge (Nakata et al. 2005), and as such should be a key element for setting objectives for water resource management for cultural outcomes.

TAK does not compartmentalise cultural, spiritual, social, environmental and economic factors as Western Science does (Turner 2016). Broad generalities could be made about linkages between the key characteristics of different aquatic ecosystems types and what they might supply in terms of natural resources to Aboriginal communities, but this simplifies the complexity and integrated nature of TAK and values associated with water built over generations that will continually evolve into the future. Each Nation will have its own specific relationship and values associated with water.

Cultural values potentially affected by water resource management can be broadly grouped into categories relating to customary, economic, spiritual, ecological, social/recreational and educational values (e.g. Constable & Love 2015; NSW Department of Primary Industries 2016; Turner 2016). Examples of the different cultural values and uses associated with different aquatic ecosystem types are starting to appear more frequently in the scientific literature (e.g. Gorman 2013a; Gorman 2013b; Jackson et al. 2014; Noble et al. 2016). Whilst there is a substantial environmental water management literature, there is growing recognition of adopting cross-cultural approaches to water resource management (e.g. Humphries et al. 1999; Ganf 2000; Bunn and Arthington 2002; Arthington et al. 2006; Dyer & Roberts 2006; Brandis et al. 2009; Capon et al. 2009; Poff & Zimmerman 2010; Alluvium 2013a; Alluvium 2013b; Davies et al. 2013; Pahl-Wostl et al. 2013; Acreman et al. 2014; Doody et al. 2015; Gillespie et al. 2015; King et al. 2016).

Contributions relating to cultural aspects mostly focus on the need for a cross-culture approach to resource management in recognition of TAK (e.g. Ens et al. 2012; Bohensky & Maru 2011; Bohensky et al. 2013; Danielsen et al. 2014) and the need for further water policy reform (e.g. Finn & Jackson 2011; Barber and Jackson 2012; Bark et al. 2012; Burdon et al. 2015; Ens et al. 2015; Jackson 2015).

3.2 Differences and similarities between cultural and environmental flows

Water resources are managed for sustainable use, and this implies management of water resources for human benefits. In Australia this has predominantly meant for consumptive use, including primary production and irrigated agriculture and horticulture (Neal et al. 2014). In theory, this should include all Australians, but to date Aboriginal cultural flow requirements have only rarely been specifically addressed.

> *"Cultural water is different from environmental water. Environmental water cannot achieve the wellbeing, social and economic outcomes that a cultural flow can."*
> – P. Sullivan, pers. comm. 2017 (Research Partner - Murrawarri)

In southeast Australia, where water abstraction, regulation and consumptive use is significantly more developed than in northern Australia, environmental water management has focused on select ecological aspects of aquatic ecosystems (mainly riverine and floodplain systems) (Pahl-Wostl et al. 2013).

A discussion of the differences and similarities between environmental and cultural flows can be structured around three main themes:

1. The assessment process to determine the flow volumes and regime to meet environmental/cultural objectives;

2. The ownership, administration and management of water allocated for the environmental/cultural purpose; and

3. The benefits of the environmental/cultural water allocation and management.

These themes can be summarised as three questions:

- How much water should be allocated and what is it allocated to?

- Who governs and controls the water allocation? and,

- Who benefits from the allocated water?

On the first question, the Project found that the process of assessing environmental flow needs is not fundamentally at odds with that of assessing cultural flow needs. The processes share many similarities, but they do differ in the scale of the area assessed, the breadth and focus of objectives, and who sets the objectives. In a cultural flow the benefits to Aboriginal Nations are both tangible and intangible, relate to the actual watering place and also the holistic concept of supporting Country specific to the cultural objectives. The objectives can be ecological, social, cultural or a combination. Environmental flows can be assessed for isolated locations, but usually the assessments are done at the scale of catchment or river system, which are represented by a limited selection of watering places that possess key ecological assets. The cultural flow assessments undertaken in the Project were local-scale, at places with recognised water-related cultural values. On the second question, the Project found that ownership, control and freedom of use of cultural water is of fundamental importance to Nations, and this cannot be offered by environmental water allocations, which are largely administered by government, usually with narrow terms of use. On the third question, the Project found that Nations could possibly derive significant benefits from application of environmental water, but the benefits would be incidental, variable, unpredictable and not likely to be focused on the key cultural needs. The benefits of environmental flows are measured using indicators of ecosystem condition, and the results are used to adapt flow management. Management of water to meet cultural objectives requires appropriate cultural indicators, which are unlikely to be included unless the assessment process is structured from the outset around cultural flow needs and objectives.

Finn and Jackson (2011) outlined three main areas distinguishing cultural and environmental water management which have been broadly supported by a number of other authors as being key features which distinguish cultural and environmental water:

1. Different set of management objectives,

2. Different suites of species, and

3. Recognition of Aboriginal worldviews and the importance of people-place relationships.

The main arguments made by Finn and Jackson (2011) are discussed below supported by examples from this Project.

1. **Different set of management objectives**

A fundamental part of any resource management, including water management, is to clearly articulate the objectives for management including the desired outcomes. Unless cultural objectives are articulated at the beginning of the planning stage they can only ever be considered in an ad hoc manner – as an afterthought. For example, environmental water allocations often target fish species of conservation value, but to meet cultural needs, objectives would need to explicitly include the requirements of hunting, fishing, trade, ceremonial, cultural use and sharing of the resource to meet cultural obligations at rates that are acceptable/desired for the local communities.

It is critical to ensure that the cultural flow objectives are determined by the Traditional Owners and the authorised knowledge holders as decided by the Research Partners. In this context, the authorised knowledge holders include any person, normally a Traditional Owner, who has been provided cultural and/or traditional knowledge of a particular place or thing through customary law and is recognised by the Traditional Owner community to have the authority to speak on or share that particular knowledge where appropriate. For this reason, it is considered essential to undertake engagement with all relevant Aboriginal and other stakeholders prior to commencement of a cultural flows assessment project. The pre-planning and project scoping phase is the time to begin setting and seeking agreement on objectives. It is important to correctly identify those best placed to represent Aboriginal interests. In the planning phase, sufficient time should be provided to accommodate appropriate decision-making processes, which will vary with different communities and Aboriginal representative organisations (Collings 2012).

In both case study locations for the Project, an inception meeting was held with the Project Team and Research Partners in order to provide an overview of the cultural flows planning process, confirm expectations, engagement and participation needs and to clarify roles and responsibilities. The purpose of these meetings were to establish and satisfy the requirements of each of the Research Partners for free, prior and informed consent, as well as establishing the context for the direction of cultural flow planning by Aboriginal partners. During the inception meetings, the Project Team worked through a deliberative process to identify resource management goals, project aspirations and engagement preferences of the Research Partners. The final choice of objectives and methods in each location was refined as a result. This ensured that Aboriginal Research Partners effectively determined objectives and subsequently the selection of data collection techniques, assessment methods and monitoring indicators tailored specifically to the needs and contexts of the case studies.

2. **Different suite of species**

Target species identified for environmental flows are likely to have some overlap with culturally important species, including species of conservation significance. However, many culturally significant species are common and widespread, contributing to Aboriginal household incomes through customary use. In Australia, these have rarely been the focus of environmental water objectives and allocations, and where they have been included, the objectives are not written for cultural outcomes, but more typically for ecological outcomes. Usually though, in the interests of expediting the environmental flow assessment process, it is simply assumed that common species are catered for by flows that protect identified keystone, rare, endangered or otherwise iconic species. Although the overarching objective of holistic environmental flow management is achievement of a healthy ecosystem, the entire list of species, communities and processes that make up an ecosystem is vast and cannot be studied in its entirety, so prioritisation and practical limitations usually leads to a focus on species of high conservation value.

At the Toogimbie site, for example, priority ecological outcomes to be targeted with a cultural flow included a range of cultural outcomes that would not typically be considered in an environmental water allocation. The Nari Nari Traditional Owners sought to use cultural flows to establish conditions to enable breeding of Black Swans, for example, which were identified as an iconic species for the site with totemic value to the Traditional Owners. Similarly, the cultural flows were intended to increase in established permanent vegetation species of customary use, including Lignum, Saltbush, Nardoo, Old Man Weed, and Common Reed, and animal species of historical and cultural importance such as Kangaroo, Emu and Koala. These targeted species are characterised by their historical abundance in the landscape and contributions to household incomes, rather than their conservation significance, although there is some clear overlap across these categories.

It is also important to note that water allocated to the environment at one location in a catchment could have additional users and uses if an unused portion travels down the catchment. It became apparent at Gooraman Swamp in particular, that cultural obligations between neighbouring communities entailed ensuring downstream communities had access to water, and that this had to be taken into consideration in planning for a cultural flow. Achieving cultural and environmental outcomes from the same volume of water is not mutually exclusive (Syme 2014) and could be increased with greater coordination in water management across users at the catchment or basin scale.

3. Recognition of Aboriginal worldviews and the importance of people-place relationships

Values and belief systems differ among different groups of people; therefore, it is not surprising that people in different demographic groups see different values in water. Understanding worldviews in regards to religion and cultural background, and residential location is important in understanding how people perceive different values of water (James et al. 2012). Australian Aboriginal communities have a moral imperative to care for surface and groundwater resources, as part of their commitment to looking after Country (Yu 2000; Goode 2003 cited in Syme et al. 2008) as evidenced by dreamtime stories and cultural and spiritual activities (Syme et al. 2008). However, this cultural view is not necessarily accounted for in current water governance.

Where cultural flow use, or cultural outcomes, is a key consideration of water resource management, then it is essential to include Aboriginal representation in water management planning from inception.

> *"For water planning to be successful, natural resource management practitioners need to better understand indigenous water values, interests, connections and relationships at the appropriate scale*." (Jackson et al. 2012 cited in Jackson & Barber 2013, p. 5).

There needs to be acknowledgement that cultural outcomes require specific objectives for water management and this cannot be established without TAK and Nation engagement/ownership (Weir et al. 2013). Similarly, environmental outcomes could be achieved through use of cultural flow if there is an understanding of the differences in perceptions of water management and the need to include broader social and cultural systems (Ens et al. 2012). Weir et al. (2013) make the critical observation in that cultural flows outcomes require a healthy river ecology as a precursor to sustainable economies.

