CULTURAL FLOWS

TOOGIMBIE WETLANDS INDICATOR FRAMEWORK & METHODOLOGY

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 Peter Cottingham, Dr Rhonda Butcher, Tom Kloeden, Dr Chris Gippel, Dr John Mackenzie and Nari Nari Tribal Council.

Cover photo: Nari Nari Tribal Council – Toogimbie Wetlands under flood. Artwork 'Cultural flows' by Luke Penrith. Cover graphic design by Mazart Design Studio.

Key Acronyms

AHD – Australian height datum

AIATSIS – Australian Institute of Aboriginal and Torres Strait Islander Studies

AWA – Aboriginal Waterway Assessment

BACI – before-after, control-impact

CEWH – Commonwealth Environment Water Holder

CEWO - Commonwealth Environmental Water Office

CHI – Cultural Health Index

CUWI - Cultural Use and Wellbeing Index

IP – Intellectual Property

IPA – Indigenous Protected Area

JAMBA/CAMBA/ROKAMBA – Japan, China and Republic of Korea-Australia migratory bird agreement, respectively

KEQ – key evaluation criteria

MDB – Murray Darling Basin

MDBA - Murray Darling Basin Authority

M&E – monitoring and evaluation

MERI – Monitoring, Evaluation, Reporting and Implementation

ML – megalitres

ML/d – megalitres per day

MLDRIN - Murray Lower Darling Rivers Indigenous Nations

NAILSMA - North Australian Indigenous Land and Sea Management Alliance

NBAN - Northern Basin Aboriginal Nations

NNTC – National Native Title Council

NSW – New South Wales

OEH – Office of Environment and Heritage NSW

QA/QC – quality assurance/quality control

RSSA – Rural Solutions SA

SSMI – single site, multiple intervention

SSSI – single site, single intervention

Cultural Terminology and Definitions

Term	Definition
Aboriginal	The people who are the original inhabitants of the land.
Aboriginal Environmental Outcomes	The term "Aboriginal environmental outcomes" has been proposed 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 (Definition of Aboriginal environmental outcomes, pamphlet). 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 endorsed by representatives from thirty-one Indigenous nations at a joint meeting of the Murray Lower Darling River Indigenous Nations (MLDRIN) and the Northern Basin Aboriginal Nations (NBAN) -The Echuca Declaration, September 2010 (NCFRP 2016).
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

Term	Definition
	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.
Contract Project Manager	Rural Solutions SA (Rowena Brown is the Interim Contract Project Manager).
Project Team	Rural Solutions SA Project Team (including Rural Solutions SA staff and subcontractors).
Research Committee	National Cultural Flows Planning and Research Committee.
Research Manager	National Cultural Flows Research Project – NNTC Research Manager (Alanna Maguire).
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 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 recognized as having a primary interest in the land and their existence is not contingent on recognition of such under white law.

Hydrological terms and definitions

Term	Definition
Hydrological	refers to the temporal (over time) pattern of water flow (ML/d), water level from a datum (m), water extent (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.
Long-term hydrological time scale	Under consideration would be 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.
A hydrological event	Is 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.
Event Time-Scale	Is in the order of days weeks or months.
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.
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* (predicts water level where water is ponded). Hydrological models can operate at any 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. Such models also have water quality prediction capability.
Water Use	In water resources management, a variable of great interest is 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 Loss	Where the loss is incurred through evapotranspiration and seepage to the ground (which is later lost to evaporation or transferred to neighbouring hydrological system).
Hydraulic	In this context hydraulic refers to certain physical characteristics of, usually, moving water. 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/m2), volume of water within a bounded area (m3), area of water within a bounded area (m2), and location of water (georeference).

Hydraulic Variables	Some hydraulic variables can be measured using velocity and depth meters, but only at a limited number of places. If it is necessary to know the value of hydraulic variables over a large area and at a high level of spatial detail, it is usual practice to model the hydraulics.
Hydraulic Models	Hydraulic models can be classified into 1D, 2D and 3D, where D means dimension. The dimension referred to here is space. o 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. o 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. o 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.

Ecological Terms and Definitions

Term	Definition
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 metres, 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 2005a), 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.
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 stabilization and erosion controls; storm protection; and stabilization 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 water bodies" "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).

EXECUTIVE SUMMARY

The National Cultural Flows Research Project ("the Project") is about developing rigorous and defendable knowledge, with the aim of securing water entitlements for the benefit of Aboriginal people across Australia (NNTC, 2014). This research relies on the participation of members of the Aboriginal Nations at two case study sites within the Murray Darling Basin to investigate and measure the cultural values of water to Aboriginal people. The Project will assess both tangible and intangible facets of water delivered to achieve cultural outcomes, with the primary focus of developing methodologies that will record and assess Aboriginal cultural values and uses regarding watering requirements.

The Project consists of the following components (NCFRP 2014):

- **One**: Describe the Indigenous cultural water values and needs across Australia (completed January 2014).
- **Two**: Develop and use methodologies to describe and measure the cultural water uses, values and needs of particular Australian Indigenous communities – Nari Nari near Hay, New South Wales (NSW), and Murrawarri at Weilmoringle, northern NSW.
- **Three**: Quantify water volumes to meet cultural values and needs (both Nari Nari and Murrawarri), and scientific assessment of a trial flow at Toogimbie Indigenous Protected Area (IPA), near Hay NSW.
- **Four**: 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.
- **Five:** Recommend policy, legal, and institutional changes that will enable the implementation of cultural flows.
- **Six**: 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.

This monitoring and evaluation (M&E) plan is part of Component Three (above) and outlines the key monitoring and evaluation activities that would be conducted by and on behalf of the Nari Nari near Hay, NSW, as part of a flow watering trial. The use of such flow events is expected to contribute to meeting the preliminary aspirations of the Nari Nari in terms of:

- Integrating Aboriginal cultural and social perspectives, which also include environmental considerations;
- The achievement of economic independence through enterprise development and water trading;
- Sustainability of the site as an educational facility for intergenerational transfer of cultural knowledge and practice;
- Fulfilment of spiritual and cultural obligations through landscape management;
- Retaining the community population with quality of life and wellbeing improvements.

The watering trial at Toogimbie IPA will occur on land that is part of the active floodplain of the Murrumbidgee River, being part of the uppermost area of the Lowbidgee floodplain. The local vegetation consists of river red gum and black box woodland along the Murrumbidgee and extensive Lignum and chenopod shrubland on the floodplain proper.

Cultural values associated with Toogimbie IPA and its surrounds have been identified from ongoing discussions meetings and field visits with the Nari Nari community, who have emphasised the importance of water and the Murrumbidgee River and its floodplain to the community. A detailed description of this process is provided in NCFRC (2016c). Values attached to the site include:

- A sense of connection and obligation to culture and country;
- A place to visit and reconnect physically and spiritually to culture and country;
- The location of sites of significance and associated cultural practices;
- A source of bush medicine, food sources and native resources that can maintain or improve the health of Nari Nari and the wider community;
- A source of socio-economic potential for Nari Nari;
- A source of pride for Nari Nari

The cultural values summarised above are inclusive of the following themes in a western science sense:

- Cultural (social, spiritual and economic) themes:
    - Source of inspiration to Nari Nari and broader community
    - Community health and well-being
    - Leadership and community governance
    - Knowledge preservation and regeneration
    - Economic independence (e.g. from tourism, harvesting of native resources, water trading)
    - Succession planning
    - Employment and training
- Environmental themes:
    - Native floodplain vegetation
    - Waterbirds
    - Frogs
    - Mammals
    - Water quality and river health.

The flow objectives, key evaluation questions and indicators to be measured in order to assess the themes listed above have been detailed so that monitoring of the outcomes expected with flow delivery as part of this Project can proceed in partnership with the Nari Nari community.

As water for this watering trial is likely to be secured from the Commonwealth Environmental Water Holder (CEWH) holdings, the monitoring of outcomes has been aligned to the monitoring, evaluation, reporting and improvement (MERI) framework used by the CEWH for managing its water holdings.

The M&E study design is one of single-site, single-intervention (SSSI) assessment, with the intervention being the delivery of water for cultural purposes (e.g. Cottingham et al. 2005). This may change in the future should additional flow allocations be made; in this case, the study design would become a single-site, multiple-intervention (SSMI) study. Sampling is to occur at the site both before and after the delivery of water so that the inference of the delivered flow being responsible for cultural and environmental (in isolation from other conditions or events) outcomes is increased – the study design will be that of before-after-intervention.

A conceptual understanding of the relationship of cultural flows with Nari Nari aspirations and watering objectives has been used to propose a series of key evaluation questions to be addressed by the M&E plan. Indicators were then selected for monitoring at Toogimbie IPA, including both governance and watering outcome indicators. Indicators of intermediate and long-term outcomes from this conceptual understanding include:

- Governance and water delivery:
    - Timing, volume and duration of water delivered;
- Cultural (social, spiritual, economic) outcomes:
    - Source of inspiration to Nari Nari and boarder community – e.g. feeling of place, protection of cultural assets;
    - Community health and well-being – e.g. visits or length of stay at healthcare facilities;
    - Leadership and community governance – e.g. increased number of young people on country;
    - Knowledge preservation and regeneration – e.g. increased inter-generational transfer of Nari Nari knowledge.
    - Economic independence– e.g. income derived from new jobs, native resource harvesting and eco-tourism
- Vegetation:
    - Lignum and river red gum condition;
    - Wetland floristics, including the abundance and extent of key species of interest (nardoo, old man saltbush) and weeds;
- Waterbirds:
    - Breeding by migratory and colonial-nesting waterbird species;
    - Waterbird species richness;
    - Abundance of selected waterbird and shrubland species;
- Frogs:
    - Frog species richness.

Standard methods have been included for each indicator, along with data collection and management standards, and a description of potential data evaluation methods. Potential risks associated with the delivery of flow events have also been included, along with any mitigation measures that might be deployed. Reporting requirements and opportunities for maintaining M&E activities into the future are also discussed.

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1 BACKGROUND

The National Cultural Flows Research Project ("the Project") is about developing rigorous and defendable knowledge, with the aim of securing water entitlements for the benefit of Aboriginal people across Australia (NCFP 2014). This research relies on the participation of members of the Aboriginal Nations at two case study sites within the Murray Darling Basin to investigate and measure the cultural values of water to Aboriginal people – it's driven by Aboriginal people, for Aboriginal people. The Project will assess both tangible and intangible facets of water delivered to achieve cultural outcomes, with the primary focus of developing methodologies that will record and assess Aboriginal cultural values and uses regarding watering requirements.

The definition of "cultural flows" was endorsed by representatives from 31 Indigenous nations at a joint meeting of the Murray Lower Darling River Indigenous Nations (MLDRIN) and the Northern Basin Aboriginal Nations (NBAN) - The Echuca Declaration, September 2010 (NCFRP 2014) 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.*

The Project seeks to assess the use of water delivered to achieve cultural outcomes in partnership with two Aboriginal Nations (Nari Nari and Murrawarri). The approach is outlined in NCFRC (2016c) and is built around planning to conduct watering trials, combining cultural, ecological and hydrological components. The long-term view is that the information collected from this project will inform future Australian water resource planning and implementation processes more generally and will provide further evidence for the need of a National Cultural Flows Framework.

Oversight of the Project is by the National Cultural Flows Planning and Research Committee (the Research Committee). The Research Committee represents its member organisations: MLDRIN; 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.

The Project consists of the following components (NCFRP 2014):

- **One**: Describe the Indigenous cultural water values and needs across Australia (completed January 2014).
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- **Three**: Quantify water volumes to meet cultural values and needs (both Nari Nari and Murrawarri), and scientific assessment of a trial flow at Toogimbie Indigenous Protected Area (IPA), near Hay NSW.
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- **Six**: 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.

This monitoring and evaluation (M&E) plan is part of Component Three (above) and outlines the key monitoring and evaluation activities to be conducted by and on behalf of the Nari Nari people as part of any future watering trial conducted as part of the Project.

Monitoring includes the measurement of indicators that will help confirm that the benefits expected from the delivery of flows occur as anticipated. Being able to demonstrate the benefits of delivering flows at Toogimbie IPA will make it easier to secure cultural flows in the future, both at Toogimbie IPA and elsewhere.

Monitoring and evaluation within a 'learning by doing' (i.e. adaptive management framework, see Section 3) will also be important should the expected outcomes not occur fully, or as anticipated, particularly within short timeframes. In such circumstances, it will be possible to consider whether factors such as the timing, volume and duration of the flow event(s) was sufficient, and whether changes to flow delivery might be required over time (e.g. outcomes might be over the medium rather than short term).

The M&E plan focuses particularly on an initial cultural water trial to deliver flows to Toogimbie IPA in the second half of 2016, subject to constraints on securing and delivering water.

This plan is structured as follows:

- **Chapter 2 -** includes a summary of Nari Nari community aspirations for the use of water allocations for cultural purposes, as well as summaries of catchment settings and water delivery issues.
- **Chapter 3 -** summarises important cultural and environmental values and their relationship to watering objectives and outcomes.
- **Chapter 4** - summarises the conceptual basis of watering to achieve cultural and environmental outcomes, along with the indicators that will be part of monitoring and evaluation. This chapter will also outline the key monitoring and measurement methods to be applied, as well as describe how monitoring data are to be analysed.
- **Chapter 5 -** outlines the process for assessing risks associated with water delivery and if, necessary, and required mitigation measures.
- **Chapter 6 -** outlines the reporting requirements of the watering trial.

2 CONTEXT

2.1 Nari Nari aspirations

The vision and aspirational goals for the use of water for cultural purposes is outlined in the Nari Nari Tribal Council (2012) *Toogimbie Plan of Management* vision statement (Figure 1). The statement highlights the interdependence of the Nari Nari connection to country (land and water) with the social, economic and spiritual wellbeing.

Figure 1: Nari Nari vision statement (from NNTC 2012).

2.2 Catchment setting

Toogimbie Station is located near the town of Hay on the Hay Plain, adjacent to the Murrumbidgee River. It is a former pastoral property dating from the introduction of farming to the region in the late 1800s (DEWR 2007). Covering around 460 square kilometres, Toogimbie IPA is owned and managed by the Nari Nari Tribal Council. The Toogimbie landscape includes flat former pasture lands contrasting with eucalypt-lined creeks and waterways, and a nearby floodplain. The traditional life of the Nari Nari people revolves around Toogimbie's wetlands, which are home to totem animals, native foods traditional medicines and natural resources (I.e. various reeds, bark and stone material).

