Amendment date: 28 June 2017

	Title of measure	**Gunbower National Park Environmental Works Project**
	Proponent undertaking the measure	**Victoria**
	Type of measure	**Supply**
1.	**Confirmation**	
	Date by which the measure entered into or will enter into operation *Must be before 30 June 2024*	This environmental works project will be operational by 30 June 2024.
	Confirmation that the measure is not an 'anticipated measure' *'Anticipated measure' is defined in section 7.02 of the Basin Plan to mean 'a measure that is part of the benchmark conditions of development'.*	Yes.
	Confirmation that the proponent state(s) undertaking the measure agree(s) with the notification ***Basin Plan 7.12(3)(c)*** *Joint proposals will need the agreement of all proponents*	Yes.
2.	**Details of the measure**	
	Capacity of the measure to operate as a supply measure *'Supply measure' is defined in section 7.03 of the Basin Plan to mean 'a measure that operates to increase the quantity of water available to be taken in a set of surface water SDL resource units compared with the quantity available under the benchmark conditions of development'.*	Yes.
3.	**Description of the works or measure**	
	The project has been developed to enable the delivery of environmental water to the wetlands and forest of the Gunbower National Park. It will mimic a natural flood event of up to 50,000 ML/day across 500 hectares. This includes almost half of the permanent and temporary wetlands in the project area and 20% (250 hectares) of the River Red Gum with flood dependent understorey. The package of works including a new irrigation weir, regulator and channel enhancements will enable the provision of water to approximately 500 hectares of Gunbower National Park, currently unable to be watered by any other infrastructure. A detailed description of the proposed works package is included in Chapters 2.3 and 11 of the business case **(Attachment A)**.	
4.	**Geographical location of the measure**	
	The Gunbower National Park is located on the mid-Murray floodplain in northern Victoria. It sits within the broader Gunbower Forest, an internationally recognised wetland system in the Murray-Darling Basin. The forest forms part of the Gunbower-Koondrook-Perricoota Forest icon site under The Living Murray Initiative, together with the Koondrook-Perricoota Forest in New South Wales.	
5.	**Representation of the project in the MDBA modelling framework**	
	The MDBA has represented the proposed infrastructure, operating strategies and water use in the MSM-BigMod model. Spatial data provided by the proponent (derived using a hydro-dynamic model) describes the areas inundated through the operating of the works. The areas inundated are combined with the timing of modelled operation by the Environmental Outcomes Scoring Tool to quantify the change in environmental outcomes, relative to the Benchmark environmental outcomes.	

6.	**Representation of each operating strategy in the MDBA modelling framework.**
	Refer to chapter 9 of the business case **(Attachment A)** Additional information on modelling the proposal can be found in **Attachment B.**
7.	**Spatial data describing the inundation extent associated with the operation of the measure**
	Provided to MDBA.
8.	**Surface water SDL resource units affected by the measure**
	This measure identifies all surface water resource units in the Southern Basin region as affected units for the purposes of notifying supplying measures. The identification of affected units does not constitute an agreement between jurisdictions on apportioning the supply contribution, which will be required in coming months.
9.	**Details of relevant constraint measures**
	Not directly linked to any specific constraint measures but implementing a confirmed package of constraint measures may have implications for the proposed operating strategy.

Attachments:

A	North Central CMA, December 2014	Phase 2 Assessment Supply Measure Business Case: Gunbower National Park Environmental Works Project
B		Amendment 1 - Gunbower National Park Floodplain Management Project

Gunbower National Park Environmental Works Project

SUSTAINABLE DIVERSION LIMIT ADJUSTMENT

Phase 2 Assessment

Supply Measure Business Case

2014

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

State Government Victoria
Department of Environment and Primary Industries

Acknowledgement of Country

The North Central Catchment Management Authority acknowledges Aboriginal Traditional Owners within the region, their rich culture and spiritual connection to Country. We also recognise and acknowledge the contribution and interest of Aboriginal people and organisations in land and natural resource management.

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The North Central Catchment Management Authority wishes to acknowledge the Commonwealth Government for providing funding for this publication through the Victorian Department of Environment and Primary Industries.

Foreword

Gunbower National Park covers approximately forty-six percent of the Gunbower Forest and is part of the Gunbower-Koondrook-Perricoota Forest icon site under The Living Murray Initiative. The forest, which is listed as a wetland of international importance under the Ramsar Convention, features a number of creeks, permanent and temporary wetlands, Black Box and Grey Box woodlands and River Red Gum forest. The forest is recognised as important due to the genetic and ecological diversity it sustains and its role in supporting large numbers of waterbirds during flood events.

The *Gunbower National Park Environmental Works Project* (the Project), described in detail in this document, is a proposed supply measure designed to off-set water recovery under the Murray-Darling Basin Plan by achieving equivalent or better environmental outcomes on the ground. Current river operations have reduced the frequency of flooding from seven years in ten under natural conditions to four years in ten at present. Following extensive investigations to align ecology, hydrology and engineering, the project will fill the current hydrological gap via a package of works that will easily integrate with river and irrigation operations.

The Project will deliver on ecological outcomes for the national park while generating water savings in the Murray-Darling Basin.

A feasibility study into the proposed project was approved on 11 December 2013 and developed into this detailed business case over a 12-month period. The Project is now sufficiently advanced that subject to funding in the order of $12.8 million, pre-construction approvals will occur in 2015 with construction ready to commence in 2016.

The upper Gunbower Forest is located in the Goulburn Murray Water-managed Torrumbarry Irrigation Area, downstream of the Torrumbarry Weir. The local community has a strong understanding of the benefits of achieving water-efficient environmental outcomes through environmental watering infrastructure. Consultation through community events and one-on-one discussions has been positive with the local community and landholders adjacent to the project area supportive of the initiative.

The North Central CMA and its partners have established a strong track record in delivering environmental watering projects as demonstrated through the recent commissioning of large-scale infrastructure for watering the mid- and lower sections of Gunbower Forest, funded though The Living Murray program. This recent construction experience by the partners positions the region well to deliver on the stakeholder engagement, approvals, construction, commissioning and operation of the proposed new infrastructure.

On behalf of the North Central CMA and our project partners, we commend this Business Case to you and emphasise that the region stands ready to proceed to the construction phase of the Project subject to funding.

David Clark
Chairman

Damian Wells
Chief Executive Officer

Document History and Status

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Executive Summary

The *Gunbower National Park Environmental Works Project* (the Project) is an environmental water infrastructure proposal that will contribute to achieving the 'Sustainable Diversion Limit (SDL) Off-set' element of the Murray-Darling Basin Plan (Basin Plan). The Project is a 'supply measure', designed to off-set the Basin Plan's water recovery target of 2,750 gigalitres (GL) by achieving equivalent or better environmental outcomes on the ground. The Project is one of nine proposed infrastructure based supply measures being investigated within Victoria, and one of two within the North Central CMA region.

The Gunbower National Park business base (the Business Case) sets out the ecological objectives, proposed infrastructure package, operating strategies, ecological risks and benefits and the costs associated with progressing the Project, from construction through to operation. It has been developed in partnership with the Department of Environment and Primary Industries (DEPI), Parks Victoria and Goulburn Murray Water (GMW). The following provides an overview of the business case and main conclusions.

Significance of the site

Gunbower National Park (8,892 hectares) is located within the broader Gunbower Forest, on the mid-Murray floodplain of northern Victoria. It is recognised as internationally significant under the *Ramsar Convention* and as an 'Icon Site' under The Living Murray (TLM) Initiative; one of six environmental assets of the River Murray that have the highest priority for rehabilitation through water management.

In 2010 the Victorian Government created the Gunbower National Park in recognition of the importance of the upper part of Gunbower Forest and its need for greater protection. This part of the forest features permanent wetlands, temporary wetlands, River Red Gum (*Eucalyptus camaldulensis*) forest and Black Box (*E. largiflorens*) and Grey Box (*E. microcarpa*) woodlands. The area also supports a range of communities and species - many of which are listed as rare or threatened under state and national legislation (e.g. Australasian Bittern (*Botaurus poiciloptilus*)). For its traditional owners, the Yorta Yorta people, Gunbower Forest is a significant cultural landscape. Scarred trees, earthen mounds, artefact scatters, shell middens and burial sites are present. In addition, the local community highly value the forest for the social and recreational values it supports.

Vision and objectives

The overall vision for Gunbower Forest is to:

Maintain and improve Gunbower Island by enabling native plants and animals to flourish, restoring the floodplain's health for future generations.

The goal for water management in the Gunbower National Park is to:

To reinstate a more natural water regime that protects and enhances the ecological values within the Gunbower National Park and, where possible, supports values in downstream areas of Gunbower Forest.

A suite of ecological objectives and targets was developed for Gunbower National Park and represent the desired ecological outcomes of enhanced flooding. The primary ecological objectives and targets are for: healthy River Red Gum flood dependent understorey and associated temporary wetlands; drought refuge habitat for fauna (particularly small-bodied native fish) in Black Charlie Lagoon; and a healthy wetland bird community through improved access to food and habitat that promote breeding and recruitment.

Proposed supply measure

Gunbower National Park relies on frequent flooding to maintain the health and diversity of habitats, and flora and fauna. The extent and duration of flooding within Gunbower Forest is determined by the height of the River Murray below the Torrumbarry Weir. Inflows commence when flows in the River Murray exceed 17,000 ML/day and increase substantially at flows greater than 30,000 ML/day. As the upper forest is higher on the floodplain, higher flows than those required for the mid to lower regions are required to inundate the Project area.

Regulation of the River Murray has significantly decreased the frequency and duration of inflows to Gunbower Forest:

- At 35,000 ML/day, frequency has almost halved to 37% of years compared to 80% of years under natural conditions.
- At 40,000 ML/day the median duration of events has halved (e.g. the median duration of 45,000 ML/day flows have reduced from 2.2 months under natural conditions to just one month at present).

The deficit in the flooding regime of the Gunbower National Park has had measurable impacts on the flood dependent communities in the upper forest. Terrestrialisation of the wetlands and River Red Gum forests has occurred, with significant alterations to understorey vegetation in particular. Reduced diversity and high levels of weed invasion have impacted on floodplain productivity, and flood dependent flora and fauna.

To address the impacts from river regulation, a package of works has been developed to mimic a natural flood event of up to 50,000 ML/day across 500 ha of the Gunbower National Park. This includes almost half of the permanent and temporary wetlands (45 and 47% respectively) in the Project area and 20% (250 ha) of the River Red Gum with flood dependent understorey.

Critical to the infrastructure package design was the ability to provide operational flexibility, minimise footprints, and generate simple, robust, and cost effective assets. The proposed works are listed in Table E-1:

Table E-1: Proposed package of works to enable environmental water delivery to the upper Gunbower National Park

Infrastructure	Function
Camerons Creek	
Regulator	Deliver environmental water from upper reaches of Camerons Creek connected to the Torrumbarry Weir pool, into Black Charlie Lagoon and the Baggots Creek area
Diversion weir (approximately 1.5 km downstream of the new regulator), pump pads and sump, short pipeline	Deliver environmental water while maintaining irrigation supply to two diverters
Baggots Creek Area	
Hardstand area for a temporary pump and temporary piping	Enable drainage of the low lying Baggots Creek area
Remedial works on levees	Minimise risk of flooding to adjacent private land
Access tracks	Access to the hardstand for pumping operations
Old Cohuna Main Channel	
Irrigation channel offtake regulator	Delivery of environmental water from the Old Cohuna Main Channel (2/4/1 Channel) part of the Torrumbarry Irrigation Area (TIA
Upgrades to three road culvert crossings	Increase capacity for delivery of water along Old Cohuna Main Channel
Forest regulator at the Old Cohuna Main Channel and forest intersection	Retain high river flooding flows within the forest

The total capital cost estimate is **$12,838,185** (as upper cost estimate). Cost estimates may be reduced during the detailed design phase as the designs are refined and contingency reduced.

Works are scheduled to be complete and operational within four years, from procurement of detailed designs to fully commissioned works.

Ecological Outcomes

Environmental water delivery to the Gunbower National Park will generate a range of environmental benefits in line with the management goal for the Project. A more natural flooding regime will promote the growth of River Red Gum flood dependent understory and wetland vegetation, providing critical habitat and food resources for native flora and fauna. Tree canopies will improve and the encroachment of terrestrials species and weed invasion will be halted.

Addressing risk

As part of the Project, a comprehensive environmental, social and economic risk assessment, compliant with AS/NZS ISO 31000:2009, was undertaken. Priority ecological risks from operation of the measure were identified with the highest priority identified as pest fish, which can reduce the ecological value of habitats. Socio-economic risks included reduced access for social and economic activities, loss of cultural heritage sites and third party impacts from flooding. During the Project's development and construction phases, priority risks include fire, injury, loss of corporate knowledge and delays due to approvals or bad weather.

For all priority risks, mitigation measures have been identified, to reduce the likelihood and consequences of their occurrence.

Implementation of the Project

The local community, Traditional Owners and stakeholders have a strong connection and interest in the Gunbower National Park and wider Gunbower Forest. Engagement of these groups and general communication activities will be a critical component of the successful implementation of the Project. Activities undertaken to date provide a strong foundation for the future, to be guided by the *Stakeholder Management Strategy*. Ownership of the Project will enhance and maximize on the environmental outcomes.

The Regulatory Governance Group established by DEPI will facilitate the streamlining of the regulatory approvals process. In addition, appropriate governance and project management arrangements will be instituted to minimise risks to investors and other parties from the proposed supply measure.

Conclusion

The *Gunbower National Environmental Works Project* has the potential to generate significant environmental outcomes through the construction and operation of smart, efficient and cost effective works. The Project demonstrates a high level of scientific rigour and is founded on strong planning, expert input and the significant experience of the community and agencies working in partnership.