> *"Indigenous people often identify Indigenous governance as a key distinction between environmental and cultural water. With cultural flows, it is the Indigenous peoples themselves who decide where and when water should be*

> *delivered, based on their priorities and goals. This direct governance role ensures that Indigenous peoples are empowered to fulfil responsibilities to care for Country (Ross 2009, p. 23).”* (Weir et al. 2013, p. 16).

Recent work, including the work undertaken as part of this Project, has illustrated the importance of using cultural indicators and ensuring communities have ownership and intellectual property rights over their information. Having a mechanism to record TAK in culturally appropriate ways, rather than being subject to Western systems of recording, is being advocated as a positive means of developing cultural indicators for inclusion in water resource management (Nursey-Bray & The Arabana Aboriginal Cooperation 2015).

In the context of the case studies, for example, it was recognised that the Murrawarri Traditional Owners have cultural obligations to maintain the ecological health of Gooraman Swamp. These obligations are both cultural and spiritual, and have direct implications for the aspirations of cultural flow entitlements as set by the Traditional Owners. This was due to the modifications to the system that have impeded the Traditional Owners capacity to fulfil these obligations. In particular, there is a responsibility to maintain the health of the River Red Gums, as spirit trees, which represent the continuing presence of the ancestors in the landscape and establish means of communication with those ancestors. There is a deep spiritual significance to the health of the River Red Gums at Gooraman Swamp, which depends on a flow regime that is no longer satisfied in the altered system.

> “That spiritual connection is hard to explain under this system. Because the environmental system is about the ecology. This is about the spirit. So that’s our religion to a certain extent. Part of our religion. That would be the equivalent of a church - kind of. That would be connected to other stories as well. That’s why this research is important, because of what it can show.“
>
> – F. Hooper, pers. comm. 2017 (Research Partner – Murrawarri)

Restoring a water regime that improved the health of the River Red Gums further enabled the resumption of Aboriginal and traditional land management at the site. The appropriate conditions for seed gathering, the re-establishment of fire management techniques and the reduction in weed species were all connected to getting water to the Swamp at the appropriate time and duration. Traditional land management by authorised Traditional Owners on their own Country was seen as integral to improved cultural esteem and identity benefits that are connected to the fulfilment of cultural management, and this is consistent with the experience of cultural management of Country around Australia. In this case, increased cultural management includes the obligations to downstream communities to maintain the home and protect the spirit of the *Mundaguddah*. These obligations were referred to in multiple interviews, and it is evident that the lack of capacity to fulfil those obligations has had an impact on the spiritual and emotional life of the Traditional Owners in the community.

This example demonstrates the necessity of both sensitive engagement and culturally appropriate indicators and methods for cultural flow assessments. Although the specific watering requirements for the health of the River Red Gums are informed by ecological science, the cultural outcomes associated with the health of those trees requires Aboriginal knowledge and participation.

4. DEVELOPING A TRIAL FLOW METHODOLOGY

> *"You do, I watch - I do, you watch,"*
> – P. Sullivan, pers. comm. 2017 (Research Partner – Murrawarri)

The methods used to develop a cultural flow methodology, and the engagement practice associated with the Project has been informed by a commitment to best practice in Aboriginal research and engagement. This included:

- A strictly upheld requirement of FPIC for all Research Partners (Tamang 2005).
- Intellectual property (IP) protection.
- Capacity building.
- Targeted research outcomes that explicitly benefit Aboriginal people in response to needs identified by Aboriginal people.

The research included the application of Participatory Action Research (PAR) principles, a research process that recognises and respects Aboriginal peoples' rights, responsibilities and ownership of the research. PAR is a process for change, driven by those most affected by the topic, where the researchers become facilitators of social learning and dialogue, rather than experts or possessors of privileged knowledge. In this process, the Research Committee, Project Team, Research Partners and Authorised Knowledge Holders are equal partners.

Our commitment to PAR principles is reflected in the approach which has prioritised:

- Engaged enquiry with the Aboriginal and other Research Partners as co-researchers,
- A flexible and responsive process that may encompass building trust and developing a common understanding,
- Collaborative identification of the research question, preferred methods of gathering data, and interpreting meaning, and,
- Achieving a beneficial outcome that meets the needs of the Research Partners.

Figure 9 provides an overview of the approach applied.

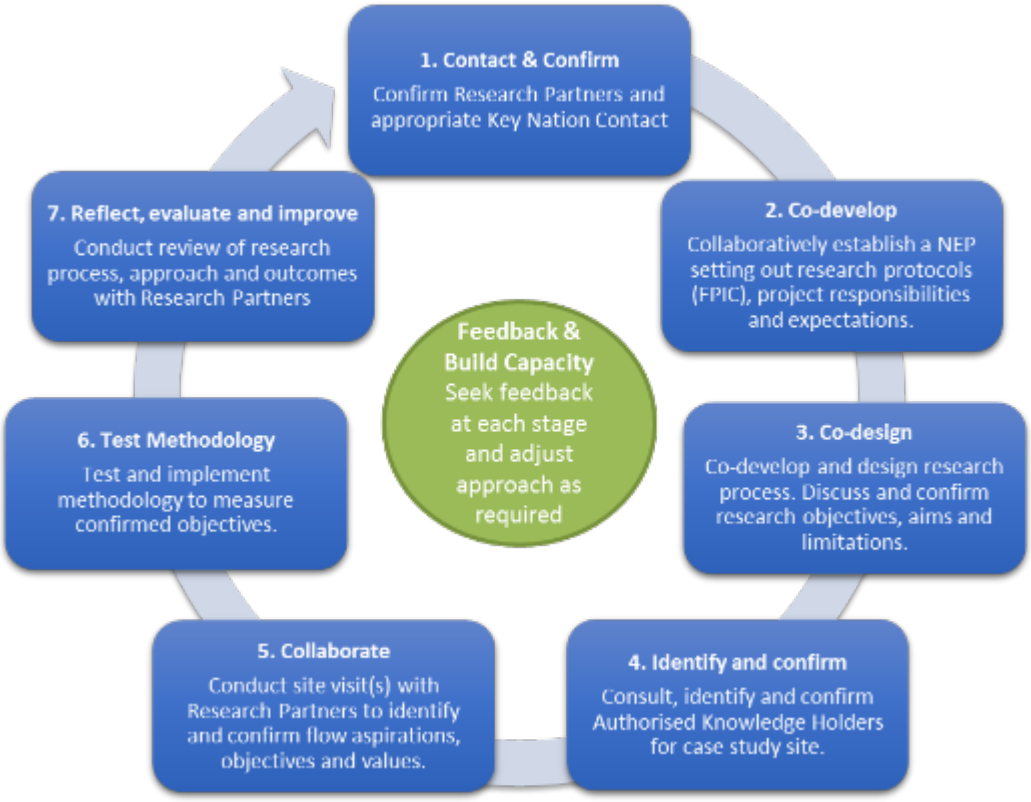

Figure 9: An overview of the NCFRP engagement approach.

4.1 Working together

Utilising a PAR approach, the applied research approach commenced with the establishment of collaborative agreement between the Project Team and Key Research Partners – Nari Nari and Murrawarri, in the form of a Nation Engagement Plan (NEP) (NCFRP 2016f; 2016g).

Drawing on our Communication and Engagement Strategy (NCFRP2016b), the NEP provided a guide for meaningful and practical engagement. Most importantly, the NEP process provided a platform for the Project Team and Research Partners to collaboratively address any concerns early and build the foundation for a strong relationship and mutual understanding throughout the research process

Integrating cultural protocols and guidelines for Ethical Research in Australian Indigenous Studies (AIATSIS 2011) and FPIC, each NEP addressed:

- Roles and responsibilities.
- Management of Intellectual Property.
- Agreed principles and protocols.
- Communication, capacity building and remuneration.
- Activities, schedule and requirements.
- Conflict resolution.
- Monitoring and evaluation of services.

"You didn't talk to us, we talked to you and you listened."
– J. Woods, pers. comm. 2017 (Research Partner – Nari Nari)

"We have both spoken the same language throughout the project."
– F. Hooper, pers. comm. 2017 (Research Partner – Murrawarri)

4.2 Developing a cultural flow trial methodology

The project adopted an approach of setting clear objectives and related Key Evaluation Questions (KEQs), based on the expected response(s) to water availability and delivery, which in turn provided the basis for working out how much water is needed and when, as well as for selecting indicators to monitor (NCFRP 2016b, c, d, e, g, h). Similar approaches have been widely adopted in terms of assessing outcomes from the delivery of environmental water across south-eastern Australia (e.g. DELWP 2016; Gawne et al. 2013; Hughes et al. 2016) and was considered appropriate for this study also.