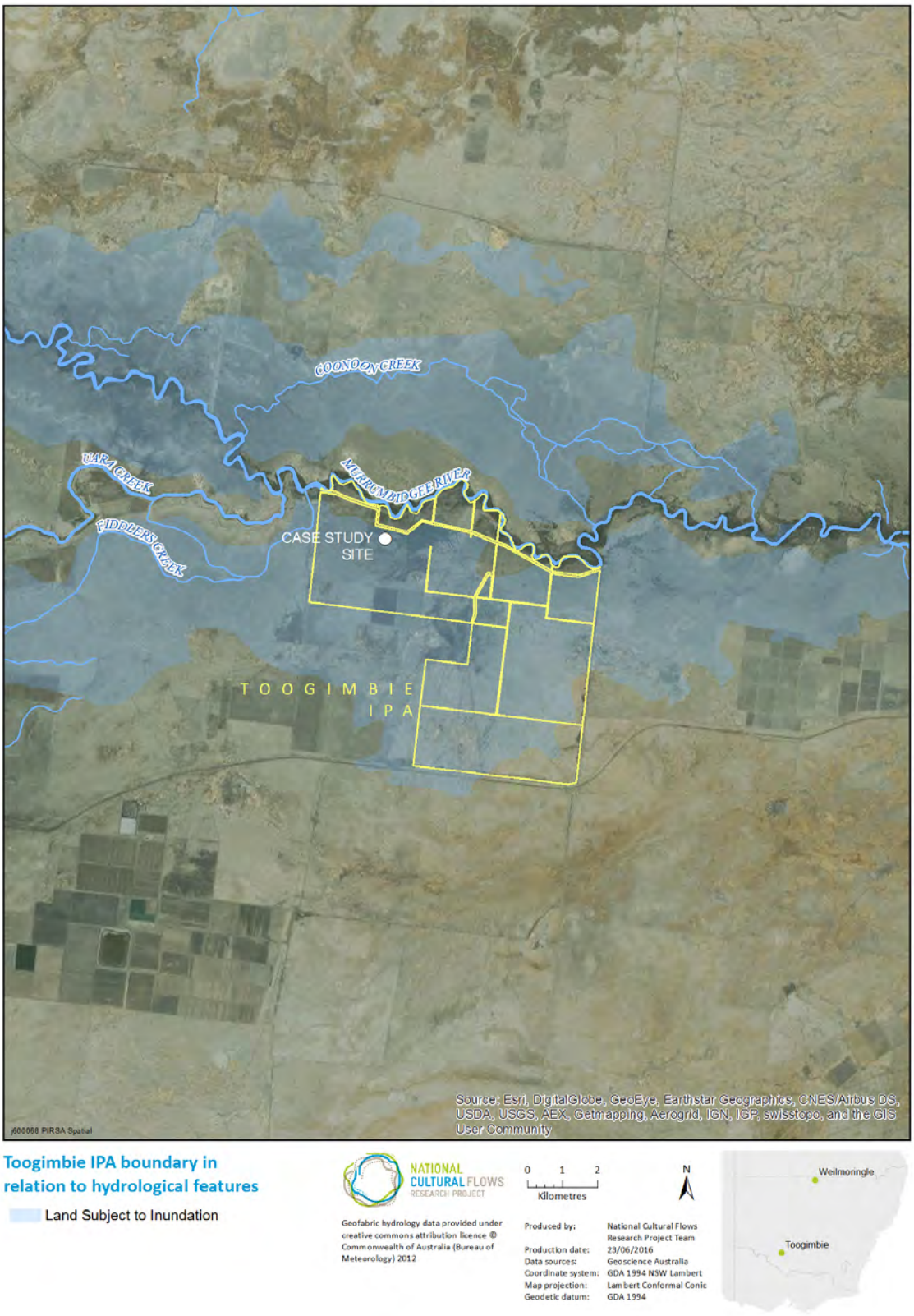

Figure 2: Case study site in relation to Toogimbie IPA and hydrological features

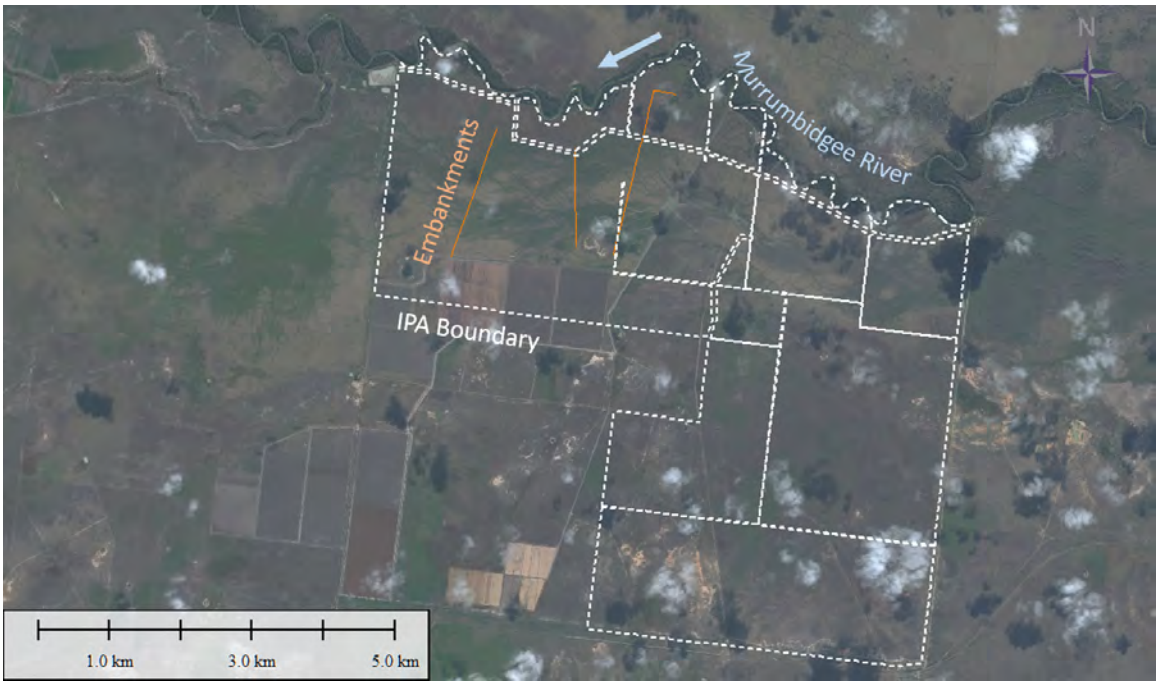

Figure 3: Outline of the Toogimbie IPA boundaries

2.3 Water delivery

The Nari Nari Tribal Council has access to 2,100 megalitres (ML) of cultural water under a cultural access licence included in the Murrumbidgee water sharing plan. Depending on the allocation available in any year, this can be used for any purpose (other than economic) as decided by the Nari Nari Tribal Council. To date water has only been used on Toogimbie, but it is likely that in future other sites (and other Aboriginal communities) may receive water for varying cultural reasons. This means that 2,100 ML of cultural access water will not always be available to the Nari Nari.

There is also potential for environmental water to be available, through the Office of Environment and Heritage (OEH NSW), or through the CEWH, if a case can be made for more extensive flooding than can be provided by the cultural allocation. Toogimbie also has a general purpose allocation, which is tied to the leased irrigation land, and a small stock & domestic licence.

For this watering trial, the Nari Nari community has the ability to access to up to 5 gigalitres (GL) of water from Murrumbidgee holdings of the CEWH. Future, ongoing access to Commonwealth environmental water is currently being established via a partnership between the Nari Nari and the CEWH. Water delivery will be managed by NSW Water on behalf of the CEWH (see Cottingham 2016). At Toogimbie IPA, water will be pumped directly from the Murrumbidgee River using existing infrastructure (pumps, water channels) at the site.

Within the Toogimbie IPA, approximately 900 hectares are contained in four previous irrigation bays (cells), of which three have the potential to receive water as part of the cultural watering trial (Figure 4). The fourth cell is unlikely to be watered as the infrastructure (e.g. embankments) at the western boundary is currently insufficient to contain water on site. The floodplain and associated flood runners within Cells 2, 3 and 6 (the 'swan rookery') are the main area of interest for the cultural watering trial because they are enclosed by levee banks, enabling water

management between each of the cells[1]. Cell 4 still remains of importance to the cultural water trial, as it will serve as a 'control' (similar to other cells but not receiving water as part of the trial) and point of comparison is assessing the outcomes at the cells that did receive water.

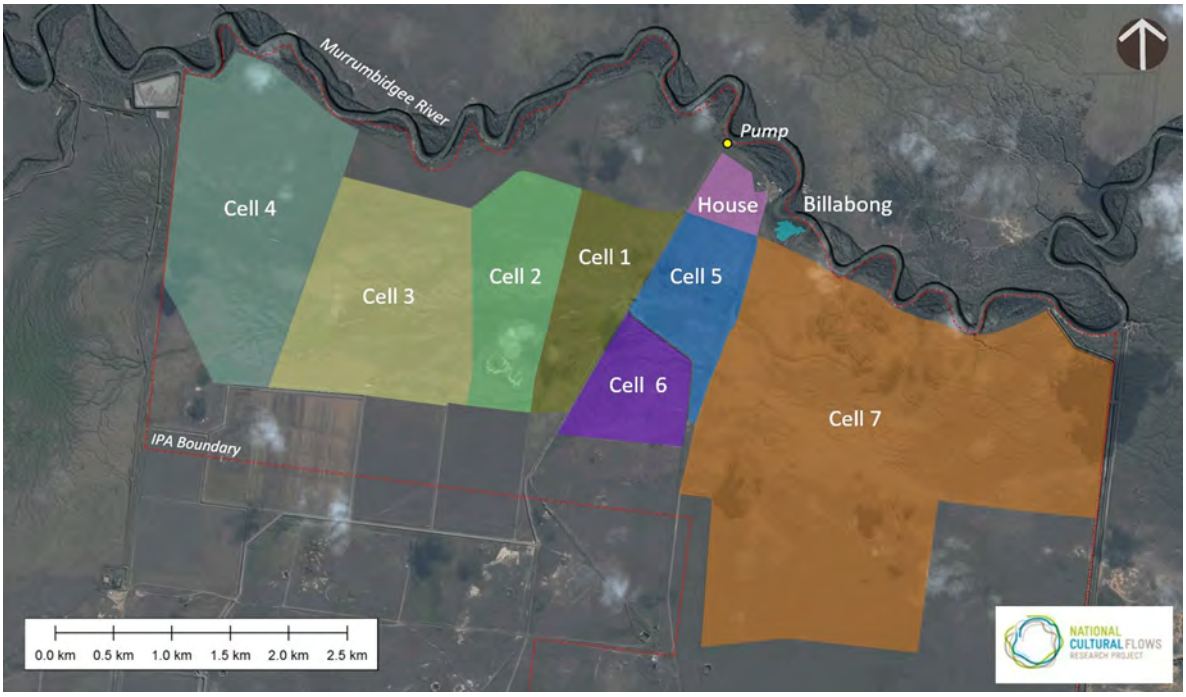

Figure 4: Locality of currently managed wetlands (Cells 1-4, House wetland) at Toogimbie, and additional wetland with potential for water management (Cells 5-7) (C. Gippel, pers. comm.).

[1] Cell 1 has been omitted from the trial, as directed by Nari Nari representatives.

3 CULTURAL AND ENVIRONMENTAL VALUES AND WATERING OBJECTIVES

This chapter summarises the links (inter-connectedness) between the cultural values and aspirations of the Nari Nari with environmental values, and ultimately the watering outcomes that are to be monitored as part of this trial and beyond. This is fundamental to the watering trial, as it is essential that the watering objectives are clearly aligned to the aspirations of the Nari Nari as well as meeting the CEWH's obligations to allocate its water holding to achieve environmental outcomes.

Section 3.1 lists the cultural values that the Nari Nari wish to preserve or improve. These underpin the aspirations noted in Figure 5. Section 3.2 lists the environmental values that are embedded in the cultural values the Nari Nari attach to Toogimbie IPA. The environmental values are important for describing in terms of the medium and long-term outcomes expected from using cultural flows, and reflect the priority ecological outcomes listed in the NCFRP Component 2 report (NCFRC 2016c). Section 3.3 lists the objectives to be pursued as flows are delivered to Toogimbie IPA.

3.1 Summary of cultural values

The management plan for Toogimbie IPA (Nari Nari Tribal Council 2012) identifies cultural values attached to the site. These include:

- A sense of ownership and connection to Culture and Country;
- A place to share and experience knowledge, stories and practices as a community
- A place to visit and reconnect physically to Culture and Country;
- The location of significant Aboriginal sites, especially burial and occupation sites;
- Socio-economic potential for community;
- Maintenance of bush medicine and food sources for generations to come;
- A place to harvest fish, hunt and gather foods and medicinal plants;
- The potential to gather and share Cultural knowledge, stories and experiences with others.

3.2 Relationship to environmental values

The Toogimbie IPA management plan (Nari Nari Tribal Council 2012) identifies environmental values attached to the site that the Nari Nari community seeks to improve by use of cultural and environmental water. These include:

- Significant nesting and breeding area for wetland bird species;
- Shrubland and plains country, unaffected by stock, and with noxious and feral species controlled;
- Riparian zones, streambank areas and the Murrumbidgee River - habitat for native aquatic and mammal species;
- The potential to attract regional threatened species, once habitat is further established and improved;
- A protected area within surrounding farmland.

Further consultation with the Nari Nari led (NCFRC 2016c) led to a refinement of the environmental values listed above, being that Toogimbie IPA supports:

- FFidentified as a priority and iconic species for the site;
- Improved habitat for migratory waterbirds, colonial nesting or shrubland nesting birds, including establishing a rookery for Black swan;
- A permanently watered site in an environmentally appropriate location on the site;
- An increase in established permanent vegetation, primarily River red gum, Lignum, Saltbush, Nardoo, Old man weed, and Common reed.
- Increased animal population, especially of threatened species such as the southern bell frog, but also animals of historical and cultural importance such as kangaroo, emu and koalas.

The values listed above have strong overlap with the expected outcomes from the use of Commonwealth environmental water in the Murrumbidgee River catchment (Commonwealth of Australia 2014; Table 1 and Figure 6). It is important to note that the outcomes expected from the use of environmental water are expected to materialise over both the short and long term, and certainly well beyond the life of the cultural watering trial at Toogimbie IPA, particularly given the length of life cycles for the flora and fauna that exist or may be attracted to the site (Figure 6).

Table 1: Expected outcomes from the use of Commonwealth environmental water in the Murrumbidgee River Valley (from Commonwealth of Australia 2014).