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Abbreviations

AAV	Aboriginal Affairs Victoria
BOC	Basin Officials Committee
CAMBA	China Australia Migratory Bird Agreement
CEWH	Commonwealth Environmental Water Holder
CEWO	Commonwealth Environmental Water Office
CHMP	Cultural Heritage Management Plan
CMA	Catchment Management Authority
CMS	Constraints Management Strategy
CRG	Community Reference Group
Cwith	Commonwealth
DBH	Diameter at Breast Height
Department	Commonwealth Department of the Environment
DEPI	Department of Environment and Primary Industries
EES	Environmental Effects Statement
EPBC Act	Environmental Protection and Biodiversity Conservation Act 1999
ESLT	Environmentally Sustainable Level of Take
ESLT report	*The proposed 'environmentally sustainable level of take' for surface water of the Murray–Darling Basin: Method and outcomes* (November 2011)
EVC	Ecological Vegetation Class
FDU	Flood-dependent Understorey
FFG Act	Flora and Fauna Guarantee Act 1988
FTU	Flood Tolerant Understorey
GIS	Geographic Information System
GMW	Goulburn-Murray Water
GST	Goods and Services Tax
Guidelines	Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases
ha	Hectare(s)
HIS	Hydrological Indicator Site
IGA	Intergovernmental Agreement on Implementing Water Reform in the Murray-Darling Basin
IGA Protocol	Schedule 1 to the IGA (Protocol for consideration of surface water Sustainable Diversion Limit (SDL) adjustment measures)
JAMBA	Japan Australia Migratory Bird Agreement
km	Kilometre(s)
MDB	Murray-Darling Basin
MDBA	Murray-Darling Basin Authority
MERI	Monitoring Evaluation Reporting and Improvement
MEP	Monitoring and Evaluation Plan
ML	Megalitres
mm/yr	Millimetres per year
MOU	Memorandum of Understanding
NPV	Net Present Value
NRSWS	Northern Region Sustainable Water Strategy
NVIRP	Northern Victorian Irrigation Renewal Project
OCMC	Old Cohuna Main Channel
OH&S	Occupational Health and Safety
RAP	Registered Aboriginal Party
RGG	Regulatory Governance Group

RiMFIM	River Murray Floodplain Inundation Model
RRG	River Red Gum
SCA	State Construction Authority
SCADA	Supervisory Control and Data Acquisition
SDL	Sustainable Diversion Limits
SDLAAC	Sustainable Diversion Limit Adjustment Assessment Committee
SDLATWG	Sustainable Diversion Limit Adjustment Technical Working Group.
SDLLAC	Sustainable Diversion Limits Adjustments Assessment Committee
SFIs	Site-specific Flow Indicators
SPW	Semi- Permanent Wetland
The Basin Plan	The Murray-Darling Basin Plan adopted by the Commonwealth Minister under section 44 of the *Water Act 2007* (Cth) on 22 November 2012
WRC	Water Regime Class

1 Introduction

The *Gunbower National Park Environmental Works Project* (the Project) has been developed as a supply measure under the Murray-Darling Basin (MDB) Plan Sustainable Diversion Limit (SDL) adjustment mechanism. The SDL adjustment mechanism enables the use of less water to achieve equivalent environmental outcomes sought by the Basin Plan. The Project is one of nine proposed infrastructure based supply measures being investigated within Victoria, and one of two within the North Central Catchment Management Authority (CMA) region.

The development of the *Gunbower National Park Environmental Works Project* business case (the Business Case) has been guided by the *Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases*. The Business Case sets out the ecological objectives, proposed infrastructure package, operating strategies, ecological risks and benefits and the costs associated with progressing the Project through to construction. It has been developed in partnership with the Department of Environment and Primary Industries (DEPI), Parks Victoria and Goulburn Murray Water (GMW).

The primary aim of the Project is to restore the ecological condition of the upper Gunbower National Park, an area situated between Camerons Creek and Broken Axle Creek (See Figure 2-1). This part of the forest features permanent wetlands, temporary wetlands, River Red Gum (*Eucalyptus camaldulensis*) forest and Black Box (*Eucalyptus largiflorens*) and Grey Box (*Eucalyptus macrocarpa*) woodlands. River regulation has depleted the flooding regime of these high value floodplain habitats, with the frequency and duration of flood events now approximately halved compared to natural conditions. The significant reduction in natural flood events has lowered the biodiversity values, by reducing the extent of temporary wetlands and the productivity and habitat value of the River Red Gum forest.

A package of works has been designed to mimic up to an equivalent 50,000 ML/day River Murray flood event across 500 hectares of the Gunbower National Park. The package of infrastructure consists of two separate inlets that will provide operational flexibility to meet the water requirements of the high value water regime classes, and reduce potential ecological and operational risks, whilst being highly cost effective.

The cost to progress this project through detailed designs, statutory approvals and construction is **$12,838,185**.

1.1 Eligibility

Victoria considers that the *Gunbower National Park Environmental Works Project* meets the relevant eligibility criteria for Commonwealth supply measure funding.

In accordance with the requirements of the Murray-Darling Basin Plan, Victoria confirms that this is a new supply measure, additional to those included in the benchmark conditions. The operation of this measure will:

- increase the quantity of water available to be taken in the Victorian Murray surface water SDL resource units;
- provide equivalent environmental outcomes with a lower volume of held environmental water than would otherwise be required to be achieved;
- ensure that there are no detrimental impacts on reliability of supply of water to holders of water access rights that are not offset or negated; and
- be designed, implemented and operational by 30 June 2024.

This business case demonstrates in detail how each eligibility requirement is met. However it is noted that this will be dependent on the final outcomes of the modelling work to be completed in 2015 by the Murray-Darling Basin Authority.

Other than the provision of financial support to develop this business case, this proposal is not a 'pre-existing' Commonwealth funded project, and it has not already been approved for funding by another organisation, either in full or in part.

2 Project Details

2.1 Locality

The Gunbower National Park is located on the mid-Murray floodplain in northern Victoria. It sits within the broader Gunbower Forest, an internationally recognised site of ecological significance in the Murray-Darling Basin. The forest is bounded to the north by the River Murray and along its southern edge by private land and Gunbower Creek (See Figure 2-2). The forest forms part of the Gunbower-Koondrook-Perricoota Forest icon site under *The Living Murray* (TLM) Initiative, together with the Koondrook-Perricoota Forest in New South Wales.

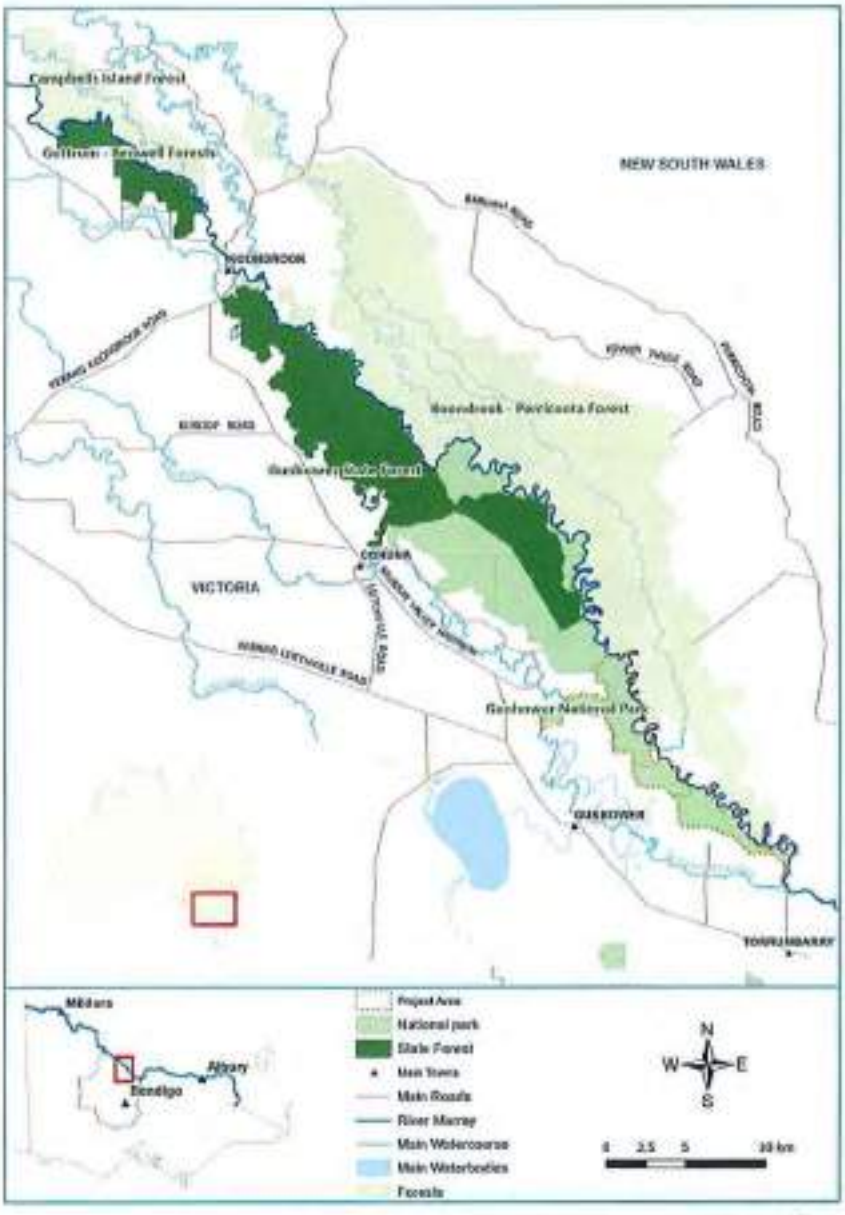


Figure 2-1: Gunbower National Park within the broader mid-Murray floodplain ecosystem

Gunbower Forest is managed as three separate land tenures (Figure 2-1):

1. Gunbower National Park, often referred to as the upper forest, which covers 8,892 ha and is managed by Parks Victoria.
2. State Forest, the mid and lower forest, which covers 8,843 ha and is managed by the Department of Environment and Primary Industries (DEPI) as part of the mid-Murray Forest Management Area.
3. The River Murray Reserve, which covers 1,666 ha and is also managed by Parks Victoria.

The regional environmental water manager is the North Central CMA and the regional water corporation is GMW.

Figure 2-2 shows the land tenure within and around the upper Gunbower National Park.

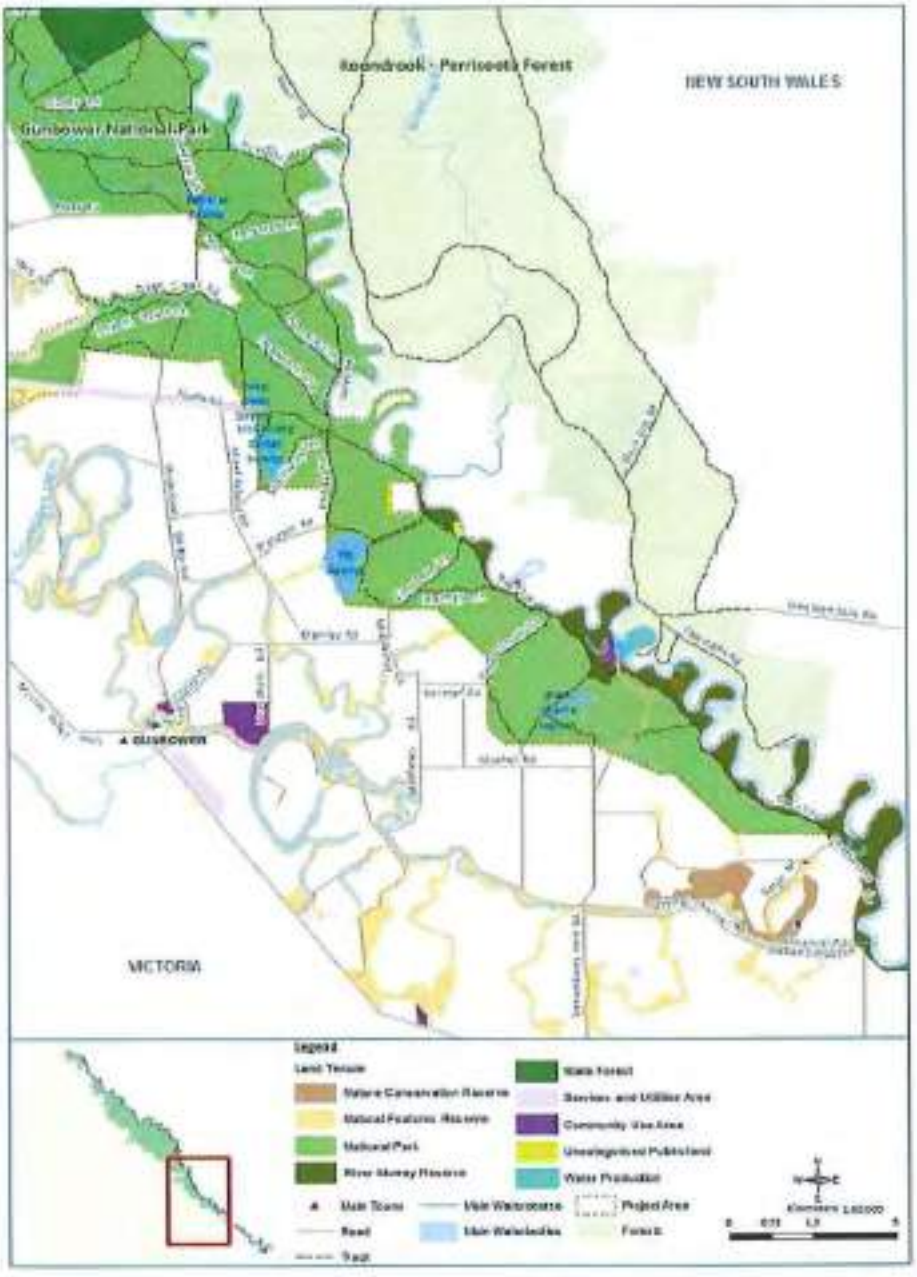


Figure 2-2: Land tenure around the upper Gunbower National Park

2.2 Significance

Gunbower National Park is part of the broader Gunbower Forest, a Ramsar Wetland of International Importance that forms part of the Gunbower-Koondrook-Perricoota Forest icon site in the mid-Murray region. River Red Gum floodplain forests are of significant ecological importance in the Murray-Darling Basin, as they provide essential habitat and resources for a range of aquatic, amphibious and terrestrial fauna (Roberts & Marston 2011).

The core ecosystem communities of the forest that are influenced by the Project comprise permanent wetlands, temporary wetlands, River Red Gum forest, native birds and native fish. Over one hundred threatened flora species have been recorded within Gunbower Forest, providing habitat for more than 130 species of birds including water and woodland birds, and important migratory birds covered by international agreements. The forest also provides critical floodplain habitat to mammals such as the Sugar Glider (*Petaurus breviceps*), as well as amphibians and reptiles such as the Broad-shelled Turtle (*Chelodina expansa*).

This project complements and builds on the ecological outcomes of TLM environmental works and measures program, which targets the lower and middle sections of Gunbower Forest. The Project will enable an additional 500 ha of permanent and temporary wetlands and River Red Gum forest to be inundated, and in combination with TLM program will enable a total of approximately 5,500 ha to be watered.

2.3 Proposed works package

The purpose of the proposed package of infrastructure is to enable delivery of environmental water to the wetlands and forest to address the hydrological deficit in the flooding regime caused by river regulation. The package has been developed to meet the water requirements of biota in the forest, including the extent of inundation, depth, and duration. The infrastructure has also been designed to minimise environmental and operational risks.