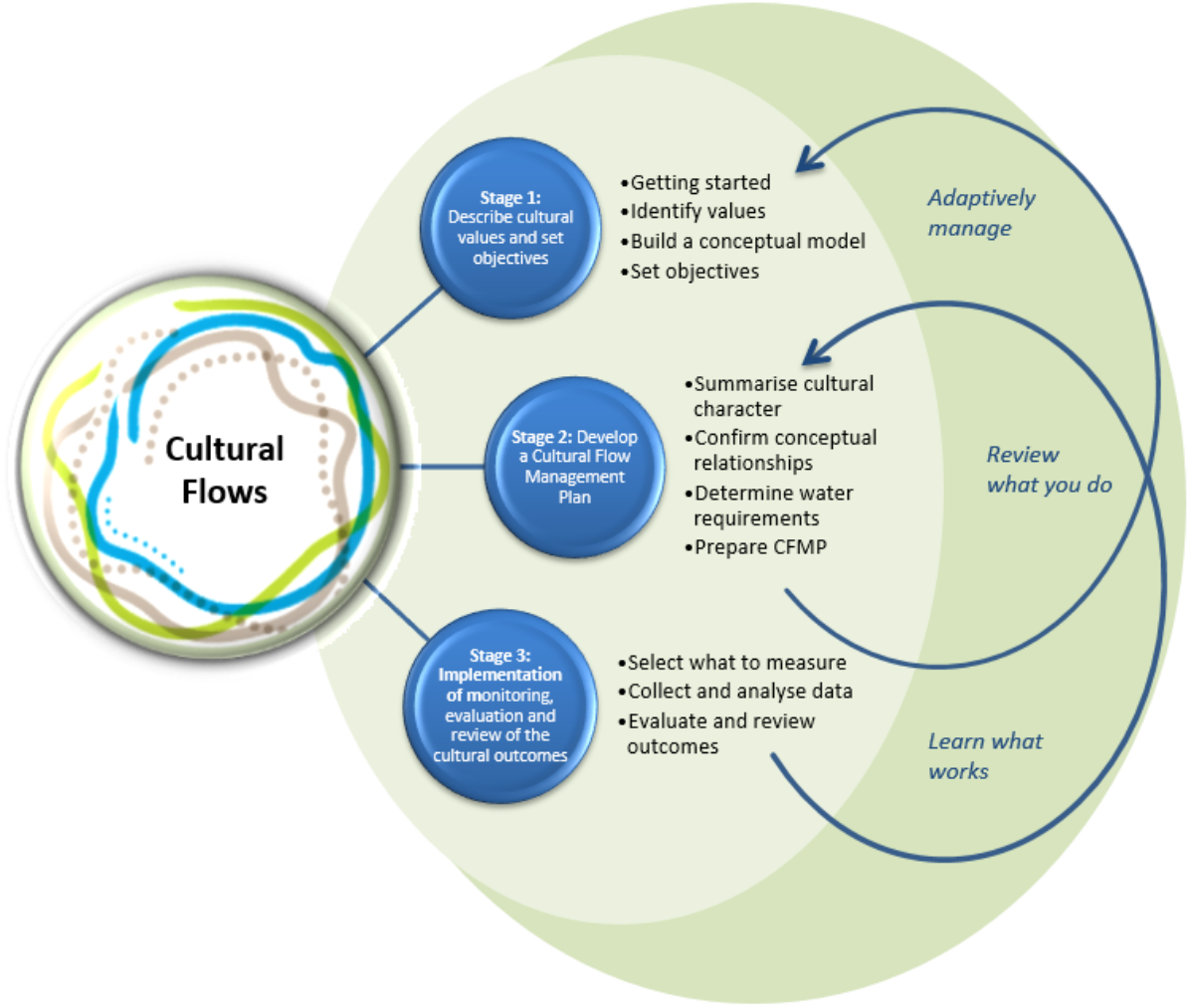

Figure 10: Overview of the Cultural Flows Guide (NCFRP 2017e; 2017f).

4.2.1 Setting objectives together

The process of setting objectives, developing a water plan and preparing and implementing monitoring plans was undertaken with Research Partners at both the case study watering places. The objective setting process involved numerous discussions between the Project Team and Research Partners. Ongoing feedback from the Research Partners had a great bearing on the objectives set at each case study site, and how water would be delivered. Important considerations during this stage included communicating:

- The information about the project that Research Partners needed to know.
- What the Project Team needed to know from the Research Partners.
- What outcomes are desired or expected, and how information might be used.

An important lesson learnt was that the general steps involved in setting clear objectives, indicator selection, study design, undertaking monitoring and interpreting results are likely to require a number of iterations to match the aspirations of Research Partners and what can realistically be monitored, depending on such things as resources and capability. This aspect will be considered further in Chapter 5.

Wherever possible, objectives and KEQs were expressed in terms that were SMART (specific, measurable, achievable, resourced and time-bound); adopting these principles means that monitoring programs were well-targeted and collected the right information. At both case study watering places, the Project identified objectives, developed KEQs and identified relevant indicators to assess watering outcomes in direct collaboration with the Research Partners. Indicator selection was based around themes, including ecological (e.g. plants, birds, fish and frogs) and social (e.g. health and wellbeing, economic value, knowledge and leadership) to help identify standard sampling methods and the capacity for measuring and interpreting results. For both Toogimbie Wetlands and Gooraman Swamp, the themes related to Research Partner wellbeing, as well as plant and animal responses to water delivery. Whether adopting themes is useful will depend on the objectives and KEQs that might apply at the watering places being monitored. A very important part of the project was that it included capacity building of Research Partners in applying the selected indicator methods at the watering place.

4.2.2 Plan for delivery

Once all cultural flow objectives were set, the volume and timing of water delivery was calculated. This involved modelling of water requirements, along with how water was to be delivered and the preparation of a water delivery plan (NCFRP 2016h). The water delivery plans were important, as water access and delivery will often require partnerships with government and water management agencies. Being able to clearly state the objectives, volume of water, risk management and other responsibilities will likely be necessary when working with such agencies on water delivery arrangements.

4.2.3 Monitor what happens

The measurement of indicators at both Toogimbie Wetlands and Gooraman Swamp were based as far as possible on published and widely accepted methods. For example, the vegetation monitoring undertaken at both watering places was based on a statewide method developed for NSW (Bowen 2013). At Toogimbie Wetlands, the project included monitoring at watering places that had been established as part of previous, related work (Smits 2014). This will help to build up

knowledge about responses at Toogimbie Wetlands and assist with interpreting results in the future.

Additional site-specific measures were also developed in collaboration with the Research Partners. For example, discussions with Murrawarri Research Partners identified the use of active nests as a useful measure of bird response to watering, and a method was developed and implemented to monitor the response at Gooraman Swamp.

> *"When the IPA was declared, the landscape was a desert. Then we set up those monitoring points – so you can clearly see the difference between what is what like then, and what it is today….. it's all there, the changes in the landscape you can see."*
>
> -I. Woods, pers. comm. 2016 (Research Partner – Nari Nari)

4.3 Hydrological and hydraulic modelling

4.3.1 Importance, role and scope of hydrological and hydraulic investigations

The process of obtaining and managing cultural flows is essentially a social process, led by local Aboriginal communities, and linked to other water users and regulatory agencies through the wider regional, state and national policies, regulations and practices that influence and control water planning, utilisation and sharing. The cultural flow assessment process is informed by a range of information, including TAK, cultural aspirations and western scientific knowledge. Hydrological and hydraulic investigations provide objective information about relevant aspects of the water cycle.

Hydrological and hydraulic investigations are important to cultural flows assessment projects because they provide the means for quantifying how much water is required to meet cultural needs. In the beginning of an assessment, the aspirations for water might be well understood in cultural terms, but not necessarily in terms of how much water, when, how long and how often. Without this information, the water allocation required to meet the needs cannot be calculated.

Hydrological and hydraulic investigations use mainly existing data, and also primary data collected from sites. These data are used to generate new knowledge in a form useful for assisting development and refinement of cultural flow objectives. After the objectives are set, the hydrological and hydraulic investigations quantify the volumes of water required to implement the desired flow regimes. Specifying the cultural flow regime in terms of magnitude, frequency and duration allows water managers to implement the allocation.

Having a model that characterises the hydrological and hydraulic behavior of the site allows "*What if…?*" questions to be asked. These are inquiries about what is likely to happen at the site if conditions change, such as a change in the pattern of river flows, changed climate, or changes in the way water is managed at the site. Even though a plan might be prepared for managing cultural flows at the site, this does not always work out in an ideal way, as future floods and droughts will inevitably affect the way the plan can be implemented. Thus, the hydrological model will provide insights into the future.

The Project aimed to develop appropriate methods for undertaking cultural flow site assessments, demonstrate their application at two case study sites, and then, on the basis of this experience, propose a general guide for undertaking cultural flow assessments nationally ("the Guide").

For the hydrological component of the Project, the task of quantifying water volumes to meet cultural values and needs at floodplain wetlands at Toogimbie and at Gooraman Swamp provided the opportunity to:

1. Critically explore a number of methodological approaches potentially applicable to the general problem at the national scale.

2. Refine the most promising methodologies.

3. Demonstrate a practical application of promising methodologies to two case studies.

4. Use the results of the research to develop a general guide for undertaking hydrological and hydraulic investigations that forms a component of the general Guide for undertaking cultural flow assessment nationally.

This covers the scope of the hydrological and hydraulic investigations undertaken for the Project.

4.3.2 The nature of hydrological and hydraulic investigations

Hydrological and *hydraulic* investigations cover procedures for *describing*, *predicting* and *simulating* hydrological and hydraulic processes.

Hydrology is the study of the water cycle and its individual components, including rainfall, evapotranspiration (ET), seepage, surface flow, subsurface flow, and the resulting flow or water level regimes of rivers and other waterbodies. Hydrological investigations can also include the related fields of fluvial geomorphology, which covers sediment supply, transport and deposition, and the landforms produced, and water quality, which covers chemical processes that occur in rivers and other waterbodies.

Hydraulics is primarily concerned with the depth, extent, velocity and shear stress characteristics of short-term hydrological phenomenon and events, such as flow along a channel or flow across a floodplain. Hydraulics also applies to the flow of subsurface water.

These are broad and complex subject matters, covered by a vast literature, and for which a great range of modelling approaches and tools can be applied. These are standard methods, not exclusive to cultural flows assessment. Although the individual methodological steps and calculations might be standard, their application in this Project to cultural flow assessment is new, and the guide proposed here is innovative for its integrated and logically-sequenced suite of methods most appropriate to the objectives.

4.3.3 Purpose of hydrological and hydraulic investigations

The main purposes of undertaking hydrological and hydraulic investigations in a cultural flows assessment project are to:

- Characterise the pattern of water flow to the site under the hypothetical scenario of no large-scale water resources development involving infrastructure of dams, diversions and/or groundwater pumping (termed no-Development scenario).

  This scenario does not include small-scale modification of hydraulics such as traditional Aboriginal aquaculture, or modification of surface runoff by human-influenced land use change, such as intentional use of fire, forest clearing, reforestation or establishment of agriculture. The latter might have altered river flows and groundwater levels, but the

effect is difficult to accurately quantify and is usually much less significant than large-scale water resources development.

Some or many cultural values would have formed prior to the historically relatively recent alteration of the natural pattern of flows due to large-scale water resources development, so at least some aspects of the natural pattern of flows are likely to be relevant to cultural flow objectives.

- Characterise the degree of alteration to the pattern of water flow to the site due to water resources development, climate change, or other factors.

  The aspects of the water regime that are most altered could be associated with loss or impairment of certain cultural values. Identification and quantification of the most impaired aspects of the flow regime is a first step towards achieving their reinstatement.

- Help document, using words / diagrams / numbers, the relationships between water availability and the cultural values.
- Contribute to an improved understanding of the importance of, and need for, cultural flows.
- Calculate the amount of water needed for a cultural flow allocation.
- Specify how to implement the cultural flows, when, how often, how much, and where.