Flow Type	Expected outcomes for 2014–15	Contributions to longer term objectives	Contribution to the following Basin Plan objective
Base flows and freshes	Vegetation condition and reproduction	Vegetation diversity	Biodiversity
	Waterbird survival and condition Waterbird chicks Waterbird fledging	Waterbird diversity	
	Other vertebrate young	Other vertebrate diversity	
	Hydrological connectivity including end of system flows	Connectivity	Ecosystem function
	Individual survival and condition (individual refuges)	Ecosystem resilience	Resilience
	Dissolved oxygen Dissolved organic carbon	Chemical	Water quality
Freshes	Biotic dispersal and movement Sediment transport	Connectivity	Ecosystem function
	Nutrient and carbon cycling	Process	

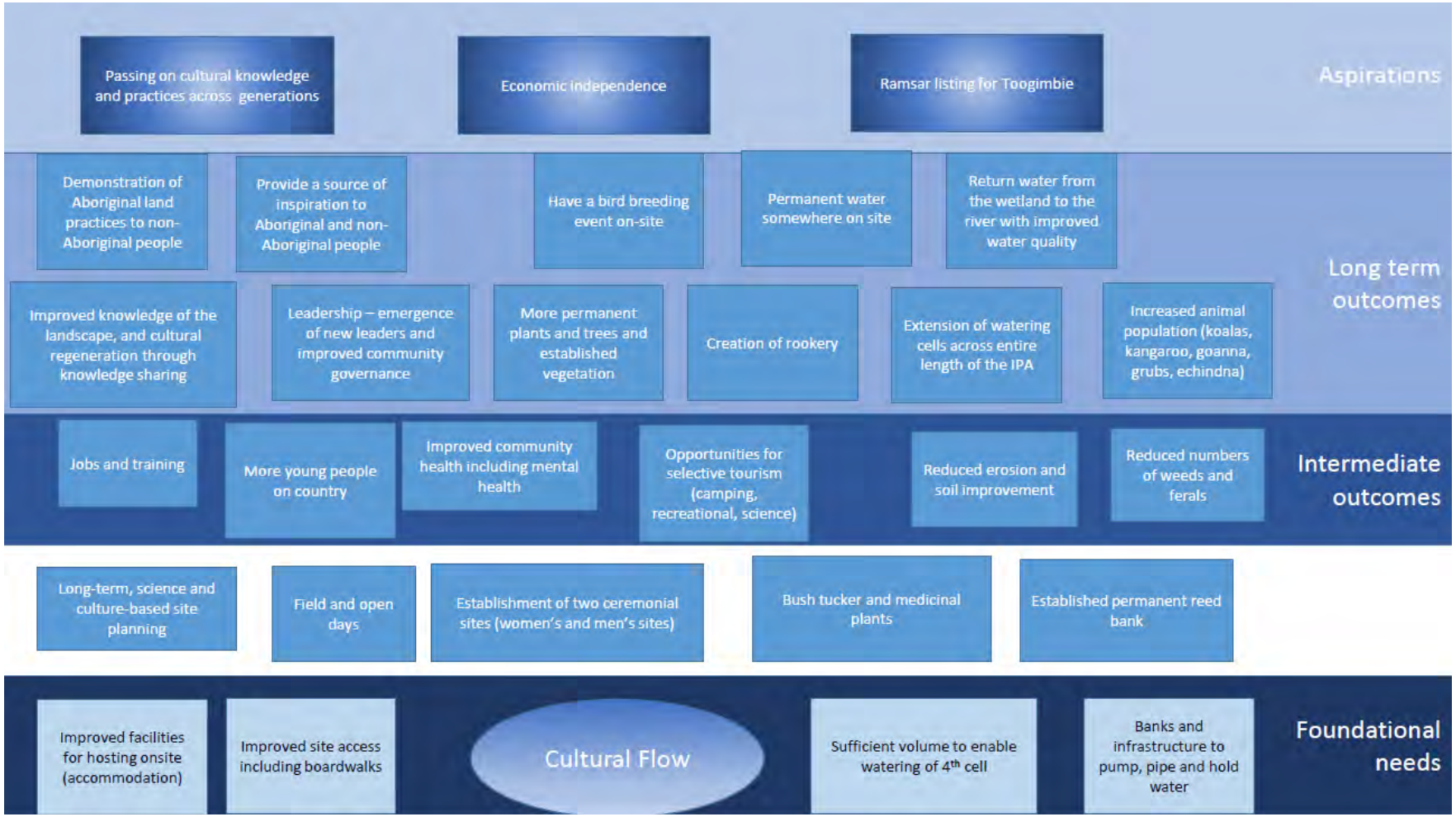

Figure 5: Summary of the inter-relationships between intermediate and long-term outcomes from cultural flows and the aspirations of the Nari Nari people (NCFRC 2016c).

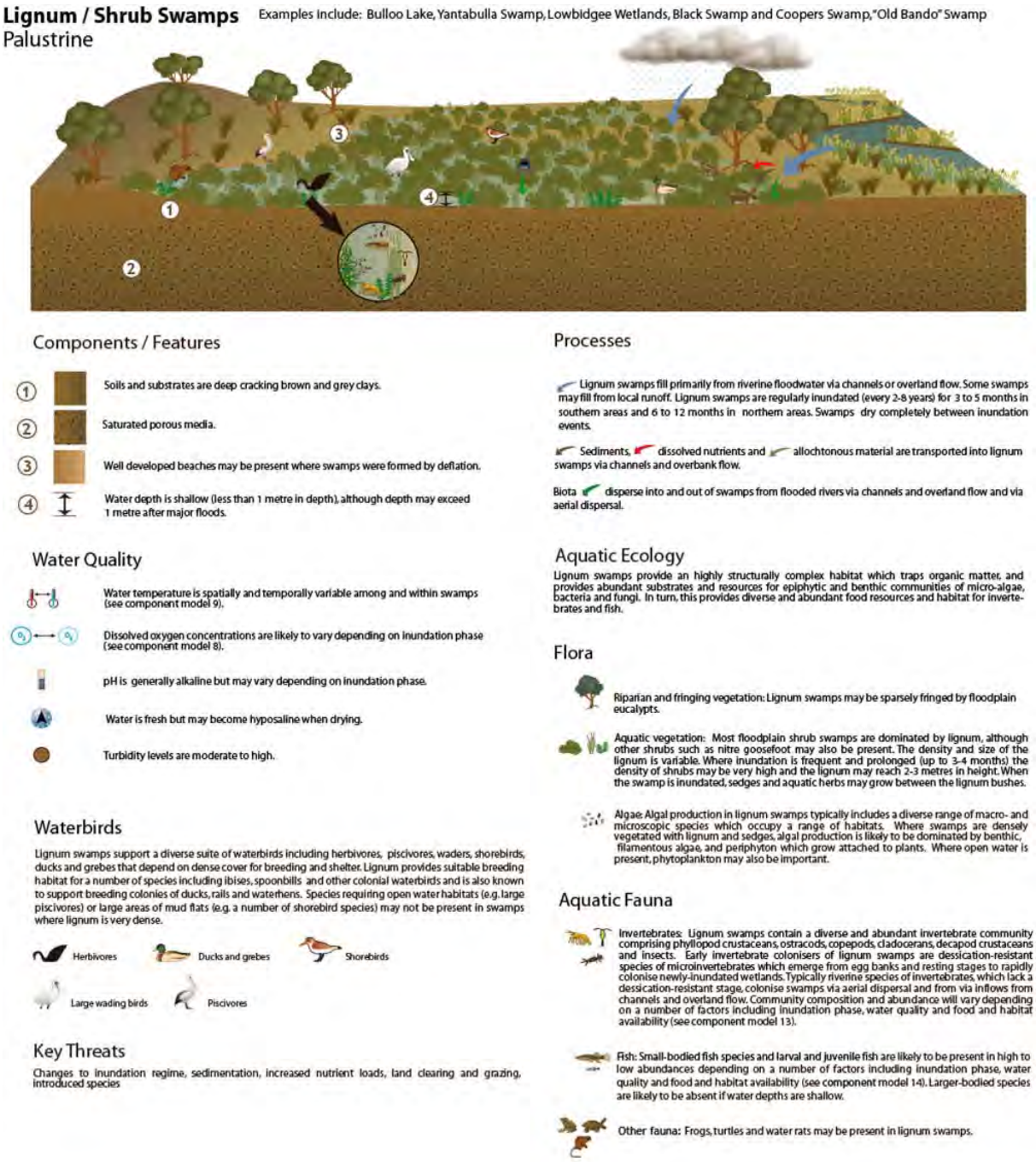

Figure 6: Lignum shrubland swamp conceptual model (from Price and Gawne 2009), indicating the type of flora and fauna likely to exist at Toogimbie IPA.

3.3 Cultural flows objectives

The Nari Nari community seeks to re-establish cultural management of country, including cultural practices and wellbeing associated with lore, ceremony, trade, language and education for inter-generational knowledge exchange in a contemporary setting (i.e. at Toogimbie IPA). The rationale for this is described in detail in NCFRC (2016c) and includes:

- Ownership of a water allocation is pivotal to enable the Nari Nari to actively participate in water planning and management with the same status and on equal terms with other water users in the system.
- Restoration of the ecology of the site has significant socio-economic potential for the community, as economic independence, 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.
- Sustainability and protection of the site as an educational facility for intergenerational transfer of cultural knowledge and practice is linked to long-term sustainability of management interventions, to cultural regeneration, to the emergence of new community leaders and to improved community governance.
- Enhancement of the site as a significant nesting and breeding area for wetland birds of cultural significance, especially the Black swan (*Cygnus atratus*), as birds of cultural and iconic significance to the Nari Nari do not have the same priority as other attributes in environmental flow releases along the Murrumbidgee River.
- Restoration and maintenance of vegetation with bush medicine, craft, ceremony artefacts and food sources is 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 (*Litoria raniformis*), but also animals of historical and cultural importance such as kangaroo, emu and koalas.
- Cultural management of Toogimbie site 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.

Ongoing consultation with the Nari Nari (NCFRC 2016c) has identified the following objectives in relation to cultural flows:

1. Acquire a permanent, tradeable water allocation for Aboriginal cultural, socio-economic, or Aboriginal Environmental Outcomes by 2020, to enable the achievement of cultural and economic independence through enterprise development and water trading.
2. Increased involvement of Aboriginal people in the traditional of *Mawambal* at Toogimbie by bringing people together in management, recreational and cultural activities on Country, with an emphasis on young people through Elders, and increased inclusivity of activities undertaken on site.
3. Increased use of the site as an educational facility for intergenerational transfer of cultural knowledge, language and practice and as an exemplary demonstration site of Aboriginal management of Country and management of the Aboriginal Estate by 2020.
    a. Improved condition of, and access to floodplain medicinal plants (Old man weed *Centipeda cunninghamii*, Nardoo (*Marsilea drumondii*), Pig face (*Carpobrotus*

glaucescens), Native geranium/Australian cranesbill (*Geranium solanderi*)) by 2020.

b. Improved condition of bushfood plants found on the floodplain (Native carrot *Daucus glochidiatus*, Native yam/black fellow yam (*murnang*) (*Microseris* spp.), common reed *Phragmites australis*) by 2020.

c. Promote seed set of key floodplain plant species (Wild flax *Linum marginale*, Boree/Myall *Acacia pendula*, Cooba/Black sallee *Acacia salicina*, Miljee *Acacia oswaldii*) to allow seed collection activities by 2025.

4. Improved on-site management through access to new information and long term planning.
    a. Increased involvement of Nari Nari in action research and training, and increase in partnerships and collaboration with science, conservation, health, youth, cultural or research organisations.
    b. New planning and management initiatives for the site launched based on new information, data, Aboriginal science or research findings.
    c. Revision of strategic and management plans for site based on new information, data or knowledge.
5. New enterprise development at Toogimbie site that contributes to community self-determination, with profits directed to social development, training, capacity-building and skill building in the community.
6. Increase in employment of Aboriginal people at Toogimbie as employees or volunteers, including the number of Aboriginal people connected to Toogimbie who obtain permanent employment.
7. Improved community health and well-being outcomes for community members involved with Toogimbie site, including supported recovery, improved self-reported health status and well-being benefits associated with increased harvest and use of traditional medicinal plants.
8. Re-establish and maintain condition of culturally significant plant and animal species to allow both cultural and language regeneration and the continued practice of cultural activities by 2020.
    a. Improved condition of water dependent riverine and floodplain plant species of exceptional cultural importance, including Lignum (*Duma florulenta*), Nardoo, and Common reed (*Phragmites australis)*.
    b. Increased number of successful breeding events of culturally important waterbird species by 2020, including Black swan (dhuundhuu/ngiyaran), Pelican (gulambali/birriyag) (*Pelecanus conspicillatus*) and Spoonbills (murrugaya) (*Platalea regia*), and local raptor species (eagles (maliyan/yibaay), hawks (dunandinang/baga-daa/dhirril) and kites).
9. Investigate options for formal, permanent recognition of the Toogimbie wetland site values, under the Aboriginal Place provision of the National Parks and Wildlife Act (1974) or other appropriate mechanism.

Although recognised as inter-connected, for simplicity the intermediate and long-term outcomes from delivering cultural flows have been summarised into the following themes to allow the design of monitoring and assessment activities at the site:

- Cultural (social, spiritual and economic) themes:
    - Source of inspiration to Nari Nari people and the broader Hay community
    - Nari Nari community health and well-being (spiritual, emotional and physical)
    - Leadership and community governance
    - Knowledge preservation and regeneration
    - Bush medicine, food and resource harvesting (i.e. tools, weaving, etc.)

    - Economic independence from income derived from new jobs, harvesting of native resources and eco -tourism.
- Environmental themes:
    - Native floodplain vegetation
    - Waterbirds
    - Frogs.

The flow objectives, key evaluation questions and indicators to be measured in order to assess the themes listed above are detailed in Chapter 4.

4 APPROACH TO MONITORING AND ASSESSMENT

4.1 MERI framework

Given that the water to be used for the watering trial at Toogimbie IPA will initially be secured from the CEWH, the monitoring of outcomes has been aligned to the monitoring, evaluation, reporting and improvement (MERI) framework used by the CEWH for managing its water holdings (Figure 7). The monitoring of watering at Toogimbie IPA will initially be focused on operational monitoring and short-term outcomes (1-5 years). However, it could be expanded to complement the CEWH's long-term ecological monitoring should there be resources to continue water delivery and monitoring activities into the future (Figure 8).

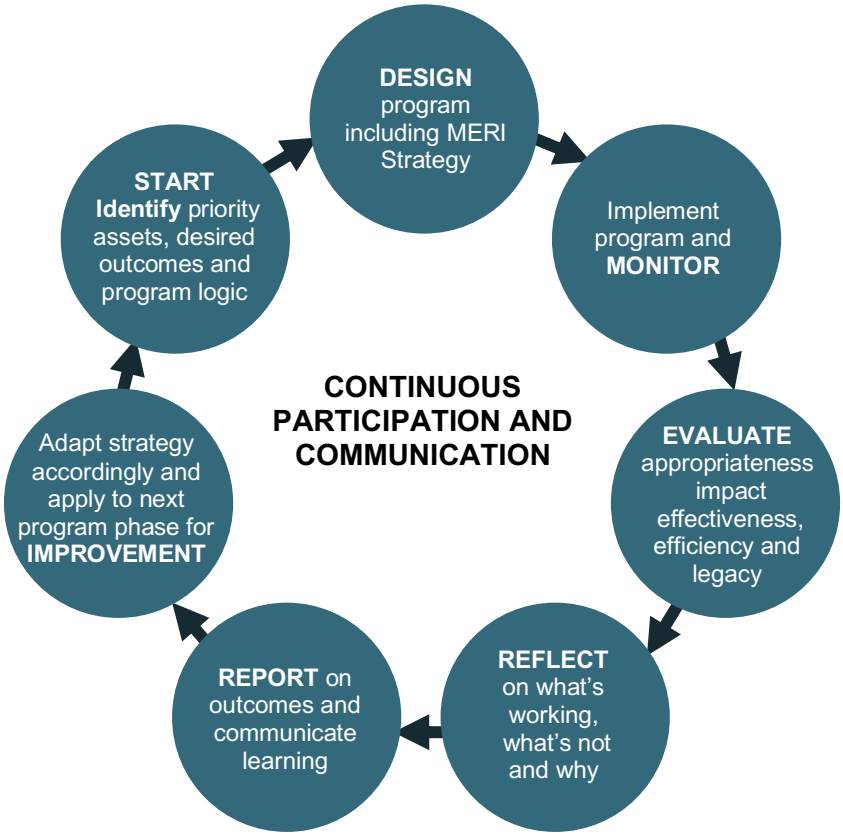

Figure 7: Overview of the Government of Australia MERI framework (CEWO 2013).