The location of works to deliver the required inundation outcomes in Gunbower National Park are shown in Figure 2-3. A short description of the package of works is provided below with the full package of infrastructure described in Section 11 and costings provided in Section 13. The *Concept Design report* provides further detail on the designs, criteria and drawings (URS 2014).

2.4 Camerons Creek

- A new replacement regulator and associated flow control works will deliver environmental water from upper reaches of Camerons Creek connected to the Torrumbarry Weir pool, into Black Charlie Lagoon and the Baggots Creek area;
- Approximately 1.5 km downstream of the new regulator construction of a diversion weir, pump pads and sump, and a short pipeline, will allow environmental watering to be conducted while maintaining irrigation supply to two diverters.

2.5 Baggots Creek area

Works to facilitate temporary pumping to drain the low lying Baggots area, which artificially retains water against perimeter levees, include:

- Instalment of a hardstand area for a temporary pump;
- Temporary piping;

Figure 2-3: Upper Gunbower National Park Works Package

- Remedial work on levees to minimise risk to adjacent private land; and
- Access tracks and ancillary works.

2.6 Old Cohuna Main Channel

- A new offtake regulator to enable delivery of environmental water from the Old Cohuna Main Channel (2/4/1 Channel) part of the Torrumbarry Irrigation Area (TIA);
- Upgrades to three road culvert crossings to increase capacity to deliver environmental water along Old Cohuna Main Channel;
- A new containment regulator at the junction of the Old Cohuna Main Channel and the forest flood levee; and
- Access tracks and ancillary works.

The combination of these works will enable the delivery of environmental water onto the forest floodplain, the provision of supplementary flows to permanent wetlands, and the extension of the duration of inundation across 500 ha of the Gunbower National Park.

The advantage of the proposed approach is its use of different watering routes to target different vegetation communities according to their watering requirements. This ensures maximum benefits and reduces any risks of over-watering of other communities. It also relies on existing assets and requires limited works, thus reducing costs and minimising potential disturbance to the forest.

2.7 Costs and proposed schedule

The total capital cost estimate (excluding GST) is **$12,838,185.**

Table 2-1: Project schedule

Stages	Year 1	Year 2	Year 3	Year 4
Planning/Detailed design				
Approvals				
Procurement				
Works				
Commissioning				

2.8 Proponent and proposed implementing entity

The feasibility study and business case for the proposed supply measure has been developed by the North Central CMA, on behalf of the Victorian Government and in partnership with DEPI, Parks Victoria and GMW, through funding from the Commonwealth Government.

As the Project owner, DEPI will have oversight responsibility for project implementation, pending confirmation of construction funding. Further information regarding the proposed governance and project management arrangements for implementation is provided in Section 16.

3 Values of the Site

3.1 Ecological values

Gunbower National Park is part of the broader Gunbower Forest, which is listed as a Wetland of International Importance under the Ramsar Convention (DSE 2003). It is recognised as an important site due to the genetic and ecological diversity it sustains and its role in supporting large numbers of waterbirds during flood events (MDBA 2012). In addition, Gunbower Forest is recognised as an icon site as part of The Living Murray Initiative; one of the six environmental assets of the River Murray that have the highest priority for rehabilitation through water management. The Victorian Government created the *Gunbower National Park* in 2010 in recognition of the importance of the mid- and upper part of Gunbower Forest and its need for greater protection (Figure 2-1)

Gunbower National Park supports a range of communities and species - many of which are listed as rare or threatened under state and national legislation. Flood dependent aquatic flora and River Red Gum dominate the more frequently flooded areas, while less flood dependent flora such as Black Box and Grey Box are more common higher in the landscape. The following sections provide an overview of the significant values of the Gunbower National Park and Appendix 1 is a full listing of the species recorded. Note that the Project area is within the upper part of the Gunbower National Park (herein referred to as upper forest or upper Gunbower National Park).

3.1.1 Vegetation communities

Gunbower National Park is located within the Murray Fans Bioregion, one of three bioregions along the River Murray floodplain downstream of the Ovens junction, and part of the Riverina Interim Biogeographic Regionalisation for Australia bioregion. The Murray Fans support a mosaic of Plains Grassy Woodland, Pine Box Woodland, Riverina Plains Grassy Woodland and Riverina Grassy Woodland Ecological Vegetation Classes (VEAC 2008). The Gunbower National Park maintains the ecological diversity of the bioregion by supporting vegetation communities representative of it. The River Red Gum Grassy Woodland ecological community that occurs across Gunbower Forest has been listed under Schedule 2 of the *Flora and Fauna Guarantee Act (FFG) (1988).*

Vegetation communities within Gunbower National Park have been mapped and classified into Ecological Vegetation Classes (EVCs). EVCs are the standard Victorian classification unit, which groups floristic communities occurring across biogeographic ranges within specific environmental niches.

The upper Gunbower National Park contains twelve EVCs, three EVC complexes and two EVC aggregates, all of which are threatened in Victoria. A list of the EVCs and their relative conservation status is presented in Table 3-1. The distribution of recently mapped EVCs is shown in Figure 3-1.

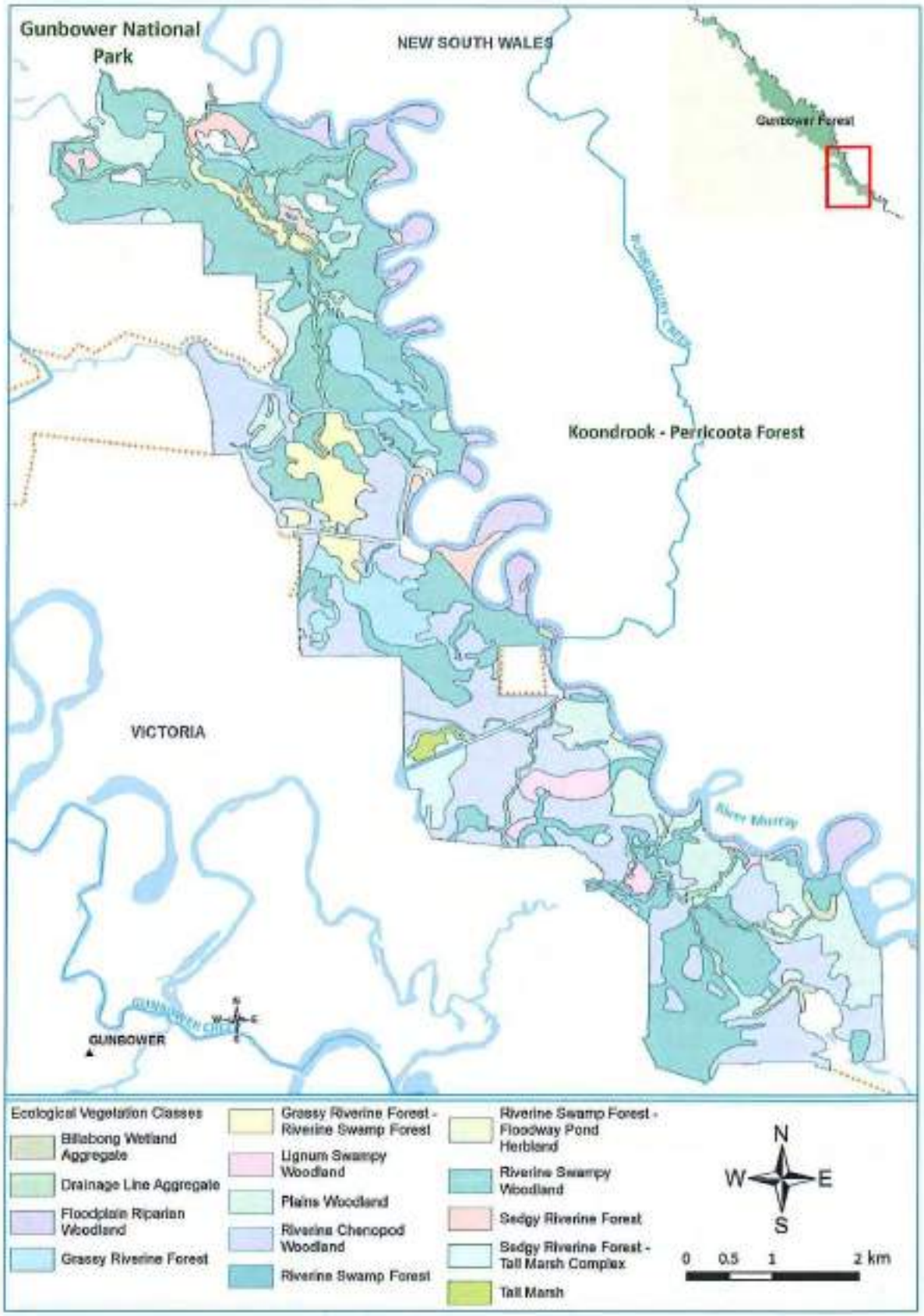


Figure 3-1: Ecological Vegetation Classes within the project area

Table 3-1: Ecological Vegetation Classes within Gunbower National Park

Ecological Vegetation Class	Conservation Status (DEPI 2014)
EVC 815 – Riverine Swampy Woodland	Vulnerable
EVC 814 – Riverine Swamp Forest	Depleted
EVC 106 – Grassy Riverine Forest	Depleted
EVC 56 – Floodplain Riparian Woodland	Depleted
EVC 816 – Sedgy Riverine Forest	Depleted
EVC 103 – Riverine Chenopod Woodland	Endangered
EVC 803 – Plains Woodland	Endangered
EVC 821 – Tall Marsh	Least concern
EVC 823 – Lignum Swampy Woodland	Vulnerable
EVCs 816/821 – Sedgy Riverine Forest/Tall Marsh Complex	Depleted
EVC 812/945 – Riverine Swamp Forest Complex/Floodway Pond Herbland[1]	Depleted
EVCs 106/814 – Grassy Riverine Forest/Riverine Swamp Forest Complex	Depleted
Billabong Wetland Aggregate[2]	-
Drainage Line Aggregate (Black Box with flood-dependent understorey)	-

Note 1: EVC complex- Floodway Pond Herbland/Riverine Swamp Forest Complex- represents areas of the two EVCs occurring in a mosaic, making it difficult to separate at a larger scale for mapping purposes.

Note 2: EVC aggregates present are areas that, at the time of mapping, represented one EVC but would be expected to change considerably under different hydrological conditions (Biosis 2014b). They are therefore mapped as aggregates to encompass the dynamic characteristics of these areas.

3.1.2 Flora

As of November 2014, 268 species of native flora have been recorded in Gunbower Forest, including 103 threatened species. Many of these have been recorded, or are expected to be present, in Gunbower National Park, as the Park includes the full range of habitats found in the lower forest as well as unique Box woodland habitats (Bennetts, K 2014, personal communication, October). Of this total flora list, one species is listed as nationally threatened under the EPBC Act (1999) – Western Water-starwort (*Callitriche cyclocarpa*) recently found in Dry Tree Creek north of the Baggotts Creek area (Frood & Bennetts 2014). At least three species are listed as threatened under the Victorian FFG Act (1988), including the Wavy Marshwort (*Nymphoides crenata*) found below Black Charlie Lagoon (Bennetts 2014a). An additional 25 species are protected under the FFG Act (1988) (public land only) and numerous species on the DEPI Advisory List of Rare and Threatened Species (2014a) have been recorded, including the water-dependent rare Riverina Bitter-cress (*Cardamine moirensis*) and vulnerable Long Eryngium (*Eryngium paludosum*) (Biosis 2014).

Long Eryngium in Gunbower– (Photo A.Chatfield)

Western Water-starwort (Photo I.Higgins)

3.1.3 Birds

The habitats across Gunbower National Park support a number of water and woodland bird species. At least one hundred and thirty-one species of birds have been recorded, 26 of which are water or wetland birds, and ten are threatened. The Australasian Bittern (*Botaurus poiciloptilus*), which is listed as threatened under the *EPBC Act* (1999) was previously recorded in Pig Swamp (DSE 2010). The lower Gunbower Forest is a breeding site for colonial nesting waterbirds, and is one of a limited number of sites in Victoria that supports breeding colonies of Intermediate Egrets (*Ardea intermedia*) (North Central CMA 2014a). Inundating the floodplain habitats of the upper forest, in Gunbower National Park, will support waterbird breeding events in the lower forest through the provision of productive foraging areas – a critical requirement for breeding success. The upper forest has been known to support species listed under the Japan Australia Migratory Bird Agreement (JAMBA), China Australia Migratory Bird Agreement (CAMBA), Republic of Korea Australia Migratory Bird Agreement (ROKAMBA) and the Bonn Convention. These species include the Eastern Great Egret (*Ardea modesta*) and the White-bellied Sea Eagle (*Haliaeetus leucogaster*), also listed in the *FFG Act* (1988) (DSE 2010).

White-bellied Sea Eagles (Photo B.Bisset)

Great Egret in flight over Gunbower (Photo D. Kleinert)

Many woodland birds are associated with floodplain forests, using them for habitat, foraging, breeding and watering (Johnson et al. 2007). Gunbower National Park also supports a number of woodland birds listed in the *FFG Act* (1988) Victorian temperate woodland bird community, including the FFG-listed Barking Owl (*Ninox connivens connivens*) and the previously recorded EPBC-listed Superb Parrot (*Polytelis swainsonii*) (DSE 2010).

3.1.4 Fish

Both the aquatic environments within Gunbower Forest and the adjacent waterways (Gunbower Creek and the River Murray) provide resources that support 13 recorded native fish species, a number of which are listed under the *FFG Act* (1988) and/or the *EPBC Act* (1999). This includes the EPBC-listed nationally vulnerable Murray Cod (*Maccullochella peelii*) and the endangered Trout Cod (*Maccullochella Macquariensis*) (North Central CMA 2014a). The native fish community in Camerons Creek, which supplies water to Black Charlie Lagoon, includes six species of native fish including the FFG-listed Murray-Darling Rainbowfish (Sharpe 2014). Black Charlie Lagoon provides drought refuge for small-bodied fish (North Central CMA 2010a), and has historically supported the vulnerable Southern Pygmy Perch (*Nannoperca obscura*) (Sharpe 2014). During recent environmental watering in the lower Gunbower Forest, both large-and small-bodied species have been observed on the floodplain (Chatfield, A 2014, personal communication, 5 November).

Southern Pygmy Perch (Photo MDBA, G. Schmida)

3.1.6 Amphibians and reptiles

The habitats across the upper Gunbower National Park support native frogs and reptiles, of which 26 species have been recorded in surveys to date. In particular, Camerons Creek and Black Charlie Lagoon are known to support six species of amphibians including the Barking Marsh Frog (*Limnodynastes fletcheri*) (DSE 2010). Numerous marshy wetland areas throughout the upper Gunbower National Park potentially also provide habitat for the EPBC-listed Growling Grass Frog (*Litoria raniformis*) including around Old Cohuna Main Channel (Biosis 2014).