There were two main outcomes from the hydrological and hydraulic research undertaken for the Project. The first was a set of results specific to cultural flow needs at each case study watering place, while the second emerged in the form of a methodological guide that will assist hydrologists tasked with undertaking similar assessments. The proposed guide for hydrological investigations is described in Section 4 of this report.

4.3.4 The main hydrological and hydraulic modelling components

The hydrological and hydraulic investigations require a considerable amount of data to be collected prior to modelling and analysis. Most of the data can be downloaded for low cost or no cost, but there is considerable time involved in checking data and deciding which data to use. Some secondary data might need to be modelled from primary data, and other data will be required from site inspection or provided by local people who have such knowledge.

For a riverine wetland site, the first step is to understand the hydraulics of water flowing to the site of interest. In most cases, the main unknown will be the river flow at which water flows into the wetland. This is termed the commence to flow, and is important information in calculating the frequency and duration of inundation under various river flow scenarios. As well as the commence to flow level, it is important to establish the flow paths, water depth distribution and inundation extent. This work is done using some form of *hydraulic model*. If the site has infrastructure to deliver water from the river to the wetland site of interest, such as pumps, pipes, and/or channels, then the hydraulic characteristics of these also needs to be understood and quantified.

After the hydraulics of the site have been modelled, the next step is to understand and quantify the hydrology of the site. Hydrology is concerned with the regime of water depth and extent over the long-term. The time-scale of interest is in the order of 100 years, represented over a daily time-step, so that the site hydrology can be characterised over a range of climatic and river flow conditions. This work is done by developing a site specific *Long-Term Site Hydrological Model*. This model has the versatility to investigate the effects of various approaches to water management on the water regime in the wetland, which links directly to the achievement of cultural flow objectives. Model output includes annual volume of water required and costs to pump the water

(if pumping is used to deliver the allocation), as well as a long time series of the resultant wetland water level and extent. Repeatedly running the model with various combinations of management decisions and parameter values (such as pump capacity, target water levels, timing of inundation etc.) will assist in refining the site management objectives and strategies. When this is agreed, a final model run will provide the estimated average and range of variability in annual cultural flow requirements.

While the *Long-Term Site Hydrological Model* identifies the range of water allocation volumes that could be required in any one year, the annual water planning process ideally requires a reasonably accurate prediction of the allocation required to meet the specific needs of the approaching cultural watering period. The water allocation planning timeframe is assumed to be less than 12 months, and usually less than about six months. To serve the purpose of planning water allocations for the approaching watering event, a predictive daily water balance model of one-year duration is used. This model, known as the *Cultural Water Annual Allocation Estimator*, uses similar algorithms to those used in the *Long-Term Site Hydrological Model*, but predicts short-term future wetland hydrology on the basis of recent historical climate, current wetland water level, statistically-generated future climate, and intended water management strategy.

5. RESEARCH OUTCOMES: WHAT IT MEANS

5.1 Examples from the case study sites

Having a monitoring and assessment plan in place is essential to measure how effective the use of cultural water has been in meeting stated objectives and outcomes. The following sections provide examples of objectives, indicators and assessment approaches developed and implemented by the Research Partners at the case study sites. The important thing to note is that such things as the stated objectives, key evaluation questions and description of indicators are all clear and easily understood.

While designing and implementing a monitoring program might seem intimidating for those with little experience in this area, it need not be overly difficult and can be a great learning experience for all involved. This is made clear in Section 5.3, which lists the outcomes experienced at the case study sites.

"We know our Country pretty well. We don't miss much. Part of it is because we are there every day… Most of our monitoring happens when we are on Country, just when you are driving past, because we notice the change in the landscape."
"As a result of the flood and the absence of a controlled flow trial, we [Nari Nari] have a greater understanding of the impact velocity plays on the site….Next time we receive a flood, we will be better prepared to return the water slowly back into the river in a more controlled or measured process."
-J. Woods, pers. comm. 2017 (Nari Nari Tribal Council Research Partner)

"My understanding of the wetland has increased [as a result of the project]. I always knew lignum needed to be watered, but not how much, or how often in order for it to be healthy."
- I. Woods, pers. Comm. 2016 (Nari Nari Tribal Council Research Partner)

5.1.1 Toogimbie Wetlands

The monitoring plan developed for Toogimbie Wetlands (NCFRP 2016e) was implemented largely as designed, even though there was a natural flood rather than managed water delivery as was planned (NCFRP 2016h). Examples of the stated objectives, KEQs and indicators of interest are listed in Table 1. In short, the study design was one of before-after (water event) comparison of outcomes.

Table 1: Objectives, KEQs and indicators for ecological elements at Toogimbie Wetlands

Watering objective	Key Evaluation Questions	Indicators
Vegetation		
Increased abundance and extent of bush tucker, medicinal and economic plant species. **Increased extent and condition of *Gweeargal* (Lignum).** **Reduced extent and abundance of weed species.**	Did the 2016 flood event increase the abundance or extent of key bush tucker, medicinal, economic and icon species? Did the 2016 flood event improve the condition of the *Gweeargal* (Lignum) community? Did the 2016 flood event increase the extent of the *Gweeargal* (Lignum) community? Did the 2016 flood decrease the abundance and extent of weed species?	Abundance and/or extent of *Nagaadha* (Nardoo - *Marsilea drummondii)* and *Budhaay* (Old Man Weed - *Centipeda cunninghamii*). Extent of the *Gweeargal* (Lignum - *Duma florulenta*) community. *Gweeargal* (Lignum) condition. Abundance and extent of weed species.

The monitoring results suggested that the selected indicators were appropriate and that changes in response to watering could be detected. The full description of monitoring outcomes can be found in NCFRP (2017a).

Figure 11: Visitation by hundreds of waterbirds at the newly established swan rookery at Toogimbie Wetlands, March 2017 (photo: J. Woods).

5.1.2 Gooraman Swamp

> *"Once you fulfil the water requirements of Gooraman Swamp, it also triggers all of these Aboriginal environmental outcomes. Because once the swamp is full, the birdlife comes back. A lot of the people from Weilmoringle were evacuated out during the 2011 floods. So they have never seen the results of the flood at the swamp. We'd sit there of an afternoon, and there would be thousands and thousands of birds just coming back to nest. It was full for probably nine months, or it at least had water in it for eight or nine months. I don't know whether you've seen all the old nests in the trees? It's also a breeding place for all different types of birds. Including migratory birds that came in, like pelicans, brolgas coming back."*
>
> -F. Hooper, pers. comm. 2016 (Research Partner - Murrawarri)

The general process of setting objectives, KEQs and identifying indicators discussed previously was also undertaken at Gooraman Swamp. However, as no water was planned to be delivered, monitoring of indicators at Gooraman Swamp (NCFRP 2016d) concentrated on establishing a baseline for future assessments for when a cultural flow does arrive. Monitoring focused on social well-being, vegetation, birds, water quality and native animals at localities both within Gooraman Swamp and along the Culgoa River. An example of objectives set for Gooraman Swamp is presented in Table 2. A very important outcome was the co-development by Research Partners of monitoring measures such as the number of active bird nests at Gooraman Swamp and Swamp Paperbark abundance along the Culgoa River.

Table 2: Example of monitoring activities at Gooraman Swamp and the Culgoa River

Theme	Site monitoring activity	Assessment approach
Birds	• Species abundance recorded at way-points and along a 250-metre meandering transect at Gooraman Swamp and along the Culgoa River. • Bird nest abundance along a 250-metre meandering transect at Gooraman Swamp.	• Summary statistics of bird species abundance (Gooraman Swamp and Culgoa River). • Summary statistics of bird nest abundance (Gooraman Swamp).

5.2 Hydrological and hydraulic analysis

5.2.1 Quantification of cultural flow needs at Toogimbie

The pattern of inundation of Toogimbie was modelled using three long-term modelled river flow series, no-Development (no large-scale water resources development), Current (baseline model with historic climate), and BP2800 (Basin Plan with 2800 GL reduction in diversions, environmental flows and historic climate; i.e. future flow).

Under no-Development conditions, Toogimbie would have been inundated in 60 percent of years, and multiple times in many years. Under Current conditions, inundation frequency has fallen to one-half of no-Development frequency, with Toogimbie experiencing inundation in only 32 percent of years. The median interval between inundation events is less than one year under Current conditions but is two months longer than under the no-Development scenario. There was no difference in the median starting date of the events between scenarios. Implementation of the Basin Plan with 2800 GL reduction in diversions across the Basin will only slightly improve the

frequency of inundation of Toogimbie. These statistics suggest that any cultural flow objectives that benefit from a frequency of inundation closer to that experienced under no-Development river flow conditions will require enhancement of wetland inundation. This has already been recognised by the Nari Nari at Toogimbie, with pumped inflows being implemented since 2009. The Project further developed this existing concept by exploring various watering options and sequences, and considering more expansive watering over the site.

Cultural flow objectives were determined by reference to historical hydrological data, TAK, and water requirements of Aboriginal environmental outcomes identified by the Nari Nari. Thus, although information generated from modelling the natural and current hydrological regimes informed the objective-setting process, restoration of the natural hydrological regime of the site was not the primary goal. Cultural flow objectives were expressed as flow events of a certain magnitude, frequency, extent, duration, depth, velocity, water volume or other relevant variables.

A field trial application of cultural flow at Toogimbie Wetlands was planned for spring 2016. The main objective of the trial was to test hypotheses concerning the relationships between application of cultural flow and achievement of cultural flow objectives, as well as to gain experience in the logistics and practicalities of delivering and managing cultural flows.

A hydrological model was developed to estimate the likely range of water volumes and timing of water delivery in order to meet the trial objectives. Around the time that the field trial was to be implemented, a major natural flood event occurred in the Murrumbidgee River. This resulted in adaption of the flow trial, as the natural flood was a much larger event than was intended for the flow trial.

To improve the knowledge base, the hydraulic and hydrological characteristics of the natural flood event of spring 2016 were measured. The flood provided an opportunity to validate some aspects of the performance of the hydrological and hydraulic models associated with natural overbank processes.