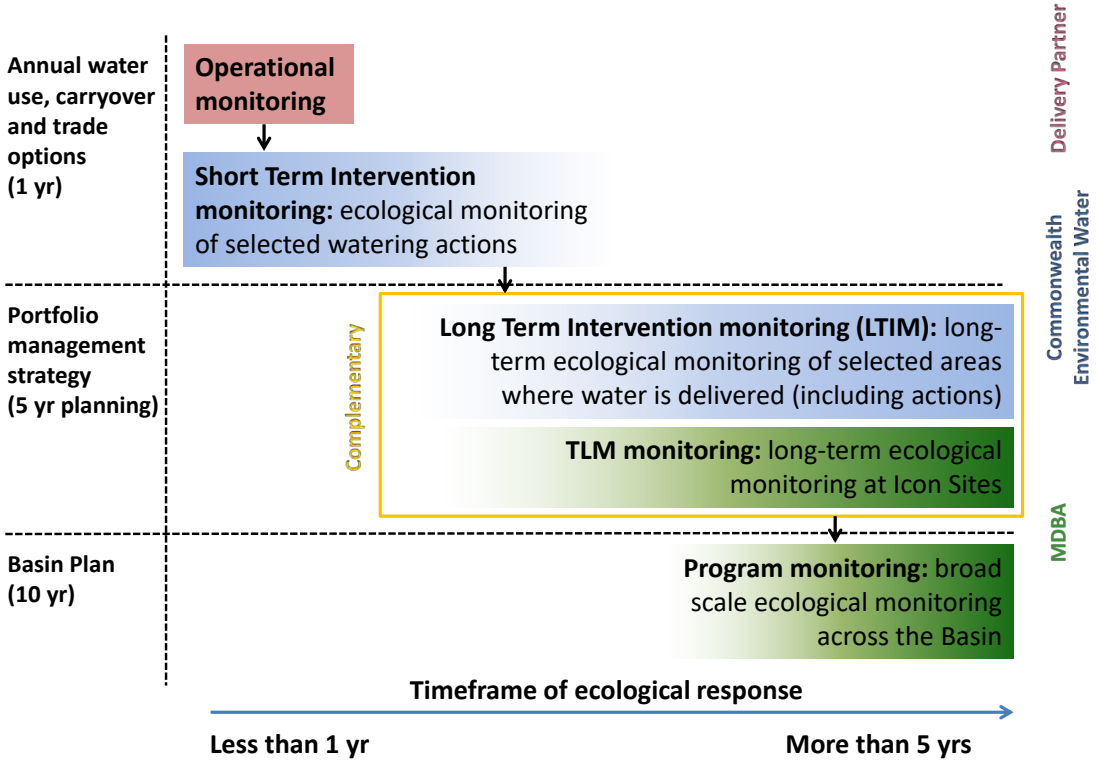

Figure 8. CEWO monitoring framework. TLM = The Living Murray program.

(©Commonwealth Environmental Water Office, accessed from https://www.environment.gov.au/water/cewo/publications/cew-monitoring-evaluation-reporting-and-improvement-framework).

The MERI process includes evaluation of both process/governance of water delivery, as well as evaluation of cultural and environmental outcomes. This is necessary so that it is possible to confirm that the water was delivered as intended (i.e. the volume, timing and rate of delivery was as planned), and so that any cultural and environmental outcomes recorded can be assigned directly to water delivery.

4.2 Study design

4.2.1 Cultural themes

For this Project, cultural themes will be explored in simple before-after assessments that focus on Nari Nari community feedback in relations to elements of:

- Source of inspiration to Nari Nari and broader community – e.g. feeling of place, protection of cultural assets.
- Community health and well-being– e.g. visits or length of stay at healthcare facilities.
- Leadership and community governance – e.g. increased number of young people on country.
- Knowledge preservation and regeneration – e.g. increased inter-generational transfer of Nari Nari knowledge and cultural practices.
- Bush medicine, food and resource harvesting – e.g. increased abundance and availability of resources.

- Economic independence e.g. income derived from new jobs, harvesting of native resources and eco -tourism.

Based on the preliminary aspirations identified to date, potential monitoring activities may include (see NCFRC 2016c):

- Monitoring of communal events at the site (including attendance, duration, youth involvement, Indigenous/non-Indigenous involvement, volunteering, satisfaction).
- Monitoring of employment status of Nari Nari employees (employment at Toogimbie or long-term employment at other locations).
- Monitoring of harvest activities at Toogimbie with estimated actual or implied economic value (hunting, fishing, bush medicine, art and crafts, artefacts etc.).
- Monitoring complaints to Council, EPA or other relevant body associated with dust and erosion from Toogimbie.
- Self-reported health and well-being of community members, including psychological distress, positive wellbeing, self-esteem, sense of support.
- Monitoring of changes in perceptions in health factors for the community as a whole.

4.2.2 Environmental themes

For this Project, the environmental theme study design is one of single-site, single-intervention (SSSI) assessment, with the intervention being the delivery of water for cultural purposes. This may change in the future should water allocations continue via the Murrumbidgee cultural access licence (CAL) (i.e. additional interventions in future years) and monitoring continues; in this case, the study design would become a single-site, multiple-intervention (SSMI) study.

The intention is that indicators of the outcomes expected with watering for cultural purposes will be monitoring both prior to and following the delivery of water; thus, the project will collect both before- and after-intervention data. The presence of Cell 4, which is similar to Cells 1-3 but will not receive a water allocation, means that there is a 'control' or 'comparison' site available to the study design. The inclusion of monitoring at this site may make it possible to use employ a before-after, control (comparison)-intervention (BACI) study design (Table 2, Figure 9). Such a study design greatly increases the inference that can be assigned to the effect of water delivery to Cells 1-3.

To adequately characterise the natural variability that occurs at the site, it is necessary to monitor parameters over a period of time, both before and after the delivery of cultural water. Understanding natural variation is important and in most cases is built over a number of years collecting data at a site. Depending on the focus of the study and logistics, (e.g. how rapidly changes in the monitored parameter are expected to occur), sampling could be expected to occur yearly, seasonally or more frequently. Sampling frequency is considered further for the various themes outlined in Chapter 5.

Table 2. Study design options for investigating the impact of interventions on wetlands receiving flows (adapted from Cottingham et al. 2005)*.

Design	Before data	After data	Control/Comparison sites	Impact sites	Design and Analysis
1	Yes	Yes	Y (>1)	Y (≥1)	Before-After-Control-Intervention (MBACI)
2	Yes	Yes	Yes (1 only)	Yes (1 only)	Before-After-Control-Intervention Paired (BACIP)
3	Yes	Yes	No	Yes	Before-After-Intervention
4	No	Yes	Yes (≥1)	Yes (≥1)	Control-Intervention
5	No	Yes	No	Yes	Intervention only

*Designs are ranked from 1 = most optimal design for detecting expected outcomes, to 5 = least optimal design for detecting expected outcomes. Projects that have before-after sampling at both 'impact' (impact is the flow event in this instance) and control or comparison sites best show that the outcomes measured will have been due to the delivery of the flow event.

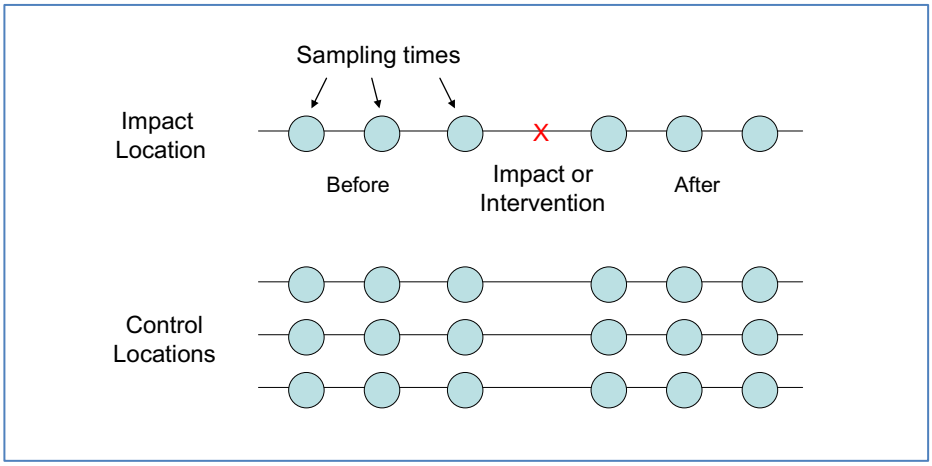

Figure 9. MBACI study design with single intervention location (from Butcher and Robinson 2016) where the impact or invention is a cultural watering trial.

To identify changes directly resulting from the impact or intervention activity, it is necessary to firstly identify changes (= After versus Before) and then to differentiate these from changes occurring naturally in the system. This is achieved by comparing changes at the impact location with those occurring at control or comparison locations (floodplain areas that were similar to the intervention wetland prior to the intervention, but were not affected by the intervention; i.e. did not receive flows). Having multiple impact and control locations can increase the inference that changes measured will have been due to the intervention.

5 MONITORING AND ASSESSING FLOW OUTCOMES

5.1 Conceptual approach

Discussions with the Nari Nari community have highlighted the inter-connectedness of watering at Toogimbie IPA with community aspirations and objectives associated with cultural flows (shown previously in Figure 5). Importantly, it was recognised that achieving community aspirations, as well as all the cultural flow objectives, will require a long-term view. For example, Figure 10 links one of the Nari Nari aspirations with a subset of both medium (5 to 15 year) and long-term (15 to20 year) cultural flow objectives. These objectives also link via key evaluation questions to the indicators that will be included for monitoring, and relate to water governance as well as cultural and environmental outcomes.

It should be noted that limited time and resources means that this M&E plan focuses ***predominantly on monitoring short to medium-term outcomes directly related to the delivery of a trial flow event to Toogimbie IPA in the spring of 2016***. However, this does not preclude other activities (both medium and long-term), particularly those that are not site-based activities, such as liaison with government agencies and water user groups to secure water delivery in the future.

For simplicity, the watering outcomes identified in Figure 5 have been summarised according to the following monitoring themes:

- **Water governance** – focusing on the delivery of water to Toogimbie IPA, as planned.
- **Cultural (social, spiritual and economic) outcomes** – focusing on the protection of Nari Nari sites of significance at Toogimbie IPA, along with measures of community health, knowledge preservation and regeneration.
- **Wetland vegetation** – focusing on culturally important vegetation communities and specific plant and tree species.
- **Wetland waterbirds** – focusing on waterbird breeding activity, species richness and the abundance of culturally important waterbird and shrubland bird species.
- **Frogs** – focusing on species richness.

Sampling sites for wetland vegetation, waterbird and frog themes within each of the Cells at Toogimbie IPA are presented in Section 5.7, while a sampling schedule is provided in Section 5.8.

What are we trying to achieve? → What do we expect the outcome to be? → What questions are we to answer? What do we measure to answer questions?

Nari Nari aspiration
Ramsar listing for Toogimbie IPA

Long term objectives

Increased extent and permanency of plants and trees (ligum, nitre-goosefoot, river red gum)

Increased frequency of migratory or colonial nesting waterbird breeding

Short term objectives

Increased abundance and extent of bush tucker, medicinal and economic plant species (old man saltbush, nardoo).

Increased condition of important shrub and tree species (lignum and river red gum).

Decreased weed cover.

Outcomes from cultural flows

Increased shrub and tree extent over 15 years from 2016 to 2031 for:
- Lignum (*Duma florulenta*)
- River red gum (*Eucalyptus camaldulensis*),

Increased breeding frequency of migratory, colonial nesting or icon waterbirds beyond 2031 for:
- White necked heron
- Australian pelican
- Black swan
- JAMBA/CAMBA/ROKAMBA listed species.

Increased abundance and extent of key bush medicine and economic species over 15 years from 2016 to 2031:
- Nardoo (*Marsilea drummondii*)
- Old man saltbush (*Atriplex nummularia*).

Increased tree condition over 15 years from 2016 to 2031 for:
- Lignum (*Duma florulenta*)
- River red gum (*Eucalyptus camaldulensis*),

Decreased extent of weed species over 15 years from 2016 to 2031.

Key Evaluation Questions

- Did the delivery of cultural flows increase the extent of lignum and river red gum between 2016 and 2031?
- Did the delivery of cultural flows lead to breeding by white necked heron, Australian pelican, black swan, and any JAMBA/CAMBA/ROKAMBA listed species between 2016 and 2031?
- Did the delivery of cultural flows lead to increased abundance of nardoo and old man saltbush?
- Did the delivery of cultural flows lead to increased lignum and river red gum condition?
- Did the delivery of cultural flows lead to decreased extent of weed species?

Indicators

- Extent of lignum and river red gum
- Number of breeding events of white necked heron, Australian pelican, black swan, and any JAMBA/CAMBA/ROKAMBA listed species
- Abundance and extent of nardoo and old man saltbush
- Lignum and river red gum condition
- Extent of weed species

Figure 10: Subset of medium-term (5 to15 year) objectives related to the Nari Nari management aspirations for Toogimbie IPA.

5.2 Water delivery and governance theme

5.2.1 Objectives, key evaluation questions and indicators

The governance objectives, key evaluation questions and indicators are summarised in Table 3. Further details on the indicators is provided in Table 4. Monitoring activities will focus on confirming the volume water delivered to Toogimbie IPA via the Murrumbidgee River, and measuring the volume of water pumped from the river and onto the site.

Table 3: Flow governance objectives, key evaluation questions and indicators

Cultural flow objective	Key Evaluation Questions	Indicators
Flows are delivered to Toogimbie IPA to achieve the Nari Nari aspiration of passing on cultural knowledge, economic independence and environmental management for Toogimbie.	Have flows been delivered at the agreed frequency, timing, volume and duration?	Daily water volume (ML/d) in the Murrumbidgee River per flow event. Water volume (ML) pumped to the Toogimbie IPA site per flow event.