Long-necked Turtle in Gunbower Forest (Photo H.McGregor)

Two other water dependent vertebrate species have been recorded within Gunbower National Park. These are the Broad-shelled Turtle (*Chelodina expansa*) and the Common Long-necked Turtle (*Chelodina longicollis*). The Broad-shelled Turtle is listed under the *FFG Act* (1988) and as endangered on the advisory list of rare or threatened vertebrate fauna in Victoria. The Common Long-necked Turtle is listed as data deficient on the advisory list of rare or threatened vertebrate fauna in Victoria (DEPI 2013).

Other recorded reptiles of note in the upper Gunbower National Park include the Woodland Blind Snake (*Ramphotyphlops proximus*), listed as near-threatened on the DEPI Advisory List (2014a).

3.1.7 Mammals

Gunbower National Park provides critical floodplain forest habitat to mammals, such as the historically recorded FFG-listed Sugar Glider (*Petaurus breviceps*) and Squirrel Glider (*Petaurus norfolcensis*) (DSE 2010). It also provides habitat for the Yellow-footed Antechinus (*Antechinus flavipes*) (North Central CMA 2012), whose preferential habitat is in decline (Lada & Mac Nally 2008).

3.1.8 Ecological functions

Gunbower National Park is, as part of the Gunbower Forest, an integral part of the River Murray floodplain. At a local (site-specific) level, the forest is critical to support water-dependent values, including but not limited to:

Food production - The conversion of matter to energy for uptake by biota, including substrate surfaces (i.e. rocks, woody debris, gravel) for biofilms and plant matter, and interactions between primary producers and consumers such as the breakdown of carbon and nutrients by zooplankton and macroinvertebrates for higher order consumers.

Provision of shade and shelter for biota - The forest's, ephemeral wetlands and shallow mudflats provide drought refuge, and feeding and breeding habitat for waterbirds, frogs and turtles.

Provision of water for consumption - Retention and storage of water for biota to enhance growth and development and to ensure survival and reproduction.

At a regional (complex) level, Gunbower National Park is critical for supporting water-dependent values, including but not limited to:

Movement/dispersal - Mobile species move to access resources such as food, breeding habitat and mates. This assists with maintaining genetic diversity within the landscape and reduces the risk of local species extinction. Movement also supports the dispersal of seeds/progapules in the landscape providing a source for colonisation.

Biological diversity - The provision of a sufficient number and range of habitat types in the landscape supports a diversity of native species. This in turn assists to safeguard the region from the impacts of local catastrophic events (i.e. loss of habitat through fire and clearing) due to there being sufficient alternative habitats available.

3.2 Water regime classes

The upper Gunbower National Park contains a range of habitat values within the 12 EVCs mapped. To facilitate the development of ecological objectives and watering targets and correlate the EVCs and values with flooding regimes, 'water regime classes' have been developed (Ecological Associates 2014). The relationship between EVCs and the upper forest's water regime classes is provided in Table 3-2.

Water regime classes (WRCs) were developed using a range of sources such as LIDAR, historical hydrological modelling and EVC mapping, and represent the hydrological requirements of vegetation that is expected to be present under a natural flooding regime. Four water regime classes are identified: permanent wetlands, temporary wetlands, and River Red Gum forest with flood dependent understorey and Box Woodlands (including Black Box and Grey Box woodlands) (Figure 3-2).

Table 3-2: Water regime classes in upper Gunbower National Park (Ecological Associates 2014).

Water Regime Class	Total area (ha)	High value EVCs within project area
Permanent wetlands	171	Billabong Aggregate EVC 56 – Floodplain Riparian Woodland
Temporary wetlands	271	EVC 815 – Riverine Swampy Woodland EVC 821 – Tall Marsh EVCs 816/821 – Sedgy Riverine Forest/Tall Marsh Complex EVCs 812 /945– Riverine Swamp Forest/Floodway Pond Herbland Complex EVCs 106/814 – Grassy Riverine Forest/Riverine Swamp Forest Complex
River Red Gum: flood dependent understorey	1253	EVC 815 – Riverine Swampy Woodland EVC 814 – Riverine Swamp Forest EVC 816 – Sedgy Riverine Forest EVC 106 – Grassy Riverine Forest
Box Woodlands	1082	EVC 103 – Riverine Chenopod Woodland EVC 803 – Plains Woodland EVC 823 – Lignum Swampy Woodland

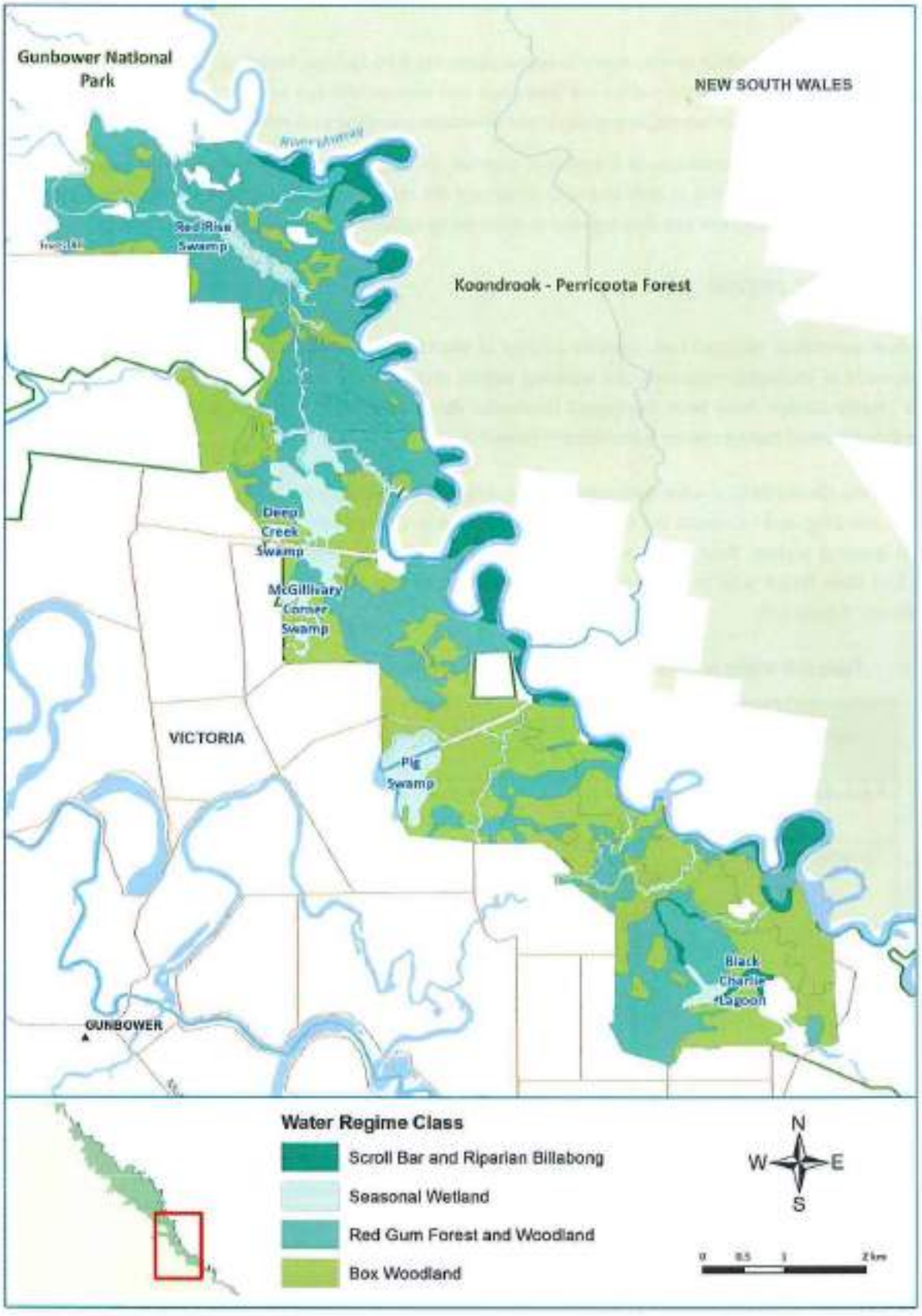


Figure 3-2: Water regime classes of the upper Gunbower National Park

3.2.1 Permanent wetlands

Permanent wetlands in the upper Gunbower National Park relate mainly to Black Charlie Lagoon, Camerons Creek and deep localised depressions along the River Murray. They provide: important habitat and a drought refuge for vegetation-dependent fish species, and support source populations of native fish that disperse to the wider forest floodplain during floods. Black Charlie Lagoon and Camerons Creek also provide breeding habitat for waterbirds and food sources for piscivorous birds and insectivorous birds and bats (Ecological Associates 2014).

Black Charlie Lagoon (Photo North Central CMA)

3.2.2 Temporary wetlands

Gunbower Forest is one of the best representatives of the freshwater, tree-dominated wetland type in the Murray Fans bioregion (Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) 2011). A diverse mosaic of smaller, shallow, temporary wetlands including flood runners exists within the forests and woodlands of the national park. These differ from the wetland complexes in the lower landscape because they are smaller and more diverse in size, shape and aquatic plant assemblages (Mallen-Cooper et al. 2014). Temporary wetlands include Baggots Creek Swamp, Deep Creek Swamp, McGillivray Swamp and Red Rise Swamp. These naturally support a diverse and productive understorey of aquatic plants and provide highly productive habitats for a range of fish species, including adults and juveniles of channel-specialist fish that access the forest during floods. Temporary wetlands also provide shelter and productive foraging areas for waterbirds, including crakes and bitterns, as well as bats and mammals (Ecological Associates 2014).

3.2.3 River Red Gum with flood-dependent understorey

Gunbower Forest is one of the largest remaining stands of River Red Gum forest in Australia. River Red Gum with flood dependent understorey (FDU) occurs in lower lying areas on the floodplain. When flooded, this water regime class provides important seasonal floodplain habitat for aquatic fauna, such as frogs and fish, which disperse from refuge habitat and breed in large numbers. Waterbirds, including waders, will make use of the abundant prey in flooded understorey. Flooding initiates the germination of a range of aquatic plants, increasing the flora diversity of the forest (Ecological Associates 2014).

3.2.4 Box Woodlands (Grey Box and Black Box)

Lower elevations of the water regime class support floodplain box woodlands i.e. box woodlands with more water-dependent understorey species. Riverine Chenopod Woodland (EVC 103) is the dominant Black Box EVC in the Gunbower National Park and is considered endangered in the Murray Fans Bioregion. Limited areas of Black Box woodland (on the periphery of the River Red Gum forests) will be inundated through the Project.

Gunbower National Park contains one of the largest remnant stands of Grey Box woodland in Victoria - the Grey Box Grassy Woodlands and Derived Native Grasslands of South-Eastern Australia ecological community, which is nationally threatened and is listed under the *EPBC Act* (1999). The box woodlands WRC displays across a range of wet to dry expressions, including terrestrial box woodlands that are located higher on the floodplain. These are comprised largely of terrestrial plant species that are not dependent on flooding. This Project will not inundate these less flood tolerant communities.

An artist's impression of water regime class progression across the landscape in the upper Gunbower National Park

3.3 Recreational values

The Gunbower National Park is an important location for social and recreation activities including camping, bird watching, walking and sightseeing.

European Heritage at Baggotts Creek (Photo: C. Corr)

3.4 Cultural values

The upper forest lies within an area of Cultural Heritage Sensitivity as defined under *the Aboriginal Heritage Act (2006)* with 248 sites on Gunbower Island registered under the *Aboriginal Cultural Heritage Register and Information System (ACHRIS)*. The Indigenous community and organisation with an interest in Gunbower National Park has been identified as the Yorta Yorta Nations Aboriginal Corporation (YYNAC). Discussions with these Traditional Owners have confirmed the high value they place on restoring the habitat of the forest by reinstating a more natural flooding frequency.

There are limited listed sites of European heritage within the forest, but evidence of the historic timber industry and other industrial pursuits is apparent in the many structures and features scattered throughout (LRGM Services 2014). Collectively, these features provide a rich historic landscape.

3.5 Threats to values

The Gunbower National Park is located in an area of low rainfall and high evapotranspiration. The average annual rainfall is less than 400 mm/yr, with evapotranspiration of around 1,700 mm/yr. This creates a significant annual water deficit and means that the health, growth and existence of the forest ecosystem are dependent on regular winter-spring inundation from high river flows (VEAC 2008). In the absence of these flows, the deficit presents a significant stressor for the forest (MDBA 2012).

River regulation and diversion of River Murray flows has resulted in a change in the flooding regime of Gunbower National Park. The frequency and duration of flooding has been reduced and the interval between events has, at times, stretched beyond the thresholds of tolerance for floodplain vegetation (see Section 8), further exacerbating the existing water deficit.

If no active management intervention is implemented to restore a more natural flooding regime and alleviate water stress within the forest, a number of threats to the health and integrity of this floodplain ecosystem are likely to manifest (Ecological Associates 2014, Bennetts 2014a, Biosis 2014):

- River Red Gum health will continue to decline in forested areas;
- Encroachment of terrestrial species into wetlands and River Red Gum with flood-dependent understorey will reduce the extent of wetland habitats;
- Exotic terrestrial species will continue to be disproportionally favoured by the altered flooding regime compared with native species;

- Permanent and temporary wetland habitat values will not be optimised for native fauna including a number of threatened species;
- The extent of foraging habitat will be reduced for waterbirds.

The provision of a more natural flooding regime is expected to assist in managing a number of these threats and improving the condition and resilience of ecological values.

4 Ecological objectives and targets

4.1 Vision for Gunbower National Park

The overall vision for Gunbower Forest is to:

Maintain and improve Gunbower Island by enabling native plants and animals to flourish, restoring the floodplain's health for future generations.

The goal for water management in the Gunbower National Park is to:

To reinstate a more natural water regime that protects and enhances the ecological values within the Gunbower National Park and, where possible, supports values in downstream areas of Gunbower Island.

4.2 Objective development

A suite of ecological objectives and targets were developed for Gunbower National Park that represent the desired ecological outcomes of enhanced flooding. These consider the current condition of ecological values and whether intervention is required; and interdependencies within and between these forests and other regional areas such as the lower Gunbower Forest and Koondrook-Perricoota Forest.

Development of the ecological objectives was supported by a range of sources to identify the hydrological requirements of ecological values in the forests. These sources included a review of the literature (North Central CMA 2014a); ecological and hydrological investigations and modelling to identify water regime classes (Frood 2014a; 2014b; Bennetts 2014a; 2014b; 2014c; Biosis 2014; Sharpe 2014; Ecological Associates 2014); consideration of previous experience in TLM for the lower Gunbower Forest and; a workshop including key stakeholders (agency staff, expert ecologists and North Central CMA staff) (North Central CMA 2014a). These objectives have been further refined as information has become available and have been subject to peer review. For further information, see the *Ecological Objectives and Hydrological Requirements Justification Paper, 2014* for Gunbower National Park.