The extent of water inundation at Toogimbie was measured using Landsat satellite imagery. The temporal pattern of area of water on the surface of the entire Toogimbie Wetlands followed the pattern of the flood hydrograph, indicating a high level of hydraulic connection between floodplain and river. This suggests that the cells do not pond large areas of water for long periods of time. Under a managed situation, maintenance of reasonably high water levels in the cells would require constant pumped inflows. The total area of land inundated during the peak of the flood event within the IPA (1791 ha), and over the current and potential future managed cells (1554 ha), greatly exceeded the area that would be inundated when all the cells were at full managed level for current conditions, a total area of 457 ha. This constitutes a significant hydraulic difference between a natural flood event and managed (pumped) watering of the cells, especially given that only Cells 1, 2, 3, House and Billabong can currently be managed. The maximum area of water that can be managed across these cells is 284 ha. The second main hydraulic difference between a natural flood event and managed watering is that natural flooding would involve flowing water, while under managed (pumped) watering, inflowing water would move across the cells very slowly, and when full, would remain ponded.

Hydrological modelling was undertaken for cells intended for management of cultural water. The approach taken to modelling was to estimate the potential water usage of each cell for two conditions: (i) assuming the constraints of the current physical conditions, and (ii) assuming the regimes described by the objectives can be implemented by modification of embankments. The

exception was Cell 9 (Billabong) where both options could be currently achieved. In practice the long-term average volumes of water that can be applied are likely to be lower than those estimated, due to the difficulty of coordinating the watering of multiple cells with overlapping demands.

The average total volume of water that can be applied annually to the site under current physical conditions (as of 2016) was estimated to be 264 ML, with a range up to 631 ML. With improvements to the embankments to enable implementation of the regimes that meet the objectives, the average total volume of water that can be applied annually to the site was estimated to be 1,050 ML, with a range up to 2,617 ML.

5.2.2 Quantification of cultural flow needs at Gooraman Swamp

The pattern of inundation of Gooraman Swamp was modelled using three long-term modelled river flow series, no-Development (no large-scale water resources development), Current (baseline model with historic climate), and BP2800 (Murray-Darling Basin Plan with 2800GL reduction in diversions, environmental flows and historic climate; i.e. future flow).

Under no-Development conditions, Gooraman Swamp would have been inundated in 68% of years, and multiple times in some years. Under Current conditions, inundation frequency has fallen to one-third of no-Development frequency, with the Swamp experiencing inundation in only 23% of years. The median interval between inundation events exceeds one year under Current conditions, and the events tend to start later in the year. Implementation of the Basin Plan with 2800 GL reduction in diversions across the Basin will improve the frequency of inundation of Gooraman Swamp, but it will still be only half the frequency of the no-Development conditions. These statistics suggest that any cultural flow objectives that benefit from a frequency of inundation closer to that experienced under no-Development river flow conditions, will require enhancement of wetland inundation. The Project developed this concept by exploring two methods of delivering cultural flows to the site.

Cultural flow objectives were determined by reference to historical hydrological data, TAK, and water requirements of Aboriginal environmental outcomes identified by the Murrawarri. Reinstatement of the no-Development water regime at Gooraman Swamp was considered by Murrawarri Research Partners a necessary condition for them to be able to fulfil cultural obligations to maintain the ecological health of the place.

While an attempt could be made to tailor water regimes to suit the known preferences and tolerances of flora and fauna found within Gooraman Swamp, the objective of reinstatement of the no-Development water regime would likely subsume such theory-based and species-specific regimes. For the purposes of expressing the key cultural flow objective in hydrological terms, it was simply stated as “reinstatement of the no-Development regime”, rather than being tabulated as a list of hydrological events of specific frequency, interval, duration and magnitude.

There are two ways to reinstate the no-Development hydrology of Gooraman Swamp:

1. Boost flows in the Culgoa River so that it floods Gooraman Swamp at the appropriate frequency and timing, or

2. Pump water from the Culgoa River to Gooraman Swamp.

While both approaches could satisfy the main Gooraman Swamp objective, the Murrawarri also stated that use of local infrastructure to pump or divert water to Gooraman Swamp was undesirable, and noted that the surrounding Country and downstream Nations would benefit from the regional-scale flooding that would be associated with filling Gooraman Swamp from overbank flows.

Modification of the hydrological regime of the Culgoa River to reinstate the natural water regime of Gooraman Swamp would be a major undertaking. The options would be to: (i) remove all the upstream water resources development; or (ii) strategically release flows from Beardmore Dam in Queensland to enhance natural flood peaks and at the same time prevent any diversions.

Both of these options would mean increased general flooding of the entire river system, some of which would be regarded as undesirable, and reducing or eliminating diversions for agriculture, which would likely meet with resistance. In comparison, the alternative method of pumping would be an expedient option with prospects for implementation in the short-term. For this reason, it was included in the modelling. Its inclusion was purely to provide objective information for consideration by relevant parties. It should not be interpreted as a recommendation, as the Project was fully aware that the Murrawarri were not in favour of pumping infrastructure.

Option 1: Boost flows in the Culgoa River

Under the no-Development flow scenario, Gooraman Swamp did not inundate every year, so reinstatement of this regime does not require boosting river flows every year. In the years when boosting was required, the volume required to boost river flows varied across a wide range, but the annualised mean for the Current flow scenario was 33 – 41 GL, and for the Basin Plan 2800 flow scenario it was 14 – 18 GL. Considering only the years when boosting was required, the annual mean for the Current flow scenario was 78 – 80 GL, and for the Basin Plan 2800 flow scenario it was 46 – 53 GL.

Option 2: Pump Water from the Culgoa River

In the years when pumping was required, the volume pumped varied across a wide range, but the annualised mean for the Current flow scenario was a modest 120 – 131 ML, and for the Murray-Darling Basin Plan 2800 flow scenario was even less, at 77 – 86 ML. However, considering only the years when pumping was required, the annual mean for the Current flow scenario was 290 – 311 ML, and for the Basin Plan 2800 flow scenario it was 215 – 228 ML. These figures could be used in the business case for an allocation, specifying the long-term annual average requirement, but also noting that in years that the allocation is required, the average value would be nearly three times that.

The pumping and river boosting options that were modelled to inform the process had vastly different water requirements, with river boosting requiring about 1000 times more water. However, that water would spread far across the landscape and far downstream, potentially delivering regional-scale cultural flow benefits, which was also a cultural flow objective documented by the Murrawarri as part of the Project. The pumping option would allow convenient water delivery, but a major disadvantage is that it would not meet the expressed values and desires of delivering cultural water without infrastructure.

If river flow boosting is to be seriously considered as a mechanism for achieving cultural flow objectives at Gooraman Swamp, a comprehensive modelling study and impact assessment of this option will be required. The hydrological and hydraulic modelling would need to consider, as a

minimum, the entire Lower Balonne River system, and preferably the entire Darling River, even the entire Murray-Darling River, system, as modification of river flows at this scale will have widespread effects.

5.3 Challenges and opportunities in regulated and unregulated systems

Although the common understanding of a regulated river is one with one or more dams upstream that modify the flow regime from its natural state, in river administration a regulated river, while necessarily having upstream storage, has a licensed entitlement regime from which orders may be placed for upstream release of a licensed allocation. While the flow regime of the Culgoa River at Weilmoringle is heavily modified from natural, and there is an upstream storage primarily used to supply irrigation water, plus private on-farm storages that harvest floodwater, technically it is part of the unregulated Barwon-Darling system. The main upstream public storage, Beardmore Dam in Queensland, is relatively small, with a storage capacity only 3% of that of Hume Dam.

In unregulated catchments, water allocated for cultural water licences cannot be delivered by upstream impoundment releases. The mechanisms available for delivering such water are based on licencing conditions that limit water extraction according to stream flow thresholds. This strategy is designed to retain water within the river channel for baseflows. With baseflows at a generally higher level, there is an increased probability that when a natural flow event occurs it will spill onto the floodplain. If structures such as instream weirs and small storages, and floodplain infrastructure such as channels and pipes, can be managed, then it might be possible to locally enhance naturally occurring high flow events to increase their peak magnitude or extend their duration. In unregulated systems, the opportunities to receive cultural water at a place are dependent on natural runoff events upstream. The disadvantage of the unpredictability and low level of control over such flows is balanced by the advantages that the water is likely to arrive at a time when the region is experiencing wet conditions, and this is likely to be a time of year when the area would have naturally received inundation. In addition, unregulated river systems would usually have fewer barriers that restrict the passage of biota.

Regulated catchments have an established system for delivering water for irrigation from upstream storages. River managers have a high level of control over water storage and delivery, and good knowledge of travel times and losses. Regulated rivers typically have installed infrastructure for delivery of water to floodplain areas by gravity, or pumping, and the systems are generally well monitored. This high level of knowledge and control enables accurate and responsive delivery of licenced allocations when called. Other potential flexibility includes tradeability of water, carryover from one season to the next if the upstream storage is large, and rules to share the reduced availability of water under drought conditions among users. These opportunities would be similarly available to deliver cultural water allocations in regulated systems, allowing for a high level of control over its use.

In setting objectives for cultural flows, the Murrawarri were not constrained by water delivery issues, expressing the desire for an unimpaired river flow regime that would inundate Gooraman Swamp plus connected upstream and downstream floodplain areas. In contrast, the Nari Nari set pragmatic objectives that could be met by the current system of regulated river operations, only requiring some additional on site earthworks and increased pump capacity.

5.4 Key findings of the research

As a result of the research conducted, the following findings were determined:

- Through research conducted under the previous components, the water requirements to meet Aboriginal cultural flow needs were able to be quantified at two watering places in the Murray-Darling Basin, using robust scientific evidence consistent with water allocation

planning methods. This outcome demonstrates the value of Aboriginal Research Partnership in cross-disciplinary action research.