Table 4: Summary of water delivery indicators for Toogimbie IPA

Item	Indicator	Measurement	Data source/management
Water release	Flow at gauging station downstream of Hay Weir on the Murrumbidgee River	Daily flow (ML/d)	Gauge downstream of Hay Weir (Station 410136) Daily data during flow delivery to be entered into an MS Excel spreadsheet. A copy is to be provided to the Research Committee and the RSSA project team.
Water pumped from the Murrumbidgee River	Pumped flow volume	Daily flow (ML/d)	Pump flow metre Data to be entered into an MS Excel spreadsheet. A copy is to be provided to the Research Committee and the RSSA project team.
Water arriving at Toogimbie IPA	Staff gauge levels in each irrigation cell*	Staff gauge height (relative metres and/or metres AHD).	Daily while the wetland is filling and weekly thereafter Data to be entered into an MS Excel spreadsheet. A copy is to be provided to the Research Committee and the RSSA project team.
Extent of flooding	GPS measurements of the extent of watering using a drone fitted with GPS and camera.	Position (boundary) and area inundated.	Nari Nari owned and operated drone, GPS and camera.

*To be installed

5.2.2 Assessment of outcomes

Assessment of water delivery and governance will include simple statements on:

- Whether water in the Murrumbidgee River was available for pumping at the agreed rate.
- Whether the volume of water pumped onto the study area of Toogimbie IPA (Cells 2, 3 and 6) was as agreed.
- Whether the water pumped onto Cells 2, 3 and 6 reached the depth and areal extent predicted.

5.3 Cultural (social, spiritual and economic) outcomes theme

Cultural objectives and outcomes associated with cultural flows have been identified in consultation with the Nari Nari community. They include:

- Source of inspiration to Nari Nari and broader community – e.g. feeling of place, protection of cultural assets;
- Community health – e.g. visits or length of stay at healthcare facilities;
- Leadership and community governance – e.g. increased number of young people on country;
- Knowledge preservation and regeneration – e.g. increased inter-generational transfer of Nari Nari knowledge.
- Bush medicine, food and resource harvesting – e.g. increased availability of the significant species will enable community to collect, treat and process species more regularly and re-instate cultural practices.
- Economic independence – e.g. income derived from new jobs, harvesting of native resources and eco-tourism.

5.3.1 Objectives, key evaluation questions and indicators

Based on the preliminary aspirations identified to date, potential monitoring activities will include (see NCFRP, 2016c):

- Monitoring of communal events at the site (including attendance, duration, youth involvement, Indigenous/non-Indigenous involvement, volunteering, satisfaction)
- Monitoring of employment status of Nari Nari employees (employment at Toogimbie or long-term employment at other locations)
- Monitoring of harvest activities at Toogimbie with estimated actual or implied economic value (hunting, fishing, bush medicine, art and crafts, artefacts etc.)
- Monitoring complaints to Council, EPA or other relevant body associated with dust and erosion from Toogimbie
- Self-reported health and well-being of community members, including psychological distress, positive wellbeing, self-esteem, sense of support.
- Monitoring of changes in perceptions in health factors for the community.

The objectives, key evaluation questions and indicators for the cultural outcomes theme are summarised in Table 5.

Table 5: Flow governance objectives, key evaluation questions and indicators

Cultural flow objective	Key Evaluation Questions	Indicators
Increased feeling of wellbeing by Nari Nari people due to the improved environmental condition of Toogimbie IPA **Increased health of the Nari Nari and wider Aboriginal community** **Increased involvement of Aboriginal people in management, recreational and cultural activities on site, with an emphasis on Elders and young people.** **Improved community governance on site due to access to new information, skills, cultural knowledge and resources.** **Increased knowledge preservation (including language), and cultural regeneration across generations of Nari Nari** **Enhanced site management for animal and vegetation species of cultural significance to enable customary practice** **Improved capacity for enterprise development including cultural, conservation and science tourism** **Improved long-term, science and culture-based site planning**	Did cultural flows increase mental health and well-being of Nari Nari people and others after visiting Toogimbie IPA? Did cultural flows increase the number of Aboriginal people involved with recreational and cultural activities at the Toogimbie IPA? Did cultural flows contribute to employment, training or educational outcomes for Nari Nari people? Did cultural flows result in the increased use of medicinal plants? Did cultural flows increase the foods and materials (for customary use) collected at Toogimbie IPA? Did cultural flows increase the presence of wetland birds of cultural or iconic significance? Did cultural flows increase traditional knowledge preservation and regeneration? Did cultural flows result in increased tourism numbers at Toogimbie IPA? Did management of cultural flows lead to improved long-term science and culture-based planning at Toogimbie IPA?	Personal mental health and wellbeing index[2] Abundance or extent of key floodplain, medicinal or food plant species, including reeds (e.g. Phragmites, Typha), Nardoo, Old man saltbush and Lignum. Number of research and management collaborations with science, conservation, health or cultural or research organisations Frequency, duration and number of participants (including the number of young people and elders) at cultural events*. Participant satisfaction at cultural events*. Number of tourism visits, (including length of stay, revenue generated, ratio of Aboriginal/non-Aboriginal participants) Five-yearly updates of Toogimbie IPA management plans based on best available science and cultural knowledge. Review of governance arrangements for succession planning of site management

** Indicators identified and developed in consultation with the Nari Nari community during preliminary fieldtrips and meetings.*

5.3.2 Assessment of outcomes

[2] Indicators have been adopted from the Australian Aboriginal and Torres Strait Islander Health Survey: http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/DF297B21938AE1CCCA257C3D0014C924?opendocument

Assessment of outcomes will be simple before-after comparisons, based on the indicators collected by or in consultation with the Nari Nari. Outcomes will be expressed in terms of:

- Community well-being,
- Community health,
- Preservation of traditional knowledge.

5.4 Floodplain vegetation theme

5.4.1 Conceptual approach

Conceptual models are used to help refine the key evaluation questions relating to the ecological outcomes of cultural watering. From these evaluation questions, indicators can be selected to inform the sampling design and method selection.

The conceptual model presented in Figure 11 illustrates the relationships between the following wetland attributes and watering to achieve vegetation objectives (modified from Butcher and Hale 2016):

- Implementation modifiers,
- Intermediate responses,
- Landscape and site modifiers,
- Ecological response.

This conceptual approach is valuable in identifying features that should be considered in measuring and interpreting any response to flow events. For this project, the implementation modifiers outlined in Figure 11 have been captured under the water governance section 3.2. Information on landscape modifiers has been collected in the ecological character description for the site (Butcher and Cottingham 2016) and should be updated prior to the delivery of flows in the future. The ecological responses and their relationship to flow objectives are outlined in the following section. The same approach has been applied to the subsequent waterbird theme (section 5.5) also.

5.4.2 Objectives and key evaluation questions

The vegetation objectives, key evaluation questions and indicators are summarised in Table 6. Details on the nominated indicators and appropriate sampling methods are provided in the following sections on sampling regime and sampling methods (below).

Table 6: Vegetation objectives, key evaluation questions and indicators

Flow objective	Key Evaluation Questions	Indicators
Increased abundance and extent of bush tucker, medicinal and economic plant species. Increased extent and condition of lignum. Increased extent and condition of river red gum	Did flows increase the abundance or extent of key bush tucker, medicinal, economic and icon species between 2016 and 2025? Did flows increase the condition of the Lignum community between 2016 and 2025?	Abundance and/or extent of Nardoo (*Marsilea drummondii*) and Old man saltbush (*Atriplex nummularia*). Extent of the Lignum (*Duma florulenta*) community. Lignum condition.

Flow objective	Key Evaluation Questions	Indicators
Reduced extent and abundance of weed species	Did flows increase the extent of reeds in the House wetland between 2016 and 2025? Did flows increase the extent of the Lignum community between 2016 and 2025? Did flows increase the condition of the River red gum community between 2016 and 2025? Did flows increase the extent of the River red gum community between 2016 and 2025? Did flows decrease the abundance and extent of weed species between 2016 and 2025?	Extent of Common reed (*Phragmites australis*) and Cumbungi (*Typha* spp). Extent of the River red gum (*Eucalyptus camaldulensis*) community. River red gum condition. Abundance and extent of weed species.

5.4.3 Vegetation sampling regime

Pre-flow monitoring data collected as part of this Project will be limited to a single sampling event in the lead up to the delivery of a trial flow. However, some of the sampling sites in each irrigation cell overlap with those established by the Nari Nari as part of previous site monitoring activities. A comparison of the pre-watering data collected during this Project with data collected previously will determine the extent to which previous data can be used for analysis in this Project.

The sampling regime will include pre-watering sampling (September 2016), followed by three post-watering sampling events spaced 6 weeks apart. Given recent (October 2016) natural flooding at Toogimbie IPA, the first post-watering sampling event will occur in mid December 2016.

5.4.4 Vegetation monitoring methods

Vegetation monitoring is proposed using the NSW OEH standard methods (OEH 2015, refer to Appendix 1 for detailed sampling regime), consistent also with the approach used for vegetation surveys and mapping across floodplain systems in NSW (Eco Logical Australia 2015). This is complemented with the vegetation mapping approach included in the Victoria WETMAP program (DELWP 2016) and Lignum condition assessment proposed by Sholz et al. (2007). The methods are detailed in Appendix 1 and based on:

- Measuring the extent of Lignum (*Duma florulenta*) communities in both the intervention sites (Cells 2, 3 and 6) and the control/comparison site (Cell 4). This will involve mapping the extent of the Lignum community, walking the boundary of each community and recording extent using GPS, supplemented by geo-referencing of aerial photography using a drone (i.e. unmanned aerial vehicle, UAV). The on-ground survey can also be applied to the extent of selected, culturally significant species such as Old man saltbush (*Atriplex nummularia*) and Nardoo (*Marsilea drummondii*).
- Measuring the condition of Lignum vegetation (50 plants, can coincide with floristic survey, below) according to the method of Scholz et al. (2007).

- Measuring the floristics of plant species in the Lignum community. This will involve measuring percentage cover, plant form (e.g. shrub, groundcover) and species within 3 randomly located 20 m by 20 m quadrats[3] per 300 hectares of the Lignum community in each of the cells included in the trial. This will also account for measuring weed species.
- Measuring the vegetation structure along 100 metre transects established as part of previous monitoring at Toogimbie IPA (Smits 2014).
- Measuring the location and extent of selected, culturally important plant species (e.g. bush tucker and medicinal plants) in each of the cells included in the trial.

5.4.5 Assessment of outcomes

Assessment of the collected data will be based on before-after-control-impact comparisons (see Table 2, above) of:

- The condition of Lignum communities in each cell;
- The extent of Lignum and reeds communities in each cell, including changes in extent due to recruitment over time;
- The abundance and/or extent of selected culturally important species over time.

Assessment will initially focus on the before-after comparison of extent, floristics and condition in the year immediately following the flow event, and on an annually basis thereafter.

[3] The shape of the quadrats can be altered to fit the shape of the vegetation community. For example, quadrats can be altered to 40 m by 10 m or 100 m by 4 m for elongated or linear shaped communities. The intention is to have quadrats of 0.04 hectares.

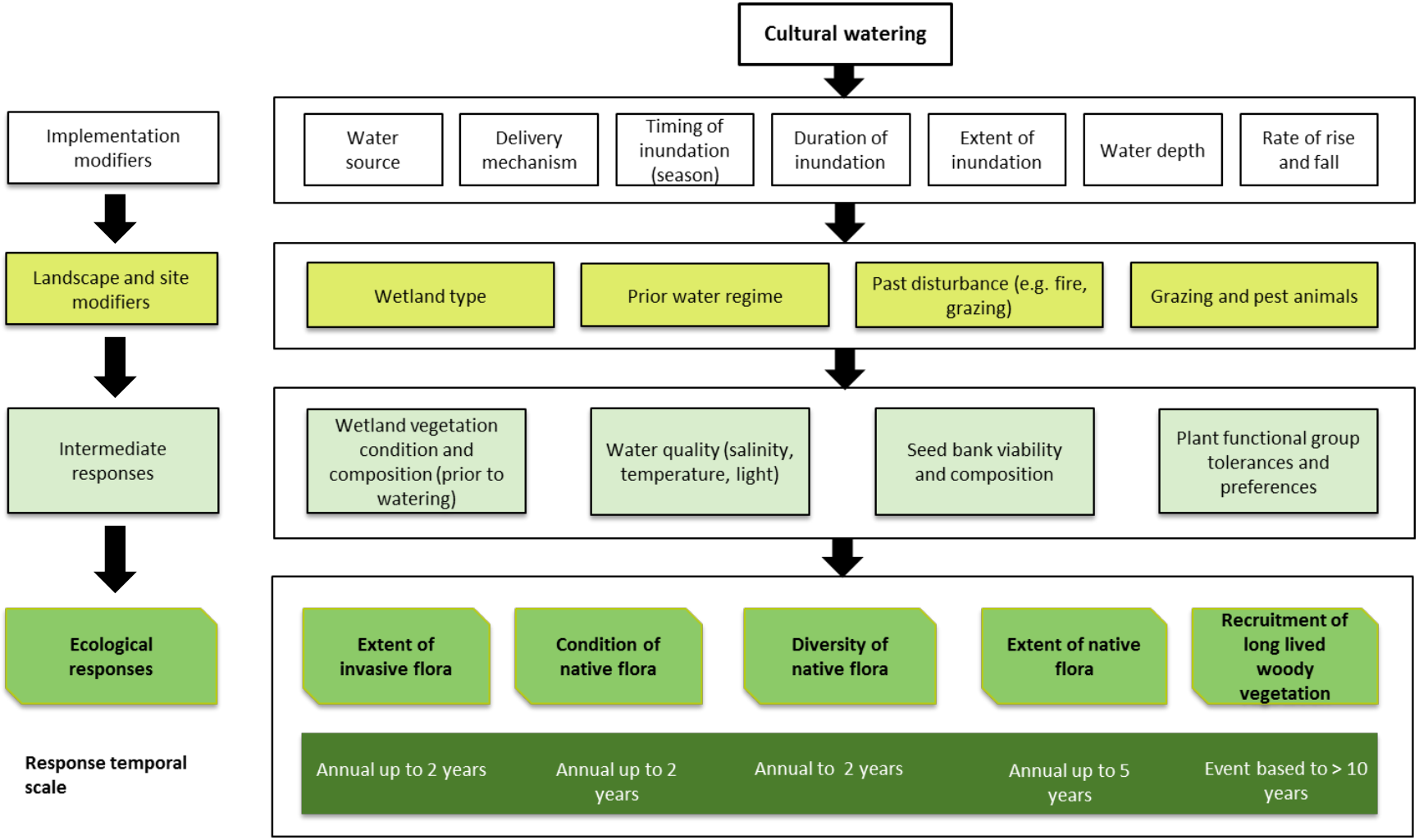

Figure 11: Conceptual model of vegetation ecological response to cultural watering (from Butcher and Hale 2016).