4.3 Objectives and targets

The draft ecological objectives and associated targets for water management of Gunbower National Park are presented in Table 4-1. The overarching objectives state the high-level broad intentions, while the targets represent measurable and achievable outcomes within the given timeframe that will ensure the objective is being achieved. The targets focus on measuring the endpoints for each objective, rather than a percentage change from a set benchmark. Every target however has a defined baseline or benchmark.

Specific ecological objectives underpin the overarching objectives and are described in *the Ecological Objectives and Hydrological Requirements Justification Paper 2014* for Gunbower National Park. A summary is provided below for each of the corresponding overarching objectives. The specific objectives identify a collection of ecological components based on the ecological values of the site and are considered integral to the restoration of a 'healthy' floodplain community. These then link to monitoring methods and reporting against targets. Monitoring methods and targets are further described in the *Monitoring and Evaluation Plan 2014* for Gunbower National Park, as well as reference points or baseline data that targets will be measured against.

Several of the detailed objectives reference a completion date of 2040. This date was selected to account for the time taken in project confirmation and construction, as well as the current condition of the ecological values and potential time-lag between environmental water delivery and outcomes being apparent and measurable.

4.3.1 River Red Gum forest

The overarching objective is for 'Healthy River Red Gum FDU and temporary wetlands'. Specific ecological objectives are to:

- Achieve an appropriate cover and diversity of species characteristic of the plant functional groups found in the River Red Gum FDU.
- Maximise the proportion of trees with healthy canopy condition in the River Red Gum FDU.
- Maintain and where possible increase the current diversity of threatened flora species.
- Reduce the area of high threat weed species.

4.3.2 Native fauna in wetlands

The overarching objective is for 'Drought refuge habitat provided for fauna (particularly small-bodied native fish) in Black Charlie Lagoon. Specific ecological objectives are to:

- Maintain and where possible improve the current diversity of the small-bodied native fish community in Black Charlie Lagoon.
- Promote recruitment of small-bodied native fish in Black Charlie Lagoon.

4.3.3 Native birds

The overarching objective is for 'Healthy wetland bird community through improved access to food and habitat that promotes breeding and recruitment'. Specific ecological objectives are to:

- Support waterfowl breeding events in most years.
- Contribute to the success of breeding events of colonial nesting waterbirds in the lower Gunbower Forest by providing foraging areas in Gunbower National Park.
- Maintain and where possible increase the current diversity of threatened wetland bird species.

Table 4-1: Ecological objectives and targets for Gunbower National Park Environmental Works Project

Objectives (by 2040)	Targets (by 2040)	Applicable values
RIVER RED GUM WITH FLOOD DEPENDENT UNDERSTOREY		
Healthy River Red Gum forests (OI: temporary wetlands)	R1: 470 ha of River Red Gum FOI with a water regime that maximises healthy condition R2: plant functional groups 2-7 have >50% of total cover occupied by at least 2/3 of all species possible R3: At least 75% of trees with 'healthy' canopy condition as defined by a crown condition index score of 4 or more by 2040 R4: >50% of threatened flora species previously recorded observed. R5: High threat exotic plants absent in >90% of total cover	EPBC-listed River Red Gum Grassy Woodland ecological community Riverine Swamp Woodland (EVC 815) vulnerable in the Murray Fans Bioregion Grassy Riverine Forest (EVC 106) depleted in Murray Fans Bioregion
NATIVE FAUNA IN WETLANDS		
Drought refuge habitat provided for fauna (particularly small-bodied native fish) in Black Charlie Lagoon.	F1: Permanent wetland habitat provided in Black Charlie Lagoon in all years F2: The five small-bodied native fish generalist species previously recorded occur every year in Black Charlie Lagoon (Carp gudgeon, Flathead gudgeon, Un-specked hardyhead, Australian smelt and Dwarf flat-headed gudgeon) F3: A range of age/size classes present for small-bodied native fish species in Black Charlie Lagoon by 2040	Black Charlie Lagoon is the deepest wetland in Gunbower Forest, perfect for drought refuge Diverse fish community. Aquatic species of conservation significance e.g. the EPBC Act listed Murray Darling Rainbowfish
NATIVE BIRDS		
Healthy wetland bird community through improved access to food and habitat that promotes breeding and recruitment	B1: Successful waterfowl breeding in 9 out of 10 years B2: 450 ha of the floodplain irrigated for colonial waterbird foraging 6 years in 10. B3: >50% of threatened wetland bird species previously recorded observed within a ten-year period by 2040. (See Monitoring & Evaluation Plan for further details).	58 wetland birds have been recorded Waterbird feeding and breeding habitat

4.4 Interdependencies

Achievement of the ecological objectives for the upper Gunbower National Park is important in a regional sense, as it forms part of a wider regional floodplain ecosystem with the lower Gunbower Forest and Koondrook-Perricoota Forest directly opposite in New South Wales, and Guttrum and Benwell forests downstream, as well as the Campbells Island State Forest in New South Wales. The Kerang Lakes Ramsar site is approximately 20km to the west. The cumulative benefits of maintaining a network of well connected, resilient and healthy wetlands is critical in addressing the decline of many threatened water-dependent species, such as the Australasian Bittern, that have lost substantial habitat across Australia. This section discusses the importance of the upper Gunbower National Park in this regional context for different types of fauna.

4.4.1 Waterbirds

Widely dispersed networks of wetlands are needed to provide sufficient habitat for waterbirds. Different types of waterbirds require different types of wetlands to feed and breed and this habitat specialisation requires them to use wetlands over large areas (Lau 2014). For example, the success of colonial waterbird breeding depends on access to foraging sites at a regional scale. Nesting birds are known to travel to wetlands within a 20 km radius of their nesting sites in search of food (Reid 2006 cited in MDBA 2012). Breeding waterbirds in Gunbower Forest have, anecdotally, been reported to move on a daily basis from the lower Gunbower forest to the adjacent Koondrook-Perricoota forest for foraging (North Central CMA 2009). Collectively, TLM and this project will increase the availability of diverse flooded habitat across Gunbower Forest, increasing the diversity and abundance of species the forest is able to support. Management of Gunbower Forest to meet objectives for foraging and nesting habitat will enhance waterbird populations throughout the region and the MDB.

4.4.2 Fish

Lateral connectivity between the River Murray and wetlands is critical for fish populations. Floodplains provide feeding and nursery zones, and a diversity of habitats that increase survival, and feeding and reproduction opportunities (Junk et al. 1989). Small-bodied fish in particular exhibit high levels of lateral movement (Lyon et al. 2010) indicating the importance of habitat connectivity for these fish communities. Flood flows on the forest floodplain are rich in food and nutrients lifted from the floodplain floor and provide an abundance of food sources for aquatic fauna (Humphries et al. 1999). Providing suitable habitat for small-bodied native fish in Camerons Creek and Black Charlie Lagoon, as well as some connectivity between channel and floodplain habitat in the Baggots Creek and central floodplain areas, will assist in achieving the objective to enhance River Murray native fish populations.

4.4.3 Reptiles and Amphibians

Reptiles such as the Common Long-necked Turtle are known to move in accordance with drought and flood cycles and associated availability of resources, and often move up to 5 km between wetlands (Roe et al. 2009). Amphibians are opportunistic users of temporary wetlands, being able to seek suitable habitats as wetlands fill and dry. Temporary waterbodies are often preferred habitat because the seasonal drying precludes predators and the availability of food sources is high (Wassens et al. 2008). However, decreases in landscape connectivity through fragmentation and habitat loss have contributed to declines in amphibian assemblages (Lehtenin et al. 1999), highlighting the importance of maintaining river-floodplain connectivity for this type of fauna. Management of the upper Gunbower National Park to meet the objectives for permanent and temporary wetlands, as well as enhancing connectivity between the floodplain and channel habitats will ensure that suitable habitat is provided for these fauna.

4.5 Contribution to Basin Plan objectives

The Project will contribute towards the environmental objectives described in the Basin Plan as outlined below.

Table 4-2: Link between Gunbower National Park Environmental Works Project and Basin Plan objectives

Basin Plan overall environmental objectives*	Contribution of the Gunbower National Park Environmental Works Project to meet overall* and specific^ Basin Plan objectives
a) to protect and restore water-dependent ecosystems of the Murray-Darling Basin	Gunbower National Park is part of a Ramsar wetland ecosystem dependent on Basin water resources to maintain its ecological character. Supports species listed under the Bonn Convention, CAMBA, JAMBA and ROKAMBA e.g. Latham's Snipe (*Gallinago hardwickii*) – Bonn, CAMBA, JAMBA and ROKAMBA and Eastern Great Egret (*Ardea modesta*) – CAMBA and JAMBA. The Project will inundate 500 hectares and result in high floodplain and wetland productivity across a range of aquatic habitats. The Project will protect and enhance water-dependent ecosystems that support numerous listed threatened species and ecological communities (refer to section 3). The Project will protect and enhance representative populations and communities of native biota.
b) to protect and restore the ecosystem functions of water-dependent ecosystems	The Project will provide opportunities for connectivity between the River Murray and permanent wetlands within the forest (Black Charlie Lagoon). Diverse habitats will be provided for biota including permanent and temporary wetlands and River Red Gum forests with flood dependent understorey. Flow requirements of these habitats will be met through this project, and timed to optimise ecosystem functions that maintain populations (e.g. recruitment and dispersal). The Project will provide wetting and drying phases that enhance ecological community structure and stimulate species interactions and food webs.
c) to ensure that water – dependent ecosystems are resilient to climate change and other risks and threats	The Project will provide Gunbower National Park with a watering regime that sustains the ecological character of the forest. Without the Project the area cannot be watered outside of natural flood events – which are of an inadequate frequency and duration even under the proposed Basin Plan. The Project will provide an important permanent wetland refuge area in the upper Gunbower Forest. The proposed water regime will protect and enhance a diversity of habitat types across the forest, which will be critical to biota under a drying climate. The water regime, including wetting and drying cycles and inundation intervals, will be tailored to meet the hydrological requirements of water-dependent values within the range of tolerance to maintain overall ecosystem resilience.

* From Chapter 5 of Basin Plan, ^ From Chapter 8 of Basin Plan

5 Anticipated ecological benefits

5.1 Current condition

The condition of Gunbower National Park has declined in response to regulation of the River Murray and artificial changes to the floodplain (e.g. levees, blockages in effluents). This decline in condition has been exacerbated by the Millennium Drought. The flooding in 2010-2012 resulted in improvements in the condition of the forest indicating that it retains the capacity to respond positively to an enhanced flooding regime.

5.1.1 River Murray regulation

Regulation of the River Murray and changes to inflow points (e.g. blockages) has created drier conditions across Gunbower National Park causing an overall shift towards more terrestrial vegetation types. The temporary wetland environments in the central forest floodplain (between Pig Swamp and Deep Creek) would naturally have supported an open River Red Gum canopy with a diverse and productive understorey of aquatic plants. The wetlands would have included dense aquatic macrophyte vegetation suitable as habitat for a variety of native fauna (Ecological Associates 2014). The current flooding regime has instead promoted the recruitment of River Red Gums, creating a closed canopy that allows less light to penetrate. Reduced flooding and light has reduced the productivity of the understorey and promoted more drought-tolerant aquatic plants such as Rush Sedge (*Carex tereticaulis*) in place of seasonal aquatic species. Consequently the wetlands provide aquatic habitat less often and for shorter periods (Ecological Associates 2014).

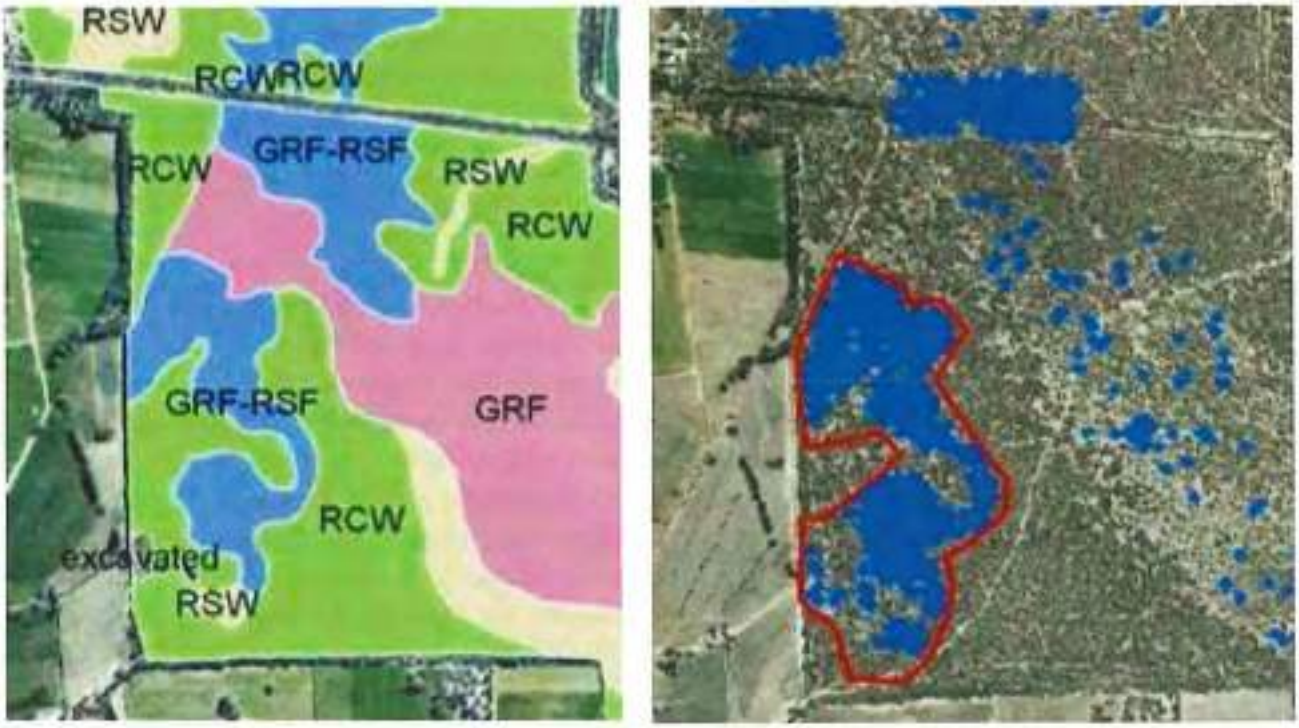
Similarly, the current water regime has resulted in the terrestrialisation of the River Red Gum forests in the Gunbower National Park. Changes include an increased tree density, closing of the canopy and pronounced alterations in understorey species composition. The understorey of the River Red Gum communities has exhibited significant loss of floristic diversity and high levels of weed invasion (Australian Ecosystems 2009). There are a greater proportion of dry-phase floodplain plants in place of the original understorey of perennial aquatic macrophytes such as Water Ribbons (*Triglochin procerum*) (Ecological Associates 2014). The River Red Gum forests in the Gunbower National Park provide aquatic habitat for fish, frogs and waterbirds less frequently, and for shorter periods, compared to natural conditions and the extent of habitat available to aquatic understorey plants has declined (Ecological Associates 2014).