- Monitoring undertaken as part of that work **demonstrated both the ecological and social benefits of cultural flow management**, especially the benefits for participants in the planning process. Participation **improved Nation knowledge and confidence** in the management of Country and contributed directly to methods for use of TAK. It also **led to new monitoring techniques** and reporting protocols for capturing the ecological and social benefits of Aboriginal management. These outcomes were achieved despite the absence of an actual trial flow at either case study site.
- Cultural flow planning is **essential for enabling Aboriginal flow management**. However, it is only one way amongst many for cultural and other interests of Aboriginal people to be incorporated in water management and reform. Cultural flows are not sufficient to address all Aboriginal interests and values in water.
- Cultural flow planning **creates legitimacy for Aboriginal flow management objectives** that are otherwise absent or marginalised by the existing process.
- The planning process **assisted in re-surfacing of cultural knowledge**, which is consistent with the cultural regeneration experienced in other Aboriginal communities as a consequence of access to land and waters. Activities connected to "bringing Country back" have been shown to have corresponding regenerative effects on landscapes, cultural practice, knowledge exchange, health and even language.
- **Cultural regeneration** (such as the Return to Country event conducted by the Murrawarri as part of the Project) has **direct and demonstrable flow-on effects linked to increased confidence, health and well-being, capacity and self-reliance**. It is evident that access to cultural flow will further promote these outcomes.
- The outcomes from cultural flows most valued by Aboriginal people are predicated upon **autonomy and access to dedicated cultural flow allocation**. There are identified empowerment, esteem and identity benefits associated with the increased capacity to fulfil cultural obligations to care for and manage Country, made possible by a cultural flow allocation.
- The **increased visibility as a recognised and valued stakeholder** by government and others involved in water management has flow-on benefits for Aboriginal governance, planning, succession and leadership. These benefits cannot be achieved through an environmental flow allocation, even where Aboriginal people have played a determining role in the planning and management of such an allocation.
- There is a high degree of confidence amongst Research Partners in the capacity of cultural flow to **deliver a wide range of social and community benefits**. There is a strong view that cultural flow can be an **equitable and a cost-effective** means to address social issues through the generation of employment and training opportunities and enterprise development. This view is strengthened by the evidence that supports individual and social learning outcomes for participants in cultural flow planning.
- This research has **confirmed the need** for Western Science to recognise TAK in ecological characterisation research nationally.
- TAK refers here to traditions, beliefs, and worldviews based on direct experience, testing, observing patterns, teachings and recordings in the collective memory through oral

tradition, storytelling, ceremonies and songs specifically relating to water. It is a holistic and inclusive form of knowledge. **TAK has a clear value to the management of water resources** generally, and especially in the context of climate change and adaptation.

- This research has shown that the **methods for cultural flow planning are available**, and can be drawn from, and adapted to a range of tools associated with water management from both Aboriginal and non-Aboriginal contexts, including the Aboriginal Water Assessment process, Monitoring, Evaluation, Reporting and Improvement (MERI) guide, program logic and tools and methods adapted from participatory environmental monitoring. The modifications required for these tools to be appropriate for establishing cultural flow requirements are minor, but significant.
- Ongoing cultural flow research presents an **important opportunity to work** with Aboriginal Research Partners across the country to further **contribute** to an ongoing **national dialogue**.

6. REFLECTIONS AND CONCLUSIONS

6.1 Differences between cultural and environmental flows

The research has highlighted significant differences between the outcomes from an environmental flow and those made possible by a dedicated cultural flow. At both case study sites, it was the **ownership and control of a cultural flow entitlement that engendered specific and measurable benefits** for the Aboriginal Research Partners. The non-use value associated with the cultural flow is described by the notion of an existence value: the Research Partners derived **benefit in knowing that a cultural flow allocation had been established**, and made available for Aboriginal people. The cultural outcomes that were valued the most by participants were fundamentally dependent upon the autonomy and independence provided by access to a dedicated cultural flow allocation. For example, there are **identified empowerment, identity and esteem benefits** associated with the **increased capacity to fulfil cultural obligations to care for and manage Country** made possible by a cultural flow allocation. Similarly, the **increased visibility as a recognised and valued stakeholder** by government and others involved in water management has flow-on benefits for Aboriginal governance, planning and leadership. These benefits cannot be achieved through an environmental water allocation, even where Aboriginal people have played a determining role in the planning and management of the allocation.

The research further demonstrated that participation in the process of planning a cultural flow has:

1. **Improved Nation knowledge** and **confidence** in the management of Country.

2. Contributed directly to methods for **use and protection** of Traditional Aboriginal Knowledge and,

3. Unformed **new monitoring techniques and reporting protocols** for capturing the ecological and social benefits of Aboriginal management.

Although similar outcomes may be possible through environmental water planning, these outcomes were **a direct consequence of the autonomy of the Research Partners** in directing the objectives of the water entitlement. This is because the process of defining the water requirements for a cultural flow is tantamount to enabling Aboriginal water management, which remains a core goal of national water reform. Enabling Aboriginal water management through the mechanism of a cultural flow **creates legitimacy for Aboriginal water management objectives** that are otherwise marginalised in water planning decisions.

6.1.1 Cultural Flow as Enabling Aboriginal Water Management

The purpose of a cultural flow as understood by participants in the research is not only to expand the remit of water management objectives, but to **deliberately enable and facilitate Aboriginal water management**. It is clear from the case studies that a cultural flow developed according to the priorities and aspirations of Aboriginal participants **will achieve both cultural and environmental outcomes**. Generally, the separation of these categories is arbitrary and analytical. In some instances, a cultural flow is likely to achieve similar outcomes to an environmental allocation or a natural flood event, but this does not mean that environmental water is sufficient to meet the objectives of a cultural flow. The key distinguishing feature of cultural flows is:

- Aboriginal people collaboratively determine how the water will be used, and
- defining that water as a cultural flow creates legitimacy for the cultural management of Country, and allows communities to make meaningful planning and management decisions without having to justify and rationalise the value of those decisions.

6.1.2 Economic and Well-Being Benefits of Cultural Flows

Cultural flow allocations would also allow Aboriginal Nations to manage their water entitlement for economic gain, which is not possible from an environmental allocation or current NSW Department of Primary Industries Cultural Access Licence (CAL). The diversity of applications of a cultural flow is part of the recognition that Aboriginal people have diverse interests in water. These interests and values are not limited to the protection of cultural values, but include downstream obligations, social and well-being interests, education, economic interests, ecological restoration activities, land use planning and participating in research or monitoring.

Key economic opportunities were identified by Research Partners in the temporary trade of entitlements when water was not required, or to provide water access to Aboriginal communities downstream. In both case studies, trade and the option to participate in water trading was considered consistent with cultural practice, and a defining distinction between cultural and environmental water allocations. As was consistently expressed by a number of Research Partners, access to cultural flow is seen as economic opportunity for reducing welfare dependence, generating direct employment and providing skill development and training.

6.1.3 Synergies with Environmental Flows

There are also important synergies between environmental and cultural flows, and this is highlighted by the process of identifying flow objectives. For example, the types of plant and animal species prioritised in a cultural flow assessment differ in emphasis from those traditionally relevant for an environmental water assessment. This is especially the case for vegetation species with traditional uses or spiritual significance, but which are relatively common in the landscape. For example, it is unlikely that an environmental assessment would prioritise Old Man Weed (*Budhaay)* as in the cultural flow assessment; however environmental water objectives are likely to have an incidental positive impact on the abundance and health of this species.

In both case study sites, the argument that cultural flows can achieve environmental outcomes, but environmental flows cannot achieve all cultural outcomes was consistently re-iterated. The case studies are suggestive of this conclusion, however, how environmental and cultural flow management differ will be context dependent and site specific, and will likely be subject to a high degree of variability over time. It is not yet possible to make definitive claims about the disparity of cultural and environmental water management goals. The differences in terms of why certain outcomes are valued or prioritised may result in different water management regimes over time. This strengthens the case for considering cultural flows not only as a (core) component of Aboriginal water management but a key feature of all water management regimes.

6.2 Research Partner perspectives

6.2.1 Murrawarri reflections

In the Murrawarri case study where access to a trial flow allocation of water was not possible, the aim of the project was to identify and confirm aspirations for a potential future cultural flow. This

included co-developing an ecological and socio-cultural monitoring guide to assess the benefits of a future allocation. For the Murrawarri participants, the core value of the project and the resulting Guide derived from the way in which the planning process appropriately and respectfully incorporated cultural knowledge and Aboriginal Intellectual Property. In evaluation of the Project, participants consistently referred to the way that the negotiations and on-ground monitoring activities revived and assisted in recording of cultural knowledge, with direct application for the management of Country. The method of cultural flow planning was seen to give credibility and legitimacy to spiritual values in the landscape connected to the water places in Murrawarri Country. These values were well known and well-understood by participants, and had been previously documented in other projects. Participation in the project allowed participants to demonstrate the importance of those cultural values, and have those values recognised in the instruments of water management through a potential future allocation of water.

> "*This project has captured us. It has made us go back to who we are.*"
> – F. Hooper, pers. comm. 2017 (Research Partner – Murrawarri)
>
> *"One thing I have seen change is the young ones come and talk about Country… like this one here (S.Kelly), everytime he talks about Country it makes me smile."*
> – P. Sullivan, pers. comm. 2017 (Research Partner – Murrawarri)
>
> *"There are places on our Country where there used to be swamps and places where the birds nest. Imagine growing up and telling your kids there used to be water there and now we can say there is water there, there is* still *water there.. instead of saying there was once ..."*
>
> – S. Kelly, pers. comm. 2017 (Research Parnter – Murrawarri)

Participants also reflected on the value of the project in improving community readiness for cultural flow planning, but additionally for water and natural resource management opportunities generally. Especially through the on-ground work, Research Partners identified that the Project reinforced connection to Country. In addition, it provided opportunity for the younger generation to learn about and engage with the process of cultural management of Country. All participants felt that the knowledge acquired through the Project supplemented their existing ecological knowledge, providing a deeper understanding of vegetation, birds and other fauna, water quality, wetland processes and tree health. The value of this was acknowledged in terms of improving the capacity of the community to engage in future projects.

Similarly, project participation 'de-mystified' the techniques of environmental management and monitoring for Research Partners, and made the science of water management and environmental monitoring more accessible. Participants also valued the work of the Project in establishing a baseline and consistent, community-based monitoring methods to document the health of the landscape over time. This was especially valuable in relation to assessing the health of the River Red Gums. Again, this baseline was seen as critical to the preparation and readiness for future cultural flow initiatives, and other potential cultural management of Country projects.

6.2.2 Nari Nari reflections

"It [the project] has been fantastic. I would recommend [other communities] to embrace it. What it did for our community, what it brought out of them [the partners]. The confidence it built, just fantastic. I see it in all them, just fantastic…I've seen a difference [in the mob] just through the workshops, the way they pulled stuff out, that I didn't even know they knew, and the capacity building, and for the next generation, that information can be passed on…."

– I. Woods, pers. comm. 2017 (Research Partner – Nari Nari)

"I would recommend [other communities] to do it [the framework], just so they are prepared for when a flow may become available. Be prepared and ready to act… Through this project so many new skills have been developed."