5.5 Waterbird theme

5.5.1 Conceptual approach

Ecological responses of waterbirds to watering such as that proposed for the trial flow has been summarised by Butcher and Hale (2016) (Figure 12) based on Brandis et al. (2009). The distribution, abundance, diversity and breeding by waterbirds are all influenced by elements of the implementation modifiers – the characteristics of the water. Landscape and site modifiers are particularly influential on the response of waterbirds to environmental water allocations, with availability of habitat in the region or past opportunities for breeding being important (Brandis et al. 2009).

5.5.2 Objectives and key evaluation questions

The governance objectives, key evaluation questions and indicators are summarised in Table 7. Details on the nominated indicators and appropriate sampling methods are provided in the following sections on sampling regime and sampling methods (below).

Table 7: Waterbird objectives, key evaluation questions and indicators

Flow objective	Key Evaluation Questions	Indicators
Increased frequency of migratory or colonial nesting waterbird breeding. Increased species richness of water birds. Increased abundance of water bird and associated shrubland species.	Did flows increase the frequency of breeding for migratory, colonial-nesting or icon species between 2016 and 2025, including: • White necked heron • Australian pelican • Black swan • Any JAMBA/CAMBA/ROKAMBA listed species? Did flows increase water bird species richness between 2016 and 2025? Did flows increase the abundance of water and associated shrubland bird species between 2016 and 2025: • Black swan • White-necked heron • Whistling Kite • Pacific black duck • Wood duck • Mountain duck • White ibis • Straw-necked ibis • Yellow rosella • White-winged fairy-wren	Breeding pairs of: • Black swan (*Cygnus atratus*) • White necked heron (*Ardea pacifica)* • Australian pelican (*Pelecanus conspicillatus*) • Any JAMBA/CAMBA/ROKAMBA listed species Waterbird species richness Waterbird species abundance, including that of: • Black swan • White-necked heron • Whistling Kite (*Haliastur sphenurus)* • Pacific black duck (*Anas superciliosa)* • Wood duck (*Chenonetta jubata*) • Mountain duck (*Tadorna tadornoides*) • White ibis (*Threskiornis moluccus*) • Straw-necked ibis (*Threskiornis spinicollis*) • Yellow rosella (*Platycercus elegans flaveolus),* • White-winged fairy-wren (*Malurus leucopterus),*

Flow objective	Key Evaluation Questions	Indicators
	• Red-capped robin	• Red-capped robin (*Petroica goodenovii)*

5.5.3 Waterbird sampling regime

Pre-flow monitoring data collected as part of this Project will be limited to a single sampling event in the lead up to the delivery of the flow event. However, any previously collected data will help inform the analysis of monitoring data collected.

Waterbird counts will be undertaken within each study cell (i.e. Cells 2, 3, 4 and 6) prior to flow delivery (September 2016), then monthly post-flood for three months after the flow delivery (i.e. beginning from mid-December 2016). This can be extended should there be waterbird breeding that is ongoing at the end of the three-month post-watering period.

5.5.4 Waterbird monitoring methods

Refer to Appendix 1 for detailed sampling methods.

Waterbird monitoring will be undertaken using a combination of photography using an unmanned aerial vehicle (UAV) and on-ground waterbird counts. The on-ground survey will adopt the existing methodology deployed at Toogimbie IPA that used timed counts at four stops along a meandering track, with 20 minutes spent at each stop to look for and count birds. This method can be altered to include counts of breeding colonies should these occur.

5.5.5 Assessment of outcomes

Assessment of the collected data will be based on before-after-control-impact comparisons of:

- The number of waterbird breeding pairs (total, and for each species);
- The species richness in each cell;
- The abundance of selected species.

Assessment will initially focus on the before-after comparison of breeding events, species richness and the abundance of selected species year immediately following the flow event, and on an annually basis thereafter.

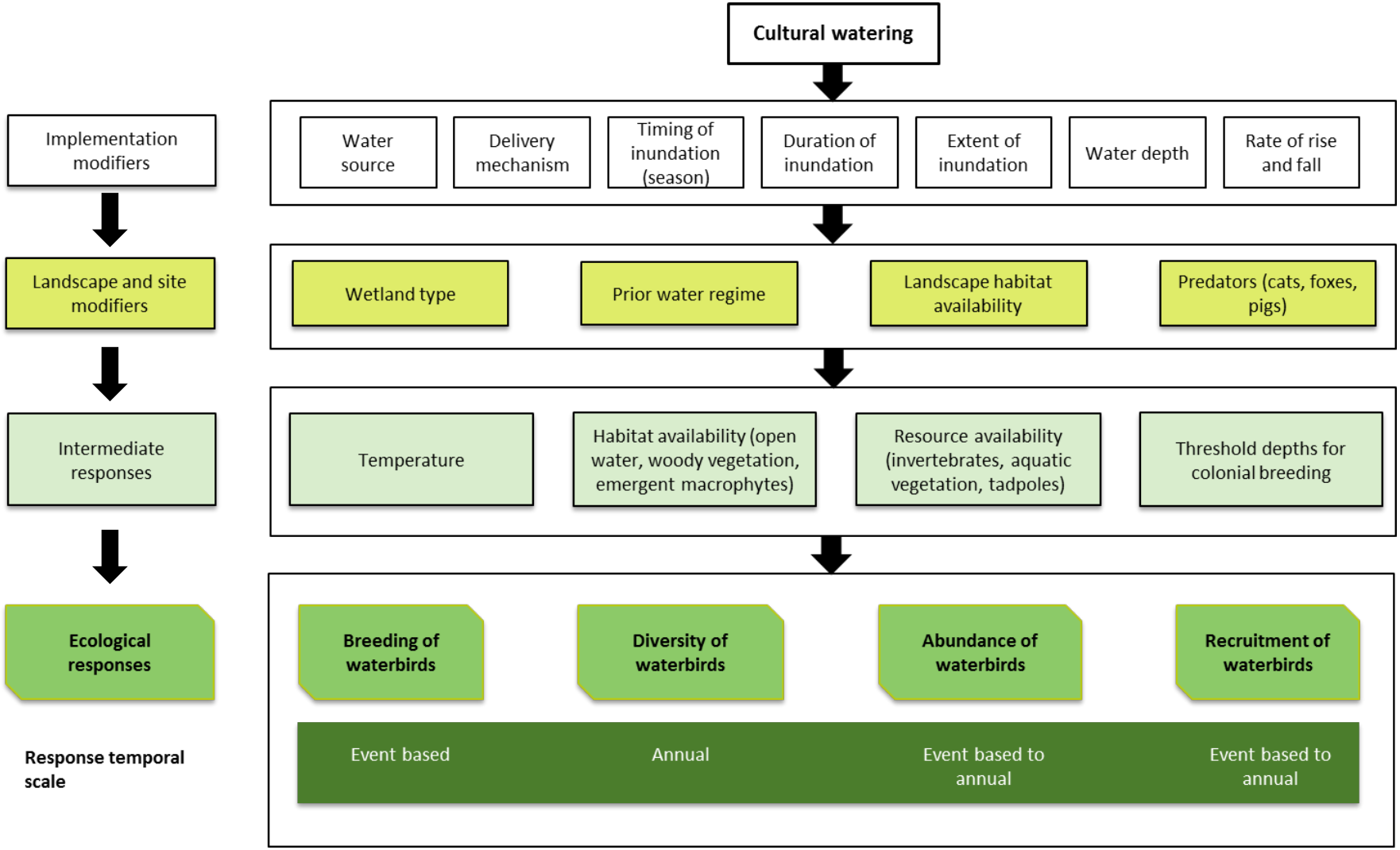

Figure 12. Ecological response conceptual model for the waterbird theme.

5.6 Frogs

5.6.1 Conceptual approach

Ecological responses of amphibians to flows has been summarised by DELWP (2016) (Figure 14). The distribution, abundance, diversity and breeding by frogs are all influenced by elements of the implementation modifiers – the characteristics of the flow event. Landscape and site modifiers are particularly influential on the response of frogs to water allocations.

5.6.2 Objectives and key evaluation questions

The frog objectives, key evaluation questions and indicators are summarised in Table 8. Details on the nominated indicators and appropriate sampling methods are provided in the following sections on sampling regime and sampling methods (below).

Table 8: Frog objectives, key evaluation questions and indicators

Flow objective	Key Evaluation Questions	Indicators
Increased frog species richness.	Did flow events increase frog species between 2016 and 2025?	Frog species richness.

5.6.3 Frog sampling regime

Pre-flow monitoring data collected as part of this Project will be limited to a single sampling event in the lead up to the delivery of the flow event. However, any previously collected data will help inform the analysis of monitoring data collected as the focus is on species richness.

Sampling frequency is to be one pre-watering sampling event (September 2016), followed by monthly sampling post-watering (i.e. beginning from mid-December 2016).

5.6.4 Frog monitoring methods

Refer to Appendix 1 for detailed sampling methods.

The method proposed by DELWP (2016) includes call detection and visual detection along 6 transects (i.e. two transect per site) in each of Cells 2 and 3, as well as at the control/comparison Cell 4. The detailed method is provided in Appendix 1 and summarised below.

Each transect should be 50 m long x 10 m wide, incorporating 5 m either side of the water line (Figure 13; note: a transect of 50 m long, rather than 30 m, is proposed as this is considered more representative, given the size of each cell at Toogimbie). The transects should be representative of microhabitats present and a minimum of 200 m apart as frog calls can be detected up to 200 m.

GPS location of each transect (start and end) should be recorded, along with weather conditions at the beginning of each diurnal and/or nocturnal survey period (see Appendix 1).

Call detection methods are applied in a hierarchy. The call detection and visual encounter survey for adults should be in the first three hours after sunset, and completed early the following morning if there is insufficient time in the evening. Call detection is undertaken by listening for calls as a static point call survey for 10 minutes

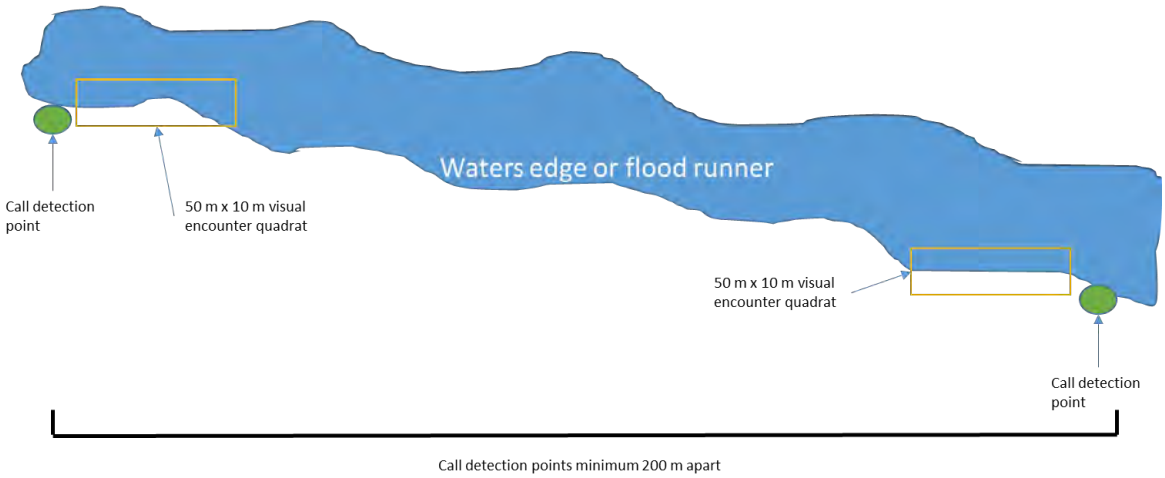

Figure 13: Schematic of call detection and visual encounter points at each wetland site (from DELWP 2016).

The visual encounter survey is undertaken after the call detection period at each transect. This involves walking the 50 m long transects for 15 minutes, searching 5 m upslope parallel to the water's edge, and into wetland for 5 m using a torch beam (Jansen and Healey 2003).

5.6.5 Sampling frequency

Sampling is to be intervention-based, so sampling should occur before and after the delivery of a flow event. Sampling is to occur 1 month before, then every month for 3 months after water delivery – total of four sampling events.

5.6.6 Timing of field sampling

Optimum conditions for call detection are after rain events or wetland filling, in early and late summer and late autumn (if predicted species are active in this period).

Call detection should be undertaken for at least 10 minutes at a time (i.e. per sample) during the first three hours after dusk (Tucker et. al. 2003).

5.6.7 Assessment of outcomes

Assessment of the collected data will be based on before-after-control-impact comparisons of frog species richness.

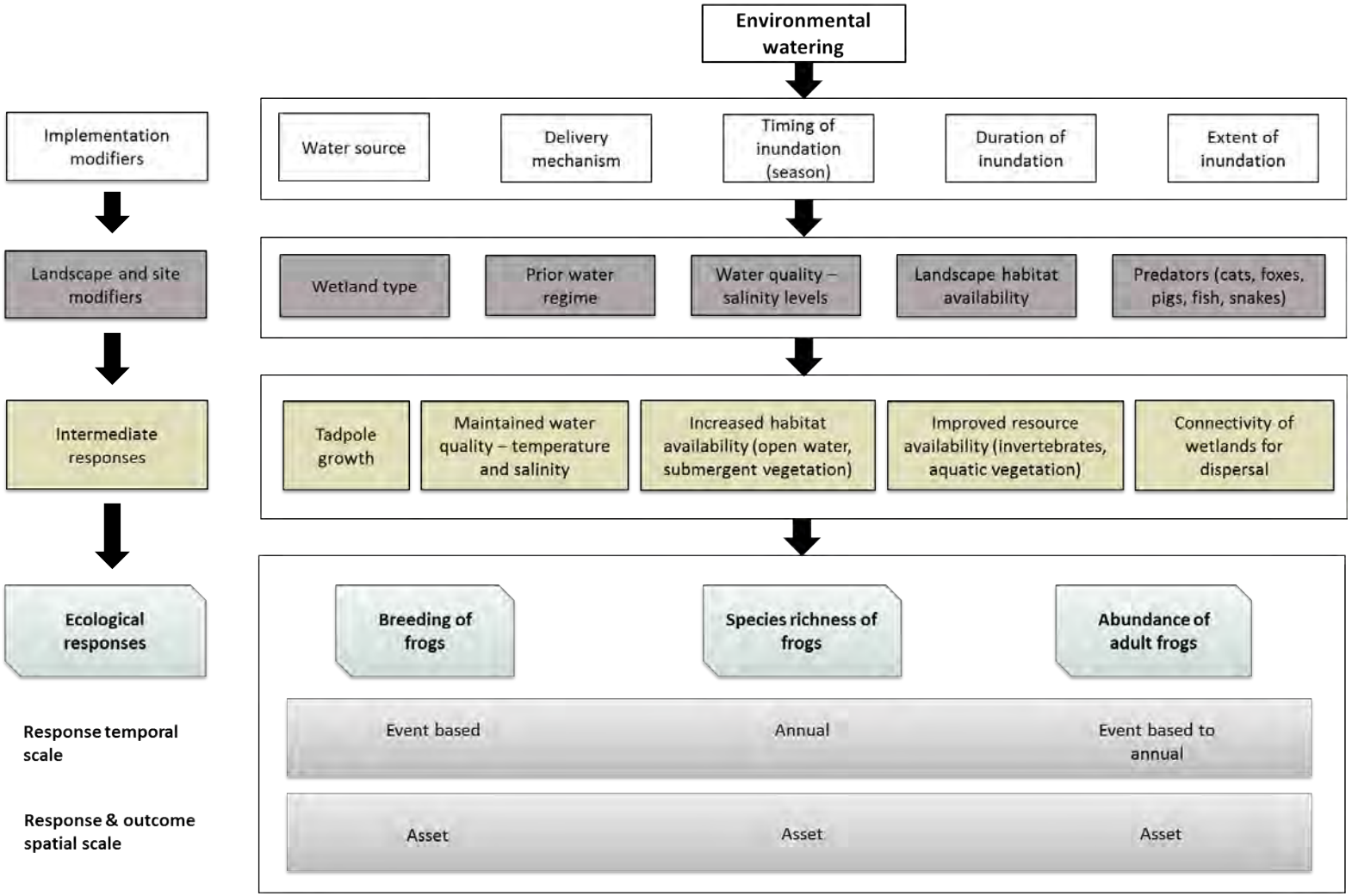

Figure 14: Conceptual model for the frog theme.