5.1.2 Drought impacts

The Millennium Drought has exacerbated the impacts of river regulation on temporary wetlands and River Red Gum FDU in the Gunbower National Park. Similar to observations in the lower Gunbower Forest during the drought (Ecological Associates 2003), the distribution of River Red Gum forest with an understorey reliant upon flooding has retracted into the lower-lying areas of the floodplain. River Red Gum forest with a more terrestrial understorey has expanded. At McGillivray Corner Wetland to the southwest of the Old Cohuna Main Channel inlet point this is particularly evident. Modelling indicates that this area will retain water for at least three months after a managed inflow[1] equivalent to a 50,000 ML/day River Murray flow (Water Technology 2014a). This type of ponding supports River Red Gum forest FDU (refer to Grassy Riverine Forest-Riverine Swamp Forest Complex – GRF-RSF on left), being outside the tolerance limits for surrounding drier vegetation communities, such as the River Red Gum forests and

[1] Inundation extent from 800 ML/day delivery via Camerons Creek (Water Technology 2014a) is less than the 1992 and 1993 flood extent that occurred after River Murray inflows above 54,000 ML/day (Ecological Associates 2014).

Black Box woodlands with flood tolerant understorey (refer to Riverine Swampy Woodland – RSW and Riverine Chenopod Woodland – RCW on left). However, based on recent EVC mapping the flood tolerant vegetation community has shifted into this area (Figure 5-1). Of particular note is the patch of flood tolerant vegetation (RSW) at the southern tip of the ponded extent (circled blue).



Current EVC distribution (survey and mapping by Ecological Associates and K. Bennetts 2014)

Modelled 3 month ponding extent (Water Technology 2014a)

Figure 5-1: Comparison of water regime class distribution (left) and 3 month ponding extent (right) at McGilivray Corner Wetland

During the Millennium Drought, the condition of the Black Box and Grey Box woodland community at higher elevations on the floodplain also declined. The decline was most evident in the understorey with reductions in diversity and cover. During the drought large areas contained only litter with limited understorey (Bennetts & Jolly, 2013).

Overall, the ten years of drought from 2000 resulted in a reduction in vegetation condition, floodplain productivity and access for native fauna to food and habitat.

5.1.3 2010-2013 floods

Following the Millennium Drought, Gunbower Forest received three years of consecutive flooding between 2010 and 2013. Almost half of Gunbower Forest was inundated including substantial areas of Gunbower National Park (Bennetts & Jolly 2013). Floodplain and wetland dependent flora and fauna responded positively to these events, with the diversity of understorey species increasing and canopies of River Red Gums showing signs of recovery (Bennetts & Jolly 2013). Waterbird feeding and nesting was also observed and colonial waterbirds bred in the hundreds in the lower forest (North Central CMA 2014b).

Monitoring of the Gunbower Forest through TLM captured several changes in the forest's condition in response to the natural flooding. For example, the decline in floristic diversity (cover and richness of characteristic flora) and canopy condition as the Millennium Drought intensified (2005-2010) was halted by the above average rainfall and widespread natural flooding that commenced in 2010. The subsequent 2011 monitoring results reported twice the diversity of understorey flora, and a flush of rare and threatened flora (such as the EPBC-listed River Swamp Wallaby-grass *Amphibromus fluitans)* compared to the previous year (Bennetts & Jolly 2013). For example, in River Red Gum FDU monitoring sites, the average number of flora species per plant functional group increased from seven in 2008 to 19 in 2011 (Bennetts & Jolly 2013). Flooded River Red Gum and Black Box sites supported more than twice the species richness and cover of characteristic species than non-flooded sites. River Red Gum trees with healthy canopies (i.e. >50% intact/original canopy) in the flood-dependent water regime class increased from 30% in 2010 to less than 50% in 2013 (Figure 5-2) (Bennetts & Jolly 2013).

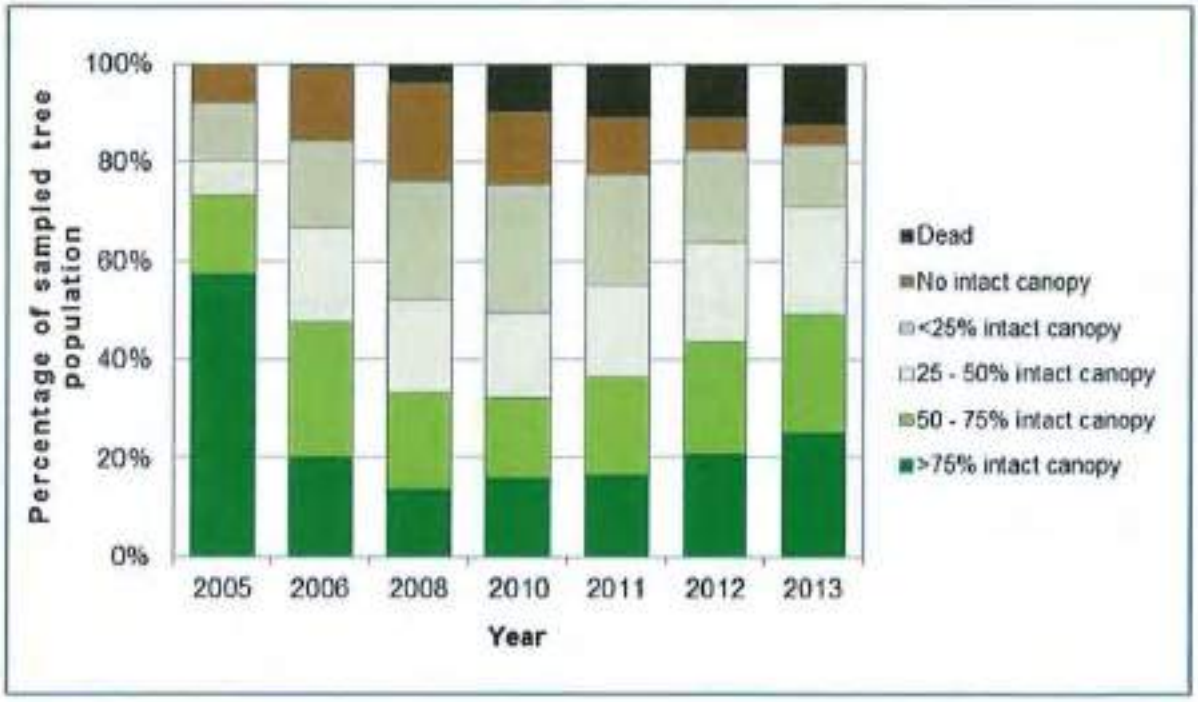


Figure 5-2: Percentage of tree population (n=1000) in each crown condition class at Red Gum flood dependent understorey sites sampled autumn 2005-2013 (Bennetts and Jolly 2013)

Although the results from the flooding events are encouraging, Gunbower Forest requires a more long-term reinstatement of a natural flooding regime if its condition is to improve. While the recent improvement in River Red Gum canopy condition (in flood dependent understorey areas) is positive, 51% of the trees were still assessed as unhealthy in 2013 (i.e. supported less than half of their potential canopy) (Bennetts & Jolly 2013). The monitoring also showed that despite the natural flooding, the overall wetland vegetation response was less than expected, with low species diversity. It is thought that this subdued response was due to the deep and prolonged flooding followed by a hot and dry 2012–2013 summer, in combination with other factors such as water quality and carp, limiting germination and establishment of plants (Bennetts & Jolly 2013).

5.1.4 Ongoing condition decline in Baggots Creek area

The vegetation in the Baggots Creek area (downstream of Black Charlie Lagoon) has experienced unseasonal and prolonged inundation. This is due to the unnatural ponding of water against the perimeter levee on the western side

of the Gunbower National Park, and the existing regulator on Camerons Creek leaking irrigation water downstream to this part of the forest. As a result, the River Red Gum forest in this area has an altered species composition (Frood 2014a). The Black Box woodlands in the lower lying areas downstream of Black Charlie Lagoon are also in poor condition, with trees beginning to die (Bennetts, K 2014, personal communication, 13 October).

Camerons Creek regulator (Photo: C. Corr)

Camerons Creek regulator (Photo: C. Corr)

5.2 Past management activities

The Gunbower National Park was declared in late 2009 and officially opened on 30 June 2010. Prior to this, it formed part of the Gunbower State Forest. Natural resource management activities in the National Park to date have focused on pest plant and animal control, threatened species management and cultural heritage protection. No previous water related management activities have occurred in Gunbower National Park.

5.3 Expected benefits of inundation

Environmental water delivery to the Gunbower National Park will generate a range of environmental benefits in line with the management goal for the Project: *To reinstate a more natural water regime that protects and enhances the ecological values within the Gunbower National Park and, where possible, supports values in downstream areas of Gunbower Island.*

5.3.1 River Red Gum forest

River Red Gum FDU

The Project will inundate bioregionally significant River Red Gum forest communities including the vulnerable Riverine Swampy Woodland EVC and the depleted Grassy Riverine Forest and Sedgy Riverine Forest EVCs. Many of the vegetation communities inundated through the Project are flood-dependent, meaning their composition and the health of individual species is reliant upon a particular flooding pattern (refer to the *Ecological Objectives and Hydrological Requirements Justification Paper*. The optimum flooding regime will be delivered through the Project as outlined in the operating plan (see Section 8.2) and will maximise the condition and function of the River Red Gum

FDU and associated temporary wetlands. For example, a healthy and diverse floodplain vegetation community will provide a range of reliable food and habitat resources for fauna.

The diversity of the flood dependent understorey in upper Gunbower Forest is expected to increase over time in response to environmental watering (Bennetts & Jolly 2013). Rare and threatened flora will be supported and observed more frequently, as was the case following the 2010-12 natural flooding (Bennetts & Jolly 2013). This includes species such as the nationally endangered Winged Peppercress (*Lepidium monoplocides*), as well as a number of FFG-listed species such as Riverina Bitter-cress (*Cardamine moirensis*) (Bennetts & Jolly 2013).

The watering will also enhance the health of the tree canopy across the River Red Gum forests following the marginal improvements that were observed after the 2010-13 floods (Figure 5-2). Improvements in soil water and groundwater recharge from flooding will be important for maintaining the health of mature trees in drier times (Roberts & Marston 2011). The improvements in tree health and the banking of water resources within the soil/groundwater system will facilitate the forest's recovery from drought and help build the resilience of the systems to future extended dry periods. Furthermore, securing the health of the canopy will help maintain future wetland productivity by ensuring the return of organic matter to the floodplain following each flood event (and therefore the release of carbon and nutrient inputs to the water column from leaf litter in future floods).

The Project will inundate a small area of Box Woodlands dominated by Black Box. Flooding of this water regime class will promote opportunistic growth of drought-tolerant plants such as Common Spike-rush (*Eleocharis acuta*) and Rush (*Juncus* spp.) and provide habitat for aquatic fauna including frogs, fish and waterbirds. Damp soil conditions from receding floodwater will promote grasses that provide food sources for woodland fauna including herbivores and granivores (such as the Diamond Firetail (*Stagonopleura guttata*)) (Ecological Associates 2014).

Habitat for aquatic fauna

Flooding triggers the rapid decay and release of minerals and carbon from organic debris on the forest floor, supporting an aquatic food web of microbes, invertebrates and small fish (Ecological Associates 2013). This in turn provides feeding opportunities for waterbirds, whether they are fish-eaters (piscivores) such as Egrets, plant eaters (herbivores) or invertebrate feeders such as grebes (NSW Department of Environment and Heritage 2013). Reinstating a diversity of foraging habitat and food sources will support a high carrying capacity of waterbirds across Gunbower Forest including those residing/breeding in the Gunbower National Park and those residing/breeding in the lower forest that use broader foraging areas. This will promote a diverse waterbird community from a range of feeding guilds.

The inundated upper Gunbower Forest floodplain will contribute to the success of threatened waterbird breeding, which depends on secure foraging areas. The Project provides more than 500 hectares of foraging habitat for colonial waterbirds, complementing the existing TLM program. Relevant species include the FFG-listed Intermediate Egret, Eastern Great Egret and Little Egret (North Central CMA 2009).

Terrestrial fauna

Improving and maintaining the health of River Red Gums on the floodplain is likely to support a healthy assemblage of woodland bird species (Fitzsimons et al. 2014). For example, the trees will directly support nectivorous and omnivorous birds such as honeyeaters and wattlebird (Ecological Associates 2013). They will provide nesting material (including hollows) and roosting habitat for waterbirds. In reciprocation, woodland birds like insectivorous species play an important ecological role in maintaining tree health and regeneration i.e. by reducing insect attack.

The recession of floodwater in the understorey will provide a highly productive environment, which together with the increased diversity of understorey flora, will provide food and habitat for a number of floodplain and terrestrial fauna e.g. seeds, fruit and forage for granivores such as finches, cockatoos, galah, lorikeet and budgerigar, the frugivorous emu and herbivorous swamp wallaby (Ecological Associates 2013).

Riverine food web

Any water draining from the forest floodplain (e.g. through hybrid events) will be rich in dissolved organic carbon, which is important for the riverine food web (Ecological Associates 2013). This will contribute to improvements in channel fish recruitment through improved instream productivity i.e. higher survival of fish larvae as floodwaters (high in phytoplankton and zooplankton) recede back into channels (Mallen-Cooper et al. 2014).

5.3.2 Wetlands

Aquatic fauna

Wetlands represent a highly productive and diverse environment important to a range of fauna species. Seasonal wetting and drying phases (involving the wetland fringe at the permanent Black Charlie Lagoon and the entire area of other temporary wetlands in the national park) promoted by the enhanced flooding regime will mineralise organic matter and support microbial and planktonic productivity. During spring, larger aquatic invertebrates, frogs and small fish species will proliferate, providing food sources for large wading birds and piscivores. Receding flood water in summer will provide foraging grounds for migratory wading birds that pick over invertebrates in drying mud (Ecological Associates 2013).