– T. Dixon, pers. comm. 2017 (Research Partner – Nari Nari)

"It's the capacity building component of this project that makes it different from all the others. Each and every Research Partner that participated in the project has learnt so much. The confidence we now have in our knowledge, practices and skillset is amazing, we are really grateful."

– K. Schade, pers. comm. 2016 (Research Partner – Nari Nari)

Nari Nari participants highlighted improved knowledge about the wetland and its management, and improved confidence of participants in undertaking environmental assessments. The accessibility of the monitoring tools was highly valued, and the two-way capacity building for aspects of the project was also seen to be a major contributing factor to the success of the project overall.

Respondents also valued the application of the participatory action research and stressed the importance of the engagement approach adopted by the Project. From the partners' perspective, the approach allowed the community to set the terms of the process and was responsive to the needs and concerns of the participants throughout. Participants indicated that their confidence in the capacity of the project to influence government policy increased over time, and especially as a consequence of participation in the field work. From the Research Partner perspective, the findings from the environmental monitoring confirmed the cultural understanding and TAK. This has strengthened the community confidence in their own management efforts, and their confidence to present the case for cultural flows to policy-makers.

Participation in the project has had a permanent impact on the management efforts at Toogimbie. The Partners have now identified cultural flows as a priority, and have resolved to actively seek funding and resourcing options to assist with achieving the objectives set through the Project. Similarly, future reporting on management activities undertaken as part of the IPA monitoring process will include key indicators that have been set by the cultural flow planning undertaken by the Project.

6.3 Conclusion

Based on the findings of the research, the authors present the following conclusions:

1. The findings of this component of the NCFRP are a proof of concept and can be used to support further research and development work for providing culturally appropriate

resources and programs to build capacity in Aboriginal communities to advocate for cultural flow allocations.

2. The findings of this component are an evidence base which can support the development and implementation of cultural flows, as defined in the Echuca Declaration and developed through the National Cultural Flows Research Project, and can support Aboriginal Nations to advocate to governments the need to improve the inclusion and protection of Aboriginal values and interests in water.

3. There is a need for further investigation into mechanisms (such as grant programs and funding arrangements) that can be established to enable Aboriginal groups to invest in water and associated infrastructure to access water for cultural purposes.

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APPENDIX 1: TERMINOLOGY AND DEFINITIONS

Aboriginal	The people who are the original inhabitants of the land.
Aboriginal Environmental Outcomes	The term "Aboriginal environmental outcomes" has been developed to describe and communicate the benefits to Aboriginal people that can be derived from environmental watering. Aboriginal environmental outcomes result from healthier rivers and wetlands, for example improved fish populations, more reeds that can be harvested and increased bird breeding events. In essence, Aboriginal environmental outcomes provide tangible physical benefits to community and Country (MLDRIN 2007). This definition was endorsed by representatives of the Murray Lower Darling Rivers Indigenous Nations (MLDRIN) and Northern Basin Aboriginal Nations (NBAN) and is recognised by the Murray-Darling Basin Authority (MDBA), Victorian Environmental Water Holder (VEWH) and Department of Environment, Land, Water and Planning (DELWP).
Authorised Knowledge Holder	A person, normally a Traditional Owner, who has been provided cultural and/or traditional knowledge of a particular place or thing through customary law and is recognised by the Traditional Owner community to have the authority to speak on or share that particular knowledge where appropriate.
Community	A group of people living in the same place or having a particular characteristic in common (e.g. people living in a suburb or town).
Cultural flows	"Water entitlements that are legally and beneficially owned by Indigenous Nations of a sufficient and adequate quantity and quality to improve the spiritual, cultural, environmental, social and economic conditions of those Indigenous Nations. This is our inherent right". This definition was developed by representatives from thirty-one Aboriginal Nations at a joint meeting of the Murray Lower Darling River Indigenous Nations (MLDRIN) and adopted by the Northern Basin Aboriginal Nations (NBAN) -The Echuca Declaration was endorsed in September 2010.
Cultural Flow Objectives	The values and benefits derived by Aboriginal people from cultural water.
Cultural Water	Perpetual or ongoing entitlements to exclusive access to a share of water which are owned by Aboriginal Nations and managed at the discretion of those Nations.
Environmental flows	Environmental flows describe the quantity, timing, and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend on these ecosystems.
Key Contact	The nominated key contact for each case study area, as provided in the case study area applications to the National Cultural Flows Research Project.
Nation facilitator	Nominated member from each case study area Nation that will receive support and training to participate in the facilitation of research engagement activities. The nominated Nation Facilitator will support the Project Team to conduct engagement sessions and workshops in a culturally respectful and appropriate manner, to suit local needs and issues; and the two-way flow of information and ideas between the Project Team and participants / Traditional Owners.

Nation	An aggregate of people that are united by a shared descent, culture and/or language and who inhabit a particular state or territory and who have a shared body of law and custom.
The Project	The National Cultural Flows Research Project.
Project Team	Rural Solutions SA Project Team (staff and subcontractors).
Research Committee	National Cultural Flows Planning and Research Committee.
Research Partner	A Traditional Owner, individual of the Research Committee and/or community nominated participant who is recognised as speaking for Country. Individuals may be involved in any/all aspects of the National Cultural Flows Research Project.
Stakeholder	A person with an interest or concern to any and/or all aspects of the National Cultural Flows Research Project.
Traditional Aboriginal Knowledge	Traditional Aboriginal knowledge includes the cultural traditions, values, beliefs, and worldviews of Aboriginal peoples as distinguished from Western scientific knowledge. Traditional Knowledge is based on direct experience, testing, observation of patterns over long periods of time, and teachings and recording in the collective memory through oral tradition, storytelling, ceremonies and songs. It is a holistic and inclusive form of knowledge" (adapted from Dei 1993:105; Augustine nd).
Traditional Owner	The Aboriginal person or people who possess rights, interests and responsibilities for an area of Country. These rights, interests and responsibilities are defined by traditional law and custom and are also handed down through this customary law. Traditional Owners are recognised as having a primary interest in the land and their existence is not contingent on recognition of such under white law.
Watering place	Consistent with Research Committee guidance, the watering place is defined as the physical location (site) to receive the cultural flow within Country. Within this report, the watering place is a specific location within Country which has connections to, and importance for, contributing to water related cultural values. It may be a single aquatic ecosystem or a complex of ecosystems and or locations, noting that Nations do not partition Country in the same way as Western Science.
Western Science	The systematic study of the nature and behaviour of the material and physical universe originating in European enlightenment. This system of knowledge is based on repeated observation, experiment, and measurement, and the formulation of laws to describe these facts in general terms (Adapted from Collins English Dictionary).

Ecological Terminology and Definitions

Aquatic ecosystem	Ecosystems that depend on flows, or periodic or sustained inundation/ waterlogging for their ecological integrity (e.g. wetlands, rivers, karst and other groundwater-dependent ecosystems, saltmarshes and estuaries) but do not generally include marine waters (defined as areas of marine water the depth of which at low tide exceeds six meters, but to be interpreted by jurisdictions). See also ecosystem
Assessment (wetland)	The identification of the status of, and threats to, wetlands as a basis for the collection of more specific information through monitoring activities. See also condition and condition assessment
Benefits	Benefits/services are defined in accordance with the Millennium Ecosystem Assessment definition of ecosystem services as "the benefits that people receive from ecosystems (Ramsar Convention 2005), Resolution IX.1 Annex A). See also “Ecosystem Services”.
Biodiversity	Biodiversity, or biological diversity, means the variety of life or variety of living things; and living things means plants, and animals, and microbes, and fungi, their DNA, and ecosystems. Biodiversity, in the full sense of the term, is not monitored and is not readily quantified.
Biota	The animal and plant life of a particular region or habitat.
Conceptual model	Conceptual models can take a number of forms. They are often defined as a type of diagram which shows of a set of relationships between factors that are believed to impact or lead to a target condition; a diagram that defines theoretical entities, objects, or conditions of a system and the relationships between them. In the context of this project conceptual models will illustrate the response of cultural and ecological values to the delivery of cultural flows.
Condition (ecosystem, vegetation, community, species)	The state or health of individual animals or plants, communities or ecosystems. Condition of an ecosystem, vegetation type, ecological community or species describes whether, and how much, it differs from an unimpacted or reference state. Condition can be described using a number of attributes. For example, in assessing vegetation condition, the most commonly-used attributes are abundance or extent, vegetation structural features, species composition, nativeness, age structure and vigour. Condition is referential, meaning the vegetation attributes at a site are compared to a reference condition or benchmark or ideal state for that site. In the case of a species, typically a tree, or a stand of trees, condition means vigour, and condition describes how vigorous the canopy appears to be. Condition is based on observations of the canopy such as canopy cover, foliage density, and extent of dieback.
Condition assessment	A means to assess long-term changes in natural conditions and to assess long-term changes resulting from widespread anthropogenic activity.

Diversity	Diversity is the number of entities in a sample and the evenness of their abundance; in the case of species diversity, number and evenness are combined into a single value, using a diversity index. Most often diversity means species diversity, but other types of diversity can be described and reported on such as structural diversity, community diversity, genetic diversity and functional diversity in ecological studies: in these cases, 'diversity' is used rather loosely to mean variability, with no standard quantitative measures. The term 'biodiversity' is not the same as species diversity and has it has its own meaning.
Ecological character	The combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time. [Within this context, ecosystem benefits are defined in accordance with the MA definition of ecosystem services as "the benefits that people receive from ecosystems".] (Resolution IX.1 Annex A) (Ramsar 2012).
Ecological community	An assemblage of organisms characterised by a distinctive combination of species occupying a common environment and interacting with one another (ANZECC and ARMCANZ 2000).
Ecosystems	The complex of living communities (including human communities) and non-living environment (Ecosystem Components) interacting (through Ecological Processes) as a functional unit which provides inter alia a variety of benefits to people (Ecosystem Services) (Millennium Ecosystem Assessment 2005).
Ecosystem components	Include the physical, chemical and biological parts of a wetland.
Ecosystem processes	Are changes or reactions which occur naturally within wetland ecosystems. They may be physical, chemical or biological. This equates to process such as carbon cycling, denitrification, acidification, sedimentation, migration, breeding, reproduction, etc.
Ecosystem functions	Are activities or actions which occur naturally in wetlands as a product of the interactions between the ecosystem structure and processes. Functions as defined by Ramsar include flood water control; nutrient, sediment and contaminant retention; food web support; shoreline stabilisation and erosion controls; storm protection; and stabilisation of local climatic conditions, particularly rainfall and temperature.
Ecosystem services	The benefits that people receive or obtain from an ecosystem. The components of ecosystem services are provisioning (for example food and water), regulating (for example flood control), cultural (for example spiritual, recreational), and supporting (for example nutrient cycling, ecological value). (Millennium Ecosystem Assessment 2005). See also "Benefits".
Geomorphology	The study of the evolution and configuration of landforms.
Goal	A goal is a concise, general statement of the overall purpose of a program. For example: "To ensure that environmental water allocations provide the greatest ecological benefits to receiving waterbodies" or "To manage wetlands to provide habitat for breeding migratory birds".