5.7 Wetland vegetation, waterbird and frog sampling sites

Wetland vegetation, waterbird and frog surveys are to be conducted at three sites within each of the Cells 2, 3, and 4 (Figure 15, Table 9). Two of the sites in each cell were established as part of previous studies at Toogimbie IPA (Smits 2014). An additional semi-random site was added to each cell; sites had to be relatively close to existing tracks for access and OH&S reasons. Three sites within Cell 6 will also be established for vegetation an waterbird survey once this cell has been established as a black swan rookery.

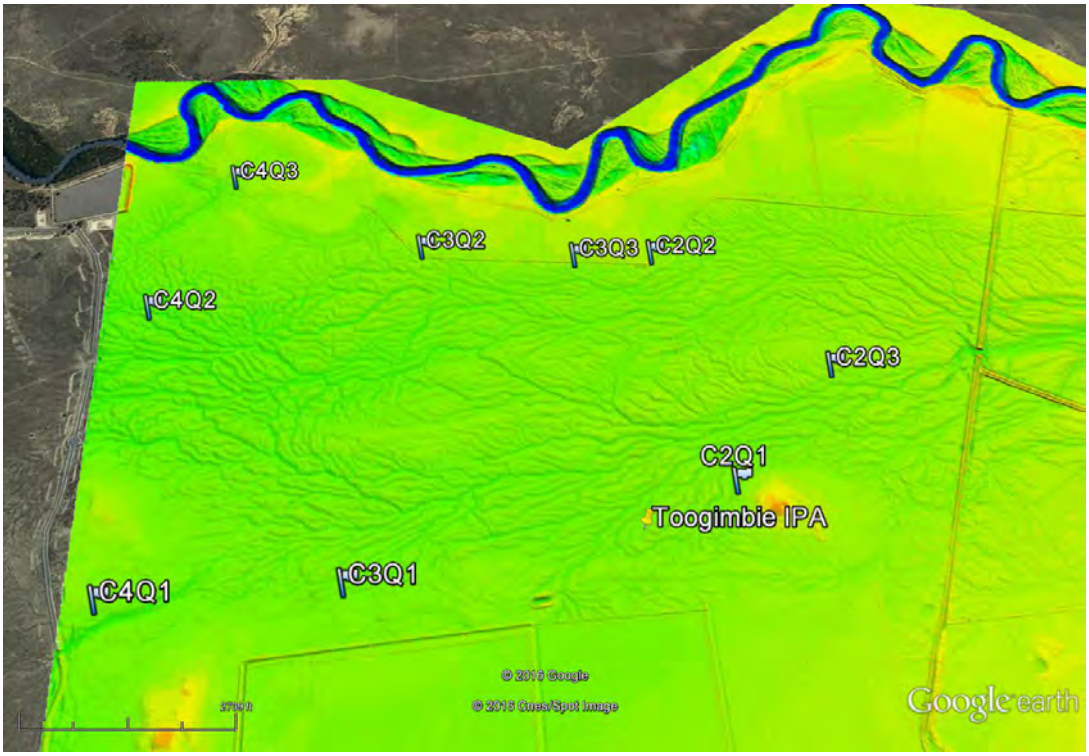

Figure 15: Map of survey sites across Toogimbie IPA

Table 9: Locality of survey sites across Toogimbie IPA

Site	Latitude	Longitude
Cell 2 Q1 (previous* Cell 2 South)	-34.562	144.472
Cell 2 Q2 (previous Cell 2 North)	-34.5499	144.466
Cell 2 Q3	-34.557	144.473
Cell 3 Q1 (previous Cell 3 South)	-34.5614	144.448
Cell 3 Q2 (previous Cell 3 North)	-34.5512	144.459
Cell 3 Q3	-34.5492	144.4624
Cell 4 Q1 (previous Cell 4 South)	-34.5604	144.437
Cell 4 Q2 (previous Cell 4 North)	-34.5476	144.44
Cell 4 Q3	-34.5413	144.4453

*'Previous' sites are those established as part of the study by Smits (2014).

5.8 Schedule of sampling events

The following scheduling of sampling events has been prepared as a guide, following the October 2016 floods at Toogimbie IPA.

Table 10: Proposed sampling schedule for the watering trial at Toogimbie.

Sampling theme	Dates
Anticipated end of flooding	31st October - 6th November 2016
Initial post-watering Waterbird and Frog sampling (conditions permitting)	14th – 16th December 2016
Initial post-watering Vegetation sampling (conditions permitting)	14th – 16th December 2016
Waterbird and Frog sampling	14th – 16th January 2017
Vegetation	30th January – 2nd February 2017
Waterbird and Frog sampling	14th – 16th February 2017
Vegetation sampling	14-16th March 2017

6 RISK ASSESSMENT AND MITIGATION

Risks associated with the delivery and management of water during the trial are summarised in Table 14, based on the ratings used in Table 11 to Table 13.

Table 11: Risk likelihood rating

Likelihood	Definition
Almost certain	Is expected to occur in most circumstances
Likely	Will probably occur in most circumstances
Possible	Could occur at some time
Unlikely	Not expected to occur
Rare	May occur in exceptional circumstances only

Table 12: Risk consequence rating

Risk	Definition
Critical	Major widespread loss of environmental amenity & progressive irrecoverable environmental damage
Major	Severe loss of environmental amenity and danger of continuing environmental damage
Moderate	Isolated but significant instances of environmental damage that might be reversed with intensive efforts
Minor	Minor instances of environmental damage that could be reversed
Insignificant	No environmental damage

Table 13: Risk analysis matrix

LIKELIHOOD	CONSEQUENCE				
	Insignificant	Minor	Moderate	Major	Critical
Almost certain	Low	Medium	High	Severe	Severe
Likely	Low	Medium	Medium	High	Severe
Possible	Low	Low	Medium	High	Severe
Unlikely	Low	Low	Low	Medium	High
Rare	Low	Low	Low	Medium	High

Table 14: Risk associated with water delivery at Toogimbie IPA

Risk type	Description	Likelihood	Consequence	Risk level	Controls
Acid sulphate soils	There is no evidence of acid sulphate soil issues along the Murrumbidgee River in the vicinity of Toogimbie IPA.	Rare	Moderate	Low	Maintenance of continuous flows should minimize this risk.
Salinity	Water along the lower Murrumbidgee River is of good quality and does not pose salinity risks.	Unlikely	Minor	Low	Salinity is monitored and additional Murrumbidgee River water could be called upon to reduce (dilute) saline water, if this was necessary (highly unlikely).
Invasive species	Carp breeding can occur, along with that of native fish. Noxious aquatic weeds such as Lippia and Alligator weed can occur in the Murrumbidgee River.	Unlikely	Moderate	Low	Carp - none practicable within the Murrumbidgee River. However, carp are unlikely to enter Toogimbie IPA in water pumped from the river. Carp breeding in response to flow pulses are more likely in winter, rather than in spring as proposed. Surveillance will be undertaken to detect the presence of aquatic weeds during pumping to the site. Pumping will cease and NSW OEH will be notified if any noxious plant species are detected. Any new infestations of noxious weeds will be treated on site using herbicides.
Poor water quality in runoff (e.g. low dissolved oxygen, increased nutrients)	Water delivery is planned for spring, a time where there is generally lower risk of black water events compared with watering in summer-autumn. Water delivered to the site will be contained and will not be returned to the river. The Nari Nari community has experience in managing water delivered to the site in an appropriate manner.	Unlikely	Moderate	Low	Diligence in managing water delivery and retention on site. Intervention to prevent water re-entering the Murrumbidgee River on standby, if required.

Risk type	Description	Likelihood	Consequence	Risk level	Controls
Water loss	To be confirmed by hydrological investigations during watering trial.	Possible	Minor	Low	Review losses along the Murrumbidgee River and also at the site. Allow for losses, if necessary, when estimating future allocations. Initial hydrological and bathymetry modelling suggests the watering trial will need far less than the 5 GL available.
Estimation of water availability and volumes required	Volumes associated with water delivery options depend on modelling. Modelling accuracy may result in underestimation of the volumes actually required. This increases the likelihood of shortfalls in actual volumes of water required to achieve objectives.	Possible	Moderate	Medium	Confirmation that volume(s) released achieve the desired hydrological and ecosystem outcomes.
Cold water releases from Lake Burrunjuck.	The release of colder bottom waters from Lake Burrunjuck mainly affects water temperature immediately downstream of the reservoir. Given the large distance, it is not expected to affect water temperature by the time it reaches Toogimbie IPA.	Low	Minor	Low	

7 KNOWLEDGE MANAGEMENT AND REPORTING

7.1 Watering trial reporting

Annual reporting will be undertaken to collate and assess the information and data collected as part of the flow delivery process. This will include, but is not limited to, the following:

- General and specific lessons learnt from the planning, delivery and monitoring of flows that will aid the future management of flow events.
- Whether governance and delivery arrangements were sufficient (was the water delivered as planned?).
- Whether the cultural outcomes expected in the timeframe occurred. If not, any obvious reasons for this will be reported, along with potential mitigation measures.
- Whether the desired environmental objectives expected to be met within the timeframe were met. If not, any obvious reasons for this will be reported, along with mitigation measures.
- Whether the delivery of future flows should be amended or refined to better align with the stated flow objectives.
- Whether the flow objectives require amendment to better align with the aspirations of the Nari Nari community.

7.2 Going forward

There are limited resources available to undertake monitoring as part of this trial, and no resources currently in place to continue monitoring in the future. This severely limits the monitoring and evaluation that can be undertaken, particularly as the cultural and environmental outcomes expected with water delivery at the site may not fully materialize for months, years or even decades.

7.2.1 Other opportunities

The following section provides examples of other local and/or regional opportunities that might arise in partnership with other organisations.

- Links to the NSW vegetation mapping exercise – can collect data in the same format and QA/QC so field results can be used for validation of vegetation mapping using remote sensing.
- Links to the CEWO LTIM project;
- Murray Darling Basin Authority;
- Local Land Services/Catchment Management Authority/NRM;
- New England University/ TAFE NSW Riverina Institute?
- Private investors;
- NSW Office for Environment and Heritage;
- Murray Darling Wetlands Working Group
- The Nature Conservancy.

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9 APPENDIX 1: VEGETATION, WATERBIRD AND FROG METHODS

9.1 Vegetation methods

The standard method is that proposed by OEH (2015), which was also applied to on-ground validation of vegetation mapping undertaken by Eco Logical (2015).

Note: the vegetation sampling at Toogimbie IPA focuses on the lignum vegetation assemblages (non-woody semi-permanent vegetation and woody low shrub lands) in each of the Cells. Methods for assessing Non-woody submerged and floating aquatic vegetation, and for Tree health have been included should these be required at Toogimbie IPA in the future.

9.1.1 Non-woody submerged and floating aquatic and fringing or dense wetland vegetation (e.g. reeds, club-rush, lignum)

Transect method (Point intercept method)
One 50 metre transect is placed from fringing edge into water to depth where vegetation no longer occurs or 1.5 metres depth is reached. Photos are taken at each end of the transect.

1. At each 100 centimetre point the species directly below or and/or touching the tape are recorded.
2. Maximum and minimum height of each species is recorded
3. Reproductive status is recorded.
4. Dead plants are recorded.
5. Water depth

Three transects per 500 ha of wetland are the minimum.

9.1.2 Non-woody semi-permanent vegetation and woody low shrub lands - floristic structure, species composition

Quadrats

For non-tree dominated vegetation communities (i.e. non-woody wetlands without standing water bodies and flood dependent open shrub lands).

1. At each survey location (per wetland) 3 replicate plots of 0.04 hectares are used within each vegetation community. The dimensions of each sample plot are usually 20x20 metres but 40x10 metres can be used in narrow sites (e.g. riverine corridors).
2. The NE corner is marked (permanently if possible) and a GPS point taken.
3. Plot is oriented north/south (i.e. tape is run 20 metres S and 20 metres W, then 20 metres N starting from the NE corner). Alternate orientation is allowable but must be recorded.
4. Corners should be marked (temporarily) with sighting flags. Four site photographs are taken; 1. from the NW corner looking SE, 2, mid-point of N boundary looking S, 3. NE corner looking SW and 4. midpoint of S boundary looking N.

Vegetation diversity and structure
Recorded for all vascular species and recorded separately for each structural component of the vegetation (tallest stratum (over storey), mid-stratum (>1 metre) and lower (<1 metre, = ground stratum)). Any species not able to be identified in the field is tagged, given a code, recorded and collected for identification.

1. **Species cover** is recorded as **Foliage Cover**12 (FC) and is the percentage of the sample plot occupied by the vertical projection of *foliage and branches* (if woody). It is recorded for each species in each stratum in which it occurs.
2. **Crown Extent** (CE) and **Canopy openness** (CO) is collected for all tree species in the tallest stratum in treed communities to allow the calculation of FC for the plot for each species (See section on *Tree canopy health* below).
3. **Per cent Litter** is the percentage of the sample plot occupied by litter (nonattached plant matter e.g. leaves and branches less than 10 cm diameter) and is recorded as the sum of submerged and non-submerged litter in flooded plots. Note: where plants are dry or dead but can still be identified to species and are attached to the base of the plant, their cover is included in the species cover not in per cent litter.
4. **Per cent Bare ground** is the percentage of the sample plot occupied by bare earth and is recorded as the sum of submerged and non-submerged bare ground in flooded plots.
    a. Note: FC for species in the lower (ground) stratum (>1 m) + % litter + %bare ground must = 100% in total, unless lower stratum (ground layer) space is occupied by mid storey emergent tussock form graminoid or spreading shrub species >1m tall (e.g. Lignum, rushes or reeds).
    b. If ground stratum (<1 m) space is occupied by emergent mid storey species then the FC lower (ground) stratum (>1 m) + % litter + %bare ground = 100% - total FC of these mid stratum species.
    c. In flooded sites total FC lower (ground) stratum includes; submerged vegetation, submerged bare ground and submerged litter.
5. **Species Abundance** (Number of individuals = actual count or estimated number from sub quadrats for superabundant species) in each stratum in which it occurs.
6. **Upper height** (average) of each species is recorded (in metres) in the upper height field.
7. **Lower height** (average) of each species is recorded (in metres) in the lower height field.
8. **Strata type** (T=tallest, M=mid (>1m), L = lower (<1 m) is recorded in the Strata Type field.
9. **Functional Group** (sensu Brock and Casanova 1997; Casanova and Brock 2000; Casanova 2011) is the category of water dependency of a species and is generated automatically from species name during data analysis from master list.
10. **Linear length of fallen timber at site** – the total length of fallen timber of diameter >10 cm is recorded.