Diverse wetland habitats will be promoted through the project including dense macrophyte beds, marshy areas with emergent macrophytes and herblands. Habitat, critical for threatened species such as the EPBC-listed Australasian Bittern, will be provided (e.g. reeds, rushes and sedges). Camerons Creek (feeding Black Charlie Lagoon) provides habitat for significant species such as the FFG-listed Broad-shelled Turtle and Murray-Darling Rainbowfish. It has also historically supported the Southern Pygmy Perch (Mallen-Cooper et al. 2014). A range of waterfowl are anticipated to use Black Charlie Lagoon including grebes, crakes, rails, waterhens and snipe (Webster, R 2014, personal communication, July). The wetland habitat will support waterfowl breeding by providing food, shelter and nesting materials (Ecological Associates 2013). The abundance of food sources will be critical to successful breeding events, as it enables waterbirds to store fat for sustenance throughout their breeding season and stimulates reproductive processes (Rogers & Ralph 2011).

Vegetation

Wetland vegetation diversity will improve on flood recession, in line with recent monitoring observations. For example, TLM sentinel wetland monitoring results show that the diversity (cover and richness) of characteristic species peaked when the permanent and semi-permanent wetlands were in receding (shallowly inundated, 2005 and 2006) or drying phases (2010) (Bennetts & Jolly 2013).

Providing a closer to natural duration of inundation will ensure that wetland plants are able to complete their life cycle by flowering and contributing to the seed bank (SKM 2007). Repeated wetting and drying phases assist in maintaining the seed and rhizome banks (Bennetts & Jolly 2013), as the combination of the two drives germination in similar wetland vegetation in south-east Australia (Leck & Brock 2000). Continual stimulation of the seedbank and

allowing plants to complete their life cycle will ensure ongoing diversity and abundance of wetland flora during flood times.

The provision of diverse wetland habitat will be critical in providing conditions suitable for rare and threatened flora, such as the EPBC-listed vulnerable River Swamp Wallaby Grass (semi-aquatic flora) and Western Water-starwort (*Callitriche umbonata*) the FFG-listed Wavy Marshwort (rhizomatous aquatic flora) and Native Couch on the Victorian Advisory List of Rare or Threatened Species (perennial mudflat flora). These have been recorded in TLM monitoring (Bennetts & Jolly 2013). Recent flooding of wetlands in Gunbower Forest has recorded an increase in River Swamp Wallaby Grass and a number of sites in upper Gunbower National Park are expected to support this species (Biosis 2014a).

Habitat for aquatic fauna

Maintenance of the only permanent wetland in Gunbower National Park – Black Charlie Lagoon- will be of particular importance in dry times, and critical for improving the resilience of waterfowl, the small-bodied native fish community, and other aquatic fauna (e.g. frogs, turtles). Small-bodied native fish and fish larvae in the River Murray, and permanently inundated sections of Camerons Creek, will make use of the food resources and habitat within Black Charlie Lagoon following environmental water delivery. Black Charlie Lagoon will support a source population of aquatic species for dispersal to other environments in flood times e.g. Murray-Darling rainbowfish.

5.4 Monitoring and Evaluation Plans

The *Monitoring and Evaluation Plan for the Gunbower National Park Environmental Works Project* (MEP) outlines the proposed monitoring protocols for the overarching objectives relating to the River Red Gum forest, native fish and native birds.

In each case there is a structured and practical monitoring method (based on that developed and used under TLM to identify the condition of attributes that are reliable indicators of ecosystem health. Progress towards ecological objectives and targets can be identified over time, as the MEP captures baseline data (where available) for each target. This in turn provides a reporting and adaptive management mechanism to give confidence to the North Central CMA, funding agencies, water holders and regional communities that the investment is achieving its intended aims. Ongoing monitoring costs have been accounted for in the Business Case costings – see Section 13.

The MEP will be formalised once funding for the Project has been confirmed. The final MEP for this supply measure will be informed by broader intergovernmental arrangements for Basin-wide monitoring and evaluation under the Basin Plan. This measure is expected to contribute to the achievement of outcomes under two key Chapters of the Plan, namely: (i) the delivery of ecological outcomes under Chapter 8; and (ii) under Chapter 10, meeting the relevant sustainable diversion limit/s (SDLs), which must be complied with under the state's relevant water resource plan/s (WRPs) from 1 July 2019.

Both Chapter 8 and Chapter 10 of the Basin Plan are captured under the MDBA's own monitoring and evaluation framework. Once specific Basin Plan Chapters commence within a state, the state must report to the MDBA on relevant matters. This will include five yearly reporting on the achievement of environmental outcomes at an asset scale in relation to Chapter 8, and annually reporting on WRP compliance in relation to Chapter 10.

The proponent is satisfied that its participation in the MDBA's reporting and evaluation framework will effectively allow for progress in relation to this supply measure to be monitored, and for success in meeting associated ecological objectives and targets to be assessed.

This approach closely aligns with agreed arrangements under the Basin Plan Implementation Agreement, where implementation tasks are to be as streamlined and cost-efficient as possible.

6 Potential adverse ecological impacts

6.1 Overview of risk assessment

A comprehensive environmental, social and economic risk assessment, in line with AS/NZS ISO 31000:2009, has been completed by the North Central CMA for the Project. This assessed both the likelihood of an event occurring and the severity of the outcome if that event occurred, for the following three aspects of the Project:

- Implementation: Project management and construction risks
- Operation of the measure: ecological, social and economic risks

The methodology generated a risk matrix in line with the ISO standards, which helped prioritise mitigation strategies and measures. Appendix 3 provides the detail (including the definitions of the various likelihood and consequence ratings used for the assessment) and the process for undertaking it.

The high priority adverse ecological impacts associated with operation of the Project (implementation of the recommended watering regime) are described below along with the associated risk mitigation and control mechanisms. Details on lower priority adverse ecological impacts are presented in the risk register in Appendix 4. The Project development/construction risks are discussed in sections 11 and 17 respectively.

The risk assessment process and outputs demonstrates that the potential risks are well understood, and that risk mitigation controls are available, and when implemented ensure residual risks are acceptable.

6.2 Priority ecological risks from operation

The risk register in Appendix 4 records the full range of potential adverse ecological impacts identified. Of these, the highest priority threat (defined as those in the 'High' or 'Very High' risk categories), pest fish, is discussed below. Table 6-1 presents the initial and residual risk ratings. Further explanation, potential impacts and proposed mitigation is provided in the following sections.

Table 6-1: High priority adverse ecological impact risk assessment

Risks	Initial risk			Residual risk		
	Likelihood	Consequence	Rating	Likelihood	Consequence	Rating
Pest fish	Almost certain	Major	Very High	Likely	Moderate	High

Note: Adverse ecological impacts allocated to the lower risk categories can be viewed in the risk register.

6.2.1 Pest fish species

There is the potential that the watering regime for the upper Gunbower National Park will introduce pest fish, which would increase the abundance of these species in the Project area, particularly Camerons Creek and Black Charlie Lagoon. Pest fish can reduce the ecological value of these habitats and potentially risk the achievement of the ecological objectives. A number of non-native fish species are expected to be present in the channels of the Torrumbarry Irrigation Area including the Torrumbarry Weir pool. Species found in the Gunbower Creek and lagoons,

which may be present in the Project's supply points, include Common Carp, Goldfish, Tench, Gambusia, Oriental Weatherloach and Redfin Perch (PIRVic 2007; Rehwinkel & Sharpe 2009).

All non-native fish compete for resources and habitat with native fish. However, carp are potentially the most destructive of these species. They are highly invasive and when present in high densities can impact on wetland plants, habitats, turbidity, and native fish (Koehn et al. 2000). Carp can dominate floodplain fish communities where the shallow warm waters provide ideal conditions for spawning and growth (Stuart & Jones 2006).

Flood events, natural or managed, are likely to promote the successful breeding of carp, amongst other pest fish species. However, outside of Black Charlie Lagoon (the only permanent wetland habitat influenced by the Project), the Gunbower National Park environmental watering will only provide temporarily inundated areas (e.g. floodplain wetlands). Within three months, these habitats will have dried as occurs after natural flooding events (Water Technology 2014a).

While the Project will provide some opportunity for small-bodied pest fish to enter the inundated floodplain and breed, the delivery of flows to targeted locations rather than providing a single, large continuous flow means there will be no opportunity for pest fish to disperse from the forest into Gunbower Creek or the River Murray downstream (unless a Gunbower National Park environmental watering event is shortly followed by a large natural overbank flow). More often, they will be retained in the temporarily inundated floodplain habitats as a food source for wetland birds and other aquatic fauna before these habitats dry completely. The initial risk rating: Very High.

Screening of adult pest fish (particularly carp) is proposed for forest inlets to prevent adults from entering the floodplain. Young pest fish will have less impact on the aquatic vegetation and still-water habitats (although it is acknowledged they will compete with native fish during the inundation period).

The Project includes a carp screen on the inlet regulator to Black Charlie Lagoon/Baggots Creek area to prevent access to the wetland and floodplain by adult carp. No carp screen is required on the Old Cohuna Main Channel as the flume crossing Gunbower Creek is expected to be a barrier to fish passage (Mallen-Cooper, M 2014 personal communication, 31 October). Carp screens will be used to provide a competitive advantage to the small-bodied native fish community – one of the primary objectives behind providing permanent refuge habitat within the Gunbower National Park. However, due to the permanent water regime, any young carp that enter into the wetland will have the opportunity to grow to adult size and therefore potentially degrade the aquatic habitat. Drying the wetland would undermine the ecological objectives for the Project regarding maintaining and improving the current diversity of the small-bodied native fish community. Therefore, complementary activities around ongoing carp management (e.g. active removal) in Black Charlie Lagoon will be a priority. The residual risk rating: High.

6.3 Other potential risks

6.3.1 Water quality and salinity risks downstream

A semi-quantitative assessment of the potential salinity impacts of environmental watering activities at Gunbower National Park was undertaken and the estimated salinity impact at Morgan under the operating scenarios was found to be negligible (<0.01 µS/cm EC) (Jacobs 2014).

Blackwater events have the potential to occur during watering of the Gunbower National Park, particularly for the floodplain watering scenario (see Section 9). Blackwater can have low levels of dissolved oxygen and may therefore cause stress to fish and other aquatic animals. However, it is also a natural part of the floodplain and river system

ecology, replenishing carbon and increasing productivity in the food web. Blackwater is most likely to occur in areas with high organic loads, little circulation and warm water and the risk of it forming in Gunbower Forest is relatively high. However, the risk of it causing ecological impacts is considered to be low.

The nature of any downstream salinity and/or water quality impacts, and any potential cumulative impacts with other measures, cannot be formally ascertained at this time. This is because such impacts will be influenced by other measures that may be operating upstream of this site, including other supply/efficiency/constraints measures under the sustainable diversion limit (SDL) adjustment mechanism, and the associated total volume of water that is recovered for the environment.

It is expected that likely or potential downstream/cumulative impacts will become better understood as the full package of adjustment measures is modelled by the MDBA and a final package is agreed to by Basin governments.

6.3.2 Connectivity

The Project does not alter the existing connectivity between the Gunbower National Park and the River Murray (including Gunbower Creek at the downstream end of the forest – Chinamens Bend). Floodplain function under natural inundation events is maintained e.g. the River Murray inlet points are not impacted under the Project, with through-flows and return flows to the River Murray at various locations retained.

However, delivery of environmental water to the central forest floodplain will be from the adjacent irrigation channel system (Old Cohuna Main Channel) rather than the River Murray. This option was chosen as alternative options for delivery to the central forest floodplain that were investigated in detail under TLM (e.g. upper forest channel from Torrumbarry Weir pool and pumping from the River Murray) were considered less feasible. While operations through the Old Cohuna Main Channel will mimic natural flood events in terms of area and location of inundation, it will not provide opportunities for connectivity with the River Murray. Connectivity will still occur through natural and hybrid events (where environmental water tops up natural inflows).

7 Current Hydrology and proposed changes

7.1 Hydrological context

Gunbower Forest is situated in the central River Murray system, comprising the River Murray and its anabranches from Yarrawonga to the confluence with the Darling River at Wentworth. Major tributaries of the central Murray system include the Goulburn, Campaspe and Loddon rivers in Victoria, and the Murrumbidgee and Wakool rivers in New South Wales.

Flows downstream of Torrumbarry Weir - the major regulating structure adjacent to Gunbower Forest- are the cumulative result of flows from the River Murray downstream of the Barmah Choke, Goulburn River flows entering upstream of Echuca, and flows from the Campaspe River entering at Echuca. At Barmah, river flows are limited by geomorphological features, with channel capacity restricted to approximately 10,000 ML/day. As levels rise, the Edward River and Gulpa system carry a larger proportion of flows, by-passing Torrumbarry Weir and the Gunbower-Koondrook-Perricoota floodplain system downstream (CSIRO 2008; Atkins et al. 1991). Flood flows at Gunbower and Koondrook–Perricoota forests therefore depend heavily on flows from the Goulburn River.

Torrumbarry Weir (Photo North Central CMA)

The extent of flooding within Gunbower Forest is determined by the height of the River Murray below Torrumbarry Weir. Natural flow diversions from the River Murray into the Gunbower-Koondrook-Perricoota forests commences at about 17,000 ML/day, with flow diversions increasing substantially as flow in the River Murray rises above 30,000 ML/day. When the observed flows downstream of Torrumbarry Weir are 30,000, 40,000 and 50,000 ML/day, the proportions of combined flow naturally diverted into the Gunbower and Koondrook–Perricoota forests are 14%, 30% and 41% respectively (NSW DECC, 2008). Flows in the River Murray at Torrumbarry Weir generally do not exceed about 60,000 ML/day even in the biggest floods (e.g. 54,000 ML/day peak flow during 2010-11 floods).

Gunbower Forest is characterised by wetlands in low-lying areas surrounded by broad areas of River Red Gum forest at a slightly higher elevation on the floodplain, and Black Box and Grey Box woodland communities situated on the highest areas. The highest elevations in the upper forest fall away to the middle and lower sections of the forest. The average fall across the island is in a north-westerly direction at a slope of 1 in 5,000 (URS 2001). Accordingly, the dominant flow path through the forest is in a north-westerly direction (

Figure 7-1).

Water begins to enter Gunbower Forest at Spur Creek, Yarran Creek and Barham Cut when flows in the River Murray reach around 14,000 - 16,000 ML/day. Combined inflows through these effluents fill the wetland complexes in the lower parts of the forest (Ecological Associates 2003). The wetlands generally function as water holding basins on the floodplain until the water is lost through seepage or evaporation.

At flows of about 27,000 ML/day, the River Murray is 'bank full' and there is significant flow into Gunbower Forest through the various effluents. To create widespread flooding of River Red Gum communities, flows in the River Murray must be sustained above 30,000 ML/day (URS 2001). During these overbank flood events the River Red Gum areas operate as a 'through-flow' system - where inflow rates cause water to spread out of the forest waterways and wetlands. This water moves gradually through the forest eventually draining back into either the Gunbower Creek or River Murray.