Indicator (ecological)	Refers to representative, measurable parameter which conveys useful information concerning ecosystem condition. These can be physico-chemical and/or biological. Ecological indicators assess the condition of the environment, and can provide an early warning signal of changes in the environment. They can also be used to diagnose the cause of an environmental problem. Ideally the suite of indicators used in a monitoring program should represent key information about structure, function, and composition of the ecological system (Dale and Beyer 2001).
Intervention	A management activity that seeks to change an ecosystem's state or condition and achieve a management objective. In this case the intervention is the delivery of a cultural flow. See also intervention monitoring.
Intervention monitoring	Supports the evaluation of management interventions by quantifying the response to specific management interventions.
Inventory (wetland)	The collection and/or collation of core information for wetland management, including the provision of an information base for specific assessment and monitoring activities
Monitoring (wetland)	Collection of specific information for management purposes in response to questions derived from assessment activities, and the use of these monitoring results for implementing management. (Note that the collection of time-series information that is not question-driven from wetland assessment should be termed surveillance rather than monitoring). The key aspects of an environmental monitoring program therefore are: • It is specific and hypothesis driven (i.e. it answers a specific question); • It involves the collection of information over time (i.e. multiple sampling events); and • It is used to inform ecosystem management.
Richness	Richness is the number recorded. It is most commonly used to refer to species, as in species richness. See: species richness.
Species richness	Species richness is the number of species recorded, for example, in a sample. Species richness is sensitive to sampling effort (number of quadrats, size of quadrats, total area sampled).

Hydrological and Hydraulic Terminology and Definitions

Dimensions (number of) modelled (in numerical hydraulic modelling)	Hydraulic models can be classified into 1D, 2D and 3D, where D means dimension. The dimension referred to here is space. • 1D model represents flow properties (depth and velocity) only in the longitudinal (downstream, X) direction. Such models are usually used to predict velocity averaged across the transversal (width, Y) and vertical (depth, Z) dimensions of a cross-section. • 2D model represents flow properties along either the longitudinal (X) and transversal (X) directions, or the longitudinal (X) and vertical (Z) directions. Such models are usually used to predict the depth and magnitude and direction (X, Y) of mean vertical velocity at points. • 3D model represents the depth and magnitude, direction, and vertical distribution (X, Y, Z) of velocity at points. Due to the computation time, difficulty in model set-up, uncertainty of results, and inability to characterise project objectives in 3D, such models are normally used only in research applications, or in small areas. 1D models provide a reliable representation of the hydraulic conditions in river channels, while 2D models can represent the hydraulic conditions on floodplain surfaces. Most river-floodplain situations involve both of these conditions, so a linked 1D-2D model is appropriate.
Fluvial geomorphology	The study of landforms shape (morphology) and processes associated with flowing water. The morphology of a channel or wetland influences the distribution of hydraulic conditions (depth, extent, velocity). Over time, as the site is subjected to flow events (either naturally or artificially generated events), the morphology can be expected to change. Fluvial geomorphology might be relevant in the context of a cultural flows assessment, depending on the site characteristics and the objectives.
Hydraulic	Certain physical characteristics of, usually, moving water. In this report the characteristics of interest are rate of flow, or velocity (m/s), depth of water from the bed or ground (m), direction of flow (bearing in degrees), bed shear stress, or force acting on the bed (N/m^2), volume of water within a bounded area (m^3), area of water within a bounded area (m^2), and location of water (defined by geographical coordinates).
Hydraulic model	There are practical limitations to measuring hydraulic variables. A hydraulic model describes the relationship between the spatial distribution of a hydraulic variable (such as water depth and presence) and river hydrology, or artificial flow delivery. The relationship can be developed using an empirical or numerical modelling approach.

Hydraulic model (empirical)	Developed from multiple observations of water extent measured using satellite imagery, aerial photography, a sensor on a low-altitude UAV (unmanned aerial vehicle), or on ground survey and water flow in the river, or flow pumped or diverted to the site, measured at the same time. With enough data points, the relationship will provide a sufficiently reliable prediction of the maximum extent of inundation that can be expected for given river flow conditions, or given inflows to the site. The distribution of water depth for any given water extent can be predicted if the topography of the site has been characterised, by LiDAR or ground survey. Provided input data are available, empirical models are relatively inexpensive to develop.
Hydraulic model (numerical)	Predicts water extent, flow rate, and flow direction, on the basis of good quality topographic data obtained by LiDAR or ground survey and well-known equations that describe the physics of water flow. Numerical models are uncertain, and require calibration against empirical data from observed flow events to provide reliable predictions. Due to high data demands, high level of spatial and temporal resolution, high data processing demands, and high-level technical modelling skills required, numerical hydraulic models are expensive to develop and expensive to run.
Hydrological	Having characteristics related to the water cycle and its individual components. In this report, it usually refers to the temporal (over time) pattern of water flow (ML/d), water level from a datum (m), water extent (ha or m^2), rainfall (mm), seepage (mm), evapotranspiration (mm or ML). The flow could be in a river, or into and out of a floodplain wetland, of cultural interest.
Hydrological component (of a wetland water regime)	The main elements of a wetland water regime, comprising Dry period, Constant level, Small inundation event, Moderate inundation event and Large inundation event.
Hydrological event	A hydrological phenomenon of relevance to cultural water needs. An event could be a period of no water, stable water level or flow, or a rise and fall in water levels in a river of wetland.
Hydrological model	Can overcome practical limitations to measuring hydrological variables. A hydrological model predicts how much water will be present in a river or wetland at any time. It relates rainfall, evapotranspiration and seepage through time using mathematical algorithms that describe fundamental physical processes. Two common types of model are rainfall-runoff model (predicts river flow from rainfall), and wetland water balance model.
Hydrological time series	Basic hydrological data concerning events, and long term hydrology are time series and can be plotted as a simple line-chart showing the observed value over time. Normally these data are simplified using statistics to characterise central tendency, dispersion, frequency, duration, and rates of change.

Regulated River	1. National administrative meaning: A river on which a licensed entitlement regime exists with centralised allocation, and from which orders may be placed for upstream release of a licensed allocation. A necessary, but not sufficient condition for a river to be regulated is that it is located downstream of a surface water storage (BoM 2017). 2. NSW administrative meaning: Under the Water Management Act 2000, a regulated river is one where downstream flows are regulated by a major storage or dam to supply irrigation water (Water NSW 2017a). 3. Common universal hydrological meaning: identified by the presence of upstream reservoirs on catchment-scale maps (Growns and Marsh 2000, p. 8), built and operated for the purposes of irrigation, public water supply, navigation, flood mitigation or electricity supply, and modifying the river flow regime from its natural state (Lloyd et al. 2004).
Scenario (in hydrological modelling)	A set of conditions that apply to the input data of a hydrological model, usually simulating a current, future or past condition, such as climate change, pre-water resources development, or with cultural flows.
Time scale (long-term hydrological)	In the order of 50 – 100 years, which is long enough to characterise the likelihood of hydrological events of cultural interest occurring in the future, under assumed conditions.
Time-scale (event)	In the order of days weeks or months.
Unregulated river	1. National administrative meaning: A river where there is no entitlement system at all or where there is an entitlement system that does not allow orders to be placed for upstream release of a licensed allocation (BoM 2017). 'Unregulated flow' can occur both in an unregulated river and in a regulated river, in case of a flow event that could not be retained and controlled by the upstream infrastructure (BoM 2017). 2. NSW administrative meaning: The term 'unregulated river' applies to rivers without major storages, or dams, as well as to rivers where the storages do not release water downstream (in these cases, water is piped to where it is needed, such as metropolitan centres). A large number of unregulated rivers are covered by water sharing plans (Water NSW 2017a). 3. Common universal hydrological meaning: identified by the absence of upstream reservoirs on catchment-scale maps (Growns and Marsh 2000, p. 8).
Water balance model (wetland)	Operates at the scale of an individual wetland to predict the water level and extent of inundation over time. Can be used to predict wetland water level and extent over the long-term scale.
Water loss	In a waterbody such as a floodplain wetland, water loss incurred through evapotranspiration and seepage to the ground (which is later lost to evaporation or transferred to neighbouring hydrological system).

Water quality	The collective physical and chemical properties of water that are usually assessed relative to tolerable and preferred ranges specific to the use of the water or waterbody, including by aquatic organisms. Water quality is commonly investigated using historical data from established monitoring programs, and can also be predicted using a coupled hydrology-water quality model. Water quality might be relevant in the context of a cultural flows assessment, depending on the watering place characteristics and the objectives.
Water resource model	Hydrological models can operate at a large scale. For management of water resources of large areas, whole of catchment models are used, such as eWater Source catchments, MSM_Bigmod (predicts the flow in the River Murray), REALM (often used in Victoria) and IQQM (often used in Queensland and NSW). These hydrological models also contain some *hydraulic* components, to explain how certain characteristics of flow are modified through time and movement. Such models also have water quality prediction capability.
Water use	Refers to how much water is used over time through events, either natural or controlled (managed) events, such as delivering water to satisfy cultural water needs. In this context, water use means the difference between the water that was available for use at the beginning of the event, and how much is available after the event.
Water year	A period of 12 months over which annual hydrological statistics are calculated and water accounting and management are conducted. The start of the water year depends on the seasonality of the river and is usually within the low flow period. For the Murray-Darling Basin, the conventional water year is July to June, such that each irrigation season belongs entirely within one year, and it avoids splitting summer flood events originating in the northern Basin into separate years.