Floristic data are entered on field data sheets or into the site specific Site Floristics entry screen on a handheld tablet / PC in Microsoft Excel or other suitable database software or paper datasheet.

Transects

The vegetation transect method deployed by Smits (2014) is to be repeated at three sites within each cell. This includes the two sites established previously by Smits (2014), as well as an additional site randomly selected but within a safe distance (for OHS reasons) from perimeter access tracks.

A 100 metre transect at each site is established using measuring tapes starting from and aligned with the established photo-points. The vegetation type present at every metre along the transect is to be recorded:

Native plants

- Perennial grasses
- Lignum <0.5 m
- Lignum >0.5 m
- Rushes
- Shrubs <2 m
- Nardoo/Old man weed/Potamageton (pond weed)
- Forbes

Exotic

- Perennial grasses
- Shrubs <2 m
- Forbes

Open water/bare ground

- Water
  - Wet soil
  - shallow (<0.5 metres)
  - deep (>0.5 metres)
- Ground
  - Bare
  - Organic matter (thin)
  - Organic matter (thick)
  - Rock.

Data are entered on field data sheets or into a handheld tablet/PC in Microsoft Excel or other suitable database software or paper datasheet.

9.1.3 Over storey tree health

For vegetation communities dominated by flood dependent trees in the over storey (Rriver red gum, Black box or Coolibah).

A 0.1 ha (20x50 metre) survey plot is used. This an extension of the 20x20 metre plot created by extending the eastern and western boundaries by 30 m thus creating a nested 0.04 ha plot within the 0.1 ha survey plot.

The orientation of the plot can be altered to suit the site however the orientation of the plot must be noted in the notes column of the data entry form if other than south.

An alternative approach would be to measure the condition of 30 to 50 trees across the study area. This could target assessment on a range of size classes/cohorts and culturally significant trees.

Understorey floristics (Vegetation community condition)

Floristic data is collected from the 0.04 hectare subplot as described above.

Tree size, canopy health and population demographics

For trees >10 cm diameter at breast height (dbh) tree health data and tree size data is collected from the entire 0.1 ha plot. Tree canopy health methods are comparable to those used in the Living Murray (TLM), Tree and Stand condition method of Cunningham et al (2009).

Tree size classes

Each tree within the 0.1 ha plot of dbh, greater than 10 cm (live or dead[4]), is numbered starting from the tree closest to the NE corner of the 0.04 ha plot.

1. Each live tree is tagged for future relocation (e.g. numbered aluminium tag and galvanized nails).

Note. All trees are recorded as being located within the 0.04 ha or within the remainder of the 0.1 ha subplots on the datasheet to allow calculation of values for %CC and %FC for species in the tallest stratum of the 0.04 ha floristic plot.

2. Data is recorded on the Tree health entry screen or paper datasheet.
3. The height (m) of all over storey trees (live or dead) is estimated and recorded.
4. Diameter at breast height (dbh) (in centimetres) of all over storey trees (recorded as live or dead) over 10 cm dbh is recorded (cm using a dbh tape).
5. For young trees (trees 5-10 cm dbh), a record of the total number of (live and dead) in this size class is recorded separately for the 0.04 ha and remainder of the 0.1 ha plot.

Size classes and number of live and dead trees is recorded on the Tree demographics data entry screen or paper datasheet.

Tree canopy health

The following metrics are used assess the size and canopy health of each numbered tree (live or dead[5]):

1. **Canopy Extent - CE $_{(tree)}$.** This is the 2 dimensional lateral spread (length x width) of the branches and foliage of a live tree, or the limbs of a dead tree, measured from the edge to edge of the remaining bare limbs or branches.

Note: CE is used to derive Canopy Cover (CC $_{(plot)}$) for the plot[6] (live trees only) and size distribution classes of trees within population at site (all trees).

[4] Dead trees only numbered for counting and demographic analysis purposes at first monitoring sample point.

[5] Dead trees are only assessed for size class analysis at time of first monitoring.

[6] Required for OEH Type Standard method (Sivertsen 2009)

2. **Canopy openness - CO $_{(tree)}$:** estimated as the percentage of the sky that is obscured by the canopy (leaves and small branches).

3. **Percentage Dead Canopy - DC $_{(tree)}$:** is the percentage of the tree canopy CE $_{(tree)}$ that is dead or severely damaged.

For example, a large dead tree with dead spreading branches measuring 10 m x 10 m and no existing foliage would have a remnant CE of 100 m^2 but would have CO = 0% and DC = 100%. A large live tree with dimensions of 10 m x 10 m would have CE of 100 m^2, but would have a DC < 100% and a CO > 0%).

4. **Epicormic growth: yes /no** Y/N is recorded for each numbered tree.

5. **Ratio of dead to live limbs - DLL** $_{(tree)}$: the number of dead major limbs as a ratio of the total number is recorded. Major limbs are limbs arising from the main trunk or from multiple stems but not branches. For example: a tree with 4 major limbs and one dead, DLL = 1 of 4.

Statistics are derive as outlined in OEH (2015).

9.1.4 Lignum condition assessment

Lignum condition is to be assessed according to the Lignum condition index proposed by Scholz et al. (2007), which is based on viability (growth) and colour (photosynthetic response) scores (Table Table 14). Thirty plants are to be assessed at or in the vicinity of each of the quadrats established for floristic survey. Sampling is to occur prior to the delivery of the flow event, then on a 6-weekly basis until the following March. Assessment is then to be repeated annually (January-February) until the next flow event.

Table 15: Lignum condition index (from Scholz et al. 2007)

Viability		Colour	
Score	%Viability	Score	Colour of viable crown
6	>95%	6	All green
5	>75% to 95%	5	All green
4	>50% to<75%	4	Mainly green
3	>25% to 50%	3	Half green, half yellow/brown
2	>5% to 25%	2	All yellow/brown
1	>0% to 5%	1	Mainly yellow/brown
0	0%	0	No viable stems

9.2 Waterbird methods

The expansive, flat terrain of Toogimbie IPA makes means that a combination of methods will be required to characterise waterbird abundance, species richness and breeding. Aerial surveillance using an unmanned aerial vehicle (UAV or drone) will be used to complement on-ground counts at both random and permanent sites in each of the cells included in the study.

9.2.1 Unmanned Aerial Vehicles (UAVs or drones)

This method is adapted from that proposed by Butcher et al. (2016) for the Victorian WETMAP program.

The method involves flying an UAV over selected areas and capturing several camera photographs during the flight. Unaltered images will then be merged (e.g. in Adobe Photoshop) to generate a composite photo of the area of interest (e.g. watered area, entire breeding colony). A grid cell can then be overlaid the composite photo and systematic counts undertaken (i.e. grid cell by grid cell). Counts undertaken using a UAV are considered to result in higher numbers and lower variance compared with traditional ground counts (Hodgson et al. 2016) as nadir (downward-facing) perspective of UAV imagery reduces the likelihood of missed counts during ground surveys due to topography and other obstructions to the counter's line of sight. UAVs also have the capacity to survey populations and places that are difficult to reach.

UAVs often fly at low altitudes, so they are directly affected by the weather. The best weather for drone flying is when it is sunny, a reasonable temperature (e.g. >20°C), and little to no wind. Accurate information about such phenomena as precipitation, cloud height and depth, and humidity can help pilots make decisions about route planning and alterations, as well as fuel management.

Survey frequency is to be monthly following the delivery of the flow event until breeding is complete. Additional observation and sampling events (e.g. every two weeks) are recommended should waterbird breeding events occur.

Information recorded during the flight

Information recorded during the aerial flights will include:

- Location of the colony as a circumscribed polygon on maps/aerial photographs and geo-referenced;
- Species composition, particularly of the colonies;
- Number of active nests, estimated if > 150 nests or total count made if < 150 nests;
- Different breeding stages of nests and an estimate of the proportion in different stages where this can be determined, including:
    - adult birds building platform nests;
    - eggs present in nests;
    - early-stage nestlings present (< two weeks old);
    - late stage-nestlings present (2-5 weeks); or
    - near-fledglings present.
- The number of nests in each vegetation type where this can be determined, such as:
    - River Red Gum;
    - Black Box;

  - Lignum;
  - Emergent aquatic vegetation (e.g. Common Reed *Phragmites* sp., Cumbungi *Typha* spp.);
  - Aquatic sedges/ grasses; and
  - Dead trees.
- The numbers of all other waterbird species detected and any breeding activity; and
- The proportion of the wetland surveyed.

9.2.2 On-ground counts

A bird monitoring method has already been established at Toogimbie IPA (Smits 2014) and applied to the home wetland; this will be continued as part of the trial. The existing monitoring includes timed counts at four stops along a meandering 200 metre path, with 20 minutes spent at each stop to look for and count birds. This method can be altered to include counts of breeding colonies should these occur. The results from on-ground counts can then be compared with those from the UAV counts to establish total counts (abundance, species richness, nests) for each cell.

Bird counts should be for each of the species of significance to the Nari Nari (Table 7), as well as the categories of 'woodland species' and 'raptors'.

9.3 Frog methods

9.3.1 Method

Six frog call listening positions and visual observation transects are to be established at each wetland, with two listening positions and two visual transects established at each site within each wetland. Each transect should be 50 m long x 10 m wide, incorporating 5 m either side of the water line. If the wetland is dry the midline of the transect should be from the high-water mark of any local drainage features.

The transects should be representative of microhabitats present. Transects should be a minimum of 200 m apart as frog calls can be detected up to 200 m.

Record either GPS location of each transect (start and end) or if whole of wetland assessed. Record weather conditions at the beginning of each diurnal and/or nocturnal survey period, including (Heard et al. 2006):

- Dry-bulb air temperature (to the nearest °C) and
- Relative humidity (to the nearest five percentage points) if available from nearby Bureau of Meteorology stations.

Record weather conditions at the beginning and end of each nocturnal survey period, including (Heard et al. 2006):

- Dry-bulb air temperature (to the nearest °C) and
- Relative humidity (to the nearest five percentage points) using a whirling psychrometer,
- Cloud cover (0–10),
- Rain intensity during survey (0–3),
- Rain intensity during previous 48 hours (nearest BoM station), and
- Wind velocity (Beaufort scale).

Call detection methods are applied in a hierarchy. The call detection and visual encounter survey for adults should be in the first three hours after sunset, and early in the following morning if required to sampling for each cell.

Call detection is undertaken by listening for calls as a static point call survey for 10 minutes. At the beginning of each visual encounter transect survey undertake a 10-minute call detection survey recording number of species heard.

Use count-estimate categories if the number of frogs calling exceeds 10, because of the difficulty in accurately estimating large numbers of calling frogs at a site (McGinness et al. 2014). Categories of 5 are used between 10 and 30 (i.e. 15, 20, 25 and 30), followed by categories of 10 between 30 and 100, and categories of 100 from 100 and higher.

After the 10-minute call detection period, undertake the visual encounter survey at the first transect. Walk the 50 m long x 10 m wide transect for 15 minutes, searching 5 m upslope parallel to the water's edge, and into wetland for 5 m using a torch beam (Jansen and Healey 2003).

Repeat until all transects are completed.

Check field sheets are correctly filled in before leaving the site. Estimate time for sampling to be in the order of two-three hours per wetland cell for the call detection and visual encounter survey sampling.

9.3.2 Site establishment – monitoring locations

Using available mapping and local knowledge, establish six random transects each 50 m long by 10 m wide at the watering and control/comparison cells.

Transects should be spaced at least 200 m apart (frog calls can be heard up to 200m away) (Figure 13, see Chapter 5). This may mean fewer listening and transect localities for the House wetland (TBC).

9.3.3 Sampling frequency

Sampling is to be intervention based therefore a before sample should be collected before and after the delivery of environmental water.

If watered every year, samples are to be collected 1 month before, then every month for 3 months after water delivery – total of 4 sampling events.

9.3.4 Timing of field sampling

Optimum conditions for call detection: Survey after rain events or wetland filling, in early and late summer and late autumn (if predicted species are active in this period).

Call detection should be undertaken for at least 10 minutes at a time (i.e. per sample) during the first three hours after dusk (Tucker et. al. 2003).

Diurnal surveys to be completed the next morning following nocturnal surveys, and completed by mid-morning.

10 APPENDIX 2: OPERATIONAL MONITORING REPORT

Commonwealth Environmental Watering Program Operational Monitoring Report Please provide the completed form to <insert name and email address>, Environmental Water Delivery Section, DEWHA within two weeks of completion of water delivery or, if water delivery lasts longer than 2 months, also supply intermediate reports at monthly intervals. Final Operational Report Intermediate Operational Report Reporting Period: From To		
Site name	<EWDS to prefill>	Date
Location	GPS Coordinates or Map Reference for site (if not previously provided)	
Contact Name	Contact details for first point of contact for this watering event	
Event details	Watering Objective(s) <EWDS to prefill>	
	Total volume of water allocated for the watering event CEWH: Other(please specify) :	
	Total volume of water delivered in watering event CEWH: Other (please specify):	Delivery measurement Delivery mechanism: Method of measurement: Measurement location:
	Delivery start date (and end date if final report) of watering event	
	Please provide details of any complementary works	
	If a deviation has occurred between agreed and actual delivery volumes or delivery arrangements, please provide detail	
	Maximum area inundated (ha) (if final report)	

	Estimated duration of inundation (if known)[7]
Risk management	Please describe the measure(s) that were undertaken to mitigate identified risks for the watering event (eg. water quality, alien species); please attach any relevant monitoring data. Have any risks eventuated? Did any risk issue(s) arise that had not been identified prior to delivery? Have any additional management steps been taken?
Other Issues	Have any other significant issues been encountered during delivery?
Initial Observations	Please describe and provide details of any species of conservation significance (state or Commonwealth listed threatened species, or listed migratory species) observed at the site during the watering event?
	Please describe and provide details of any breeding of frogs, birds or other prominent species observed at the site during the watering event?
	Please describe and provide details of any observable responses in vegetation, such as improved vigour or significant new growth, following the watering event?
	Any other observations?
Photographs	Please attach photographs of the site prior, during and after delivery[8]

[7] Please provide the actual duration (or a more accurate estimation) at a later date (e.g. when intervention monitoring reports are supplied).
[8] For internal use. Permission will be sought before any public use.