When flows reach 40,000 – 50,000 ML/day and above, the highest elevations in the upper Gunbower Forest are inundated, flooding a large component of the Black Box and Grey Box communities.

7.2 Current floodplain hydrology

Historical image of Cohuna Pumphouse (Photo: North Central CMA)

The upper Gunbower Forest comprises the area between Camerons Creek and Broken Axle Creek. The corridor is 15 km long and generally 2.5 km wide, lying between the River Murray to the east and agricultural land to the west. The upper forest was originally part of a continuous floodplain system between the River Murray and Gunbower Creek. However, the western part of the floodplain has been reclaimed for agricultural development by the construction of a forest levee to contain floodwater near the River Murray. The forest boundary levee and historical earthworks associated with the development of early irrigation schemes (since the early 1900s) have altered the hydraulics of the upper Gunbower Forest significantly (Ecological Associates 2014).

The current hydraulics of the upper forest can be described according to four general zones (Figure 7-1):

Zone 1: River Murray bends

Zone 2: Upper section - Camerons Creek to Brereton Farm, including Pig Swamp

Zone 3: Central section - Brereton Farm to Red Rise

Zone 4: Downstream section - Red Rise to Broken Axle Creek

A brief description of the hydraulics within each of these upper forest hydraulic zones is provided below.

Zone 1 – River Murray bends

The low-lying scroll bars (i.e. river bends) of the upper Gunbower Forest along the River Murray bank are the first areas to be flooded when flows are above 25,000 ML/day. These scroll bars are dominated by River Red Gums with several featuring deep billabongs which retain water after flood peaks pass (Ecological Associates 2014).

Zone 2 – Upper section - Camerons Creek to Brereton Farm, including Pig Swamp

The most upstream section of Gunbower Forest between Camerons Creek and Brereton Farm generally has a high flood threshold but is crossed by several floodplain effluents which receive inflows at moderate River Murray flows (Ecological Associates 2014).

Camerons Creek diverges from the river above Torrumbarry Weir and flows parallel to it towards Black Charlie Lagoon. The ground between the River Murray and Camerons Creek is elevated and generally remains dry even when flows in the River Murray are very high (Ecological Associates 2014). The creek is permanently inundated by the weir pool as far as Camerons Creek regulator. This regulator controls flows to the downstream section, but is leaky and provides permanent inundation in the channel and Black Charlie Lagoon. The regulator is opened from time to time to supply diverters downstream of the structure (Ecological Associates 2014).

As Black Charlie Lagoon spills the natural flow path is for water to flow through a series of shallow floodrunners which distribute water across the forest floor before flowing on to the Baggots Creek area. The natural path of water out-falling from Black Charlie Lagoon has been blocked by the forest boundary levee causing water to pond in this area (Ecological Associates 2014).

Figure 7-1: Hydraulic zones of Gunbower National Park

Other floodplain watercourses in the upstream section of the forest also direct minor flood flows towards Baggots Creek including Dry Tree Creek, Baggots Creek and Emu Hole Lagoon. Under natural conditions these watercourses were activated by river discharges exceeding 25,000 to 30,000 ML/day. However blockages constructed on these effluents at the river bank may have raised the flow threshold to over 50,000 ML/day. Prior to the construction of the forest boundary levee these watercourses would have eventually drained through to the Gunbower Creek (Ecological Associates 2014).

Flood waters entering the upper forest through these channels now pool against the forest levee altering the water regime and vegetation structure. For example Emu Hole Lagoon, which is part of the effluent that drains into Baggots Creek, now acts as a wetland that retains water for several months (Ecological Associates 2014).

High ground in the vicinity of Straight Cut Channel, a former irrigation supply channel that extends from the River Murray to Gunbower Creek, limits the potential for the northward flow of water. Under natural conditions, before the forest levee was built, this may have occurred only in exceptionally large floods (Ecological Associates 2014).

Zone 3 – Central section - Brereton Farm to Red Rise

The central section of upper Gunbower Forest lies between Brereton Farm and Red Rise. Deep Creek is the major effluent activated at River Murray levels of 30,000 ML/day (

Figure 7-1). However, natural inflows to Deep Creek are now restricted by a block bank near the River Murray with a 300 mm pipe (Ecological Associates 2014). Under natural conditions Deep Creek may have received inflows at river flows as low as 20,000 ML/day (Tate, B 2014, personal communication, 26 November).

Historically, Deep Creek has been used as an irrigation supply channel and has been straightened, deepened and confined by levees on either side. The levees have been breached at several locations facilitating the northern movement of water (Ecological Associates 2014).

River flows exceeding approximately 30,000 ML/day allow water to spill upstream from Deep Creek towards Old Cohuna Main Channel and beyond. A floodplain depression in this area retains water to a depth of approximately one meter on the flood recession and supports a River Red Gum with flood dependent understorey, that when flooded is interspersed with shallow temporary wetlands. At 30,000 ML/day water also spills northwards from Deep Creek along the Deep Creek Branch (Ecological Associates 2014).

Deep Creek. Old Straight Cut Channel showing immature eucalypts and dry channel (Photo: M. Barker)

The Old Cohuna Main Channel is a man-made feature within Zone 3 which affects the hydrology of the upper Gunbower Forest. The Old Cohuna Main Channel is a former irrigation channel that crosses the floodplain upstream of Deep Creek. Substantial banks prevent water entering the channel from the River Murray. It is excavated into the forest floor and confined by levee banks on either side. These levee banks have been breached in places, however still impede the flow of water across this part of the forest, effectively ponding water on the upstream side (Ecological Associates 2014).

Once river levels exceed 50,000 ML/day extensive flooding of the central section of the upper forest occurs. Broad overbank flows occur at McKay Mill Bend and Bell Bend. Water from McKay Mill Bend travels across the forest and pools against the forest boundary levee where it then moves in a broad north-easterly flow path towards Red Rise.

Flows of 50,000 ML/day tend to remain within the areas which support River Red Gum with flood dependent understorey. When flows of 50,000 ML/day are sustained for more than one month, or if flows exceed 55,000 ML/day, the higher-level floodplain areas of Box woodland are inundated.

Zone 4 - Downstream section - Red Rise to Broken Axle Creek

Downstream of Deep Creek the flow path across the forest becomes more confined within incised channels between areas of higher ground. A reduction in channel capacity may contribute to flooding in the Deep Creek area. Beyond this constriction the Deep Creek Branch joins the Kate Malone Branch to form the well-defined and incised Broken Axle Creek.

Summary

The general distribution of water on the rising River Murray hydrograph in Gunbower Forest is summarised below.

Water inundation pattern for Gunbower Forest

25,000 ML/day: water first enters the Gunbower National Park and floods scroll bar systems along the river channel. Several of these areas feature deep billabongs which retain water after flood peaks pass.

30,000 ML/day: water begins to enter Deep Creek from the River Murray and spills both upstream and downstream.

35,000 – 40,000 ML/day: inflows via Deep Creek increase causing inundation of the River Red Gum forests and temporary wetlands in the central forest floodplain.

50,000 ML/day: inflows begin in floodplain watercourses in the upper part of the national park including Dry Tree Creek, Baggots Creek and at Worthy Bend. Water flows eastward, filling Pig Swamp, Emu Hole Lagoon and Baggots Creek Swamp. Flows of this size inundate River Red Gum forest and temporary wetlands and some areas of Black Box woodland when flows are sustained for more than one month.

> 55,000 ML/day: inflows into the central forest floodplain and upper forest floodplain increase causing inundation of the higher-level floodplain including Box Woodland.

7.3 Altered flooding regime of the forest

To understand the altered flooding regime of Gunbower National Park - the frequency, duration and timing of inundation - the flow pattern within the River Murray downstream of Torrumbarry was modelled. The mean daily flow series from Torrumbarry was evaluated from 1/7/1895 and 30/6/2009 (114 years) for historical 'natural' conditions, 'current' conditions (with TLM works), Basin Plan 2750 GL and Basin Plan 2100 GL. Spells analyses were undertaken for flow thresholds between 10,000 ML/day and 55,000 ML/day at 5,000 ML/day intervals (Gippel 2014).

This has provided the associated flooding regime for the forest pre and post river regulation, and the potential regime under implementation of the Basin Plan 2750 GL.

Table 7-1 and Figure 7-2 summarise the outputs.

Table 7-1: Spells analysis for downstream of Torrumbarry over 114 year modelled period

Flow threshold exceeded (,000 ML/day)	Natural conditions		Current conditions *		Basin Plan (2750,000 ML)	
	Mean frequency (events/100yrs)	Mean duration (days)	Mean frequency (events/100yrs)	Mean duration (days)	Mean frequency (events/100yrs)	Mean duration (days)
>10	103.5	204	103.5	83	113.2	133
>15	100.9	174	79.8	76	95.6	97
>20	98.2	149	63.2	77	80.7	87
>25	93.9	118	50.0	81	69.3	76
>30	83.3	101	45.6	67	54.4	84
>35	79.8	79	36.8	63	47.4	73
>40	68.4	84	37.7	39	40.4	62
>45	60.5	68	30.7	30	34.2	55
>50	51.8	53	24.6	37	28.1	35
>55	39.5	37	10.5	35	10.5	37

Source: Gippel 2014; * Benchmark conditions (run 6575)

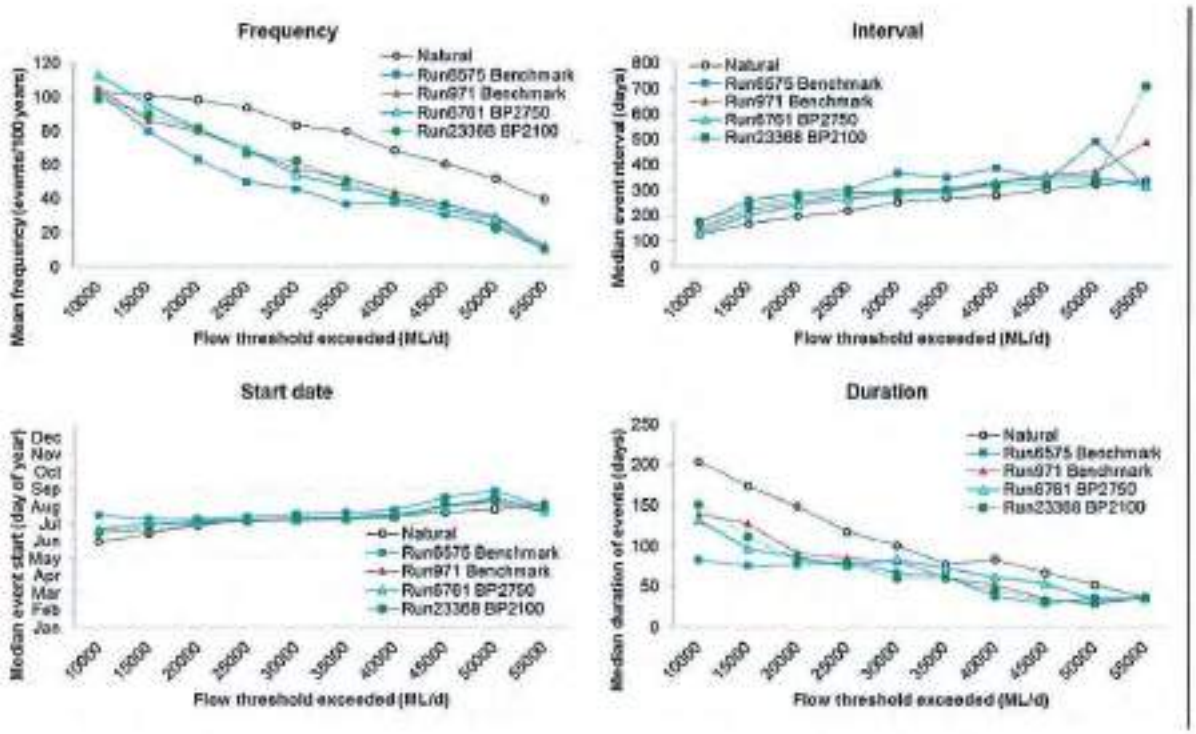


Figure 7-2: Outputs of spells analyses for River Murray at Torrumbarry (Gippel 2014).

7.3.1 Frequency

Moderate inflow into the Gunbower National Park commences when River Murray flows are greater than 35,000 ML/day (Ecological Associates 2014; Ecological Associates 2010). The modelling shows there has been significant reduction in the frequency of flood events that inundate the upper Gunbower Forest.

The most significant reduction in flooding frequency occurs in flows of 35,000 ML/day, where the flow frequency has been almost halved to 37% of years compared to almost 80% of years under natural conditions. Flows of 45,000 ML/day now occur in only 30% of years, compared to 60% naturally. Events exceeding 55,000 ML/day occur in only 11% of years compared to almost 40% under natural conditions (Figure 7-3) (Gippel 2014).

Under the Basin Plan 2750 GL scenario, there is only a minor improvement in the frequency of events of 35,000 ML/day and for flows above 40,000 ML/day (to be mimicked by this project) the improvement in frequency is insignificant.

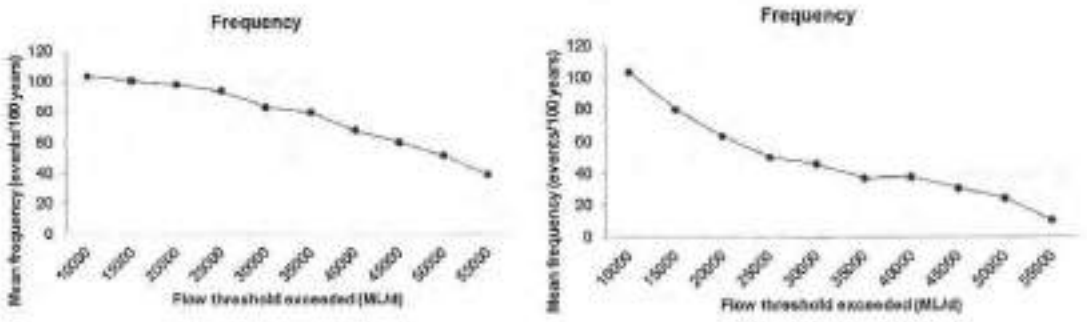


Figure 7-3: Frequency of River Murray flow events at Torrumbarry for natural and current conditions.

7.3.2 Duration

Under natural conditions the median duration of events of 40,000 ML/day and above is between two and three months, however under current conditions the median duration has been halved. For example the median duration of 45,000 ML/day flows has reduced from 2.2 months to just one month (Gippel 2014). Under current conditions there has been little change to the median duration of flows above 55,000 ML/day from what occurred naturally (Figure 7-4).

Comparing natural conditions to those under the proposed 2750 GL Basin Plan, a marginal improvement on current conditions is apparent, for flows between 40,000 ML/day and 50,000 ML/day, but a deficit in duration of flow events still remains (Gippel 2014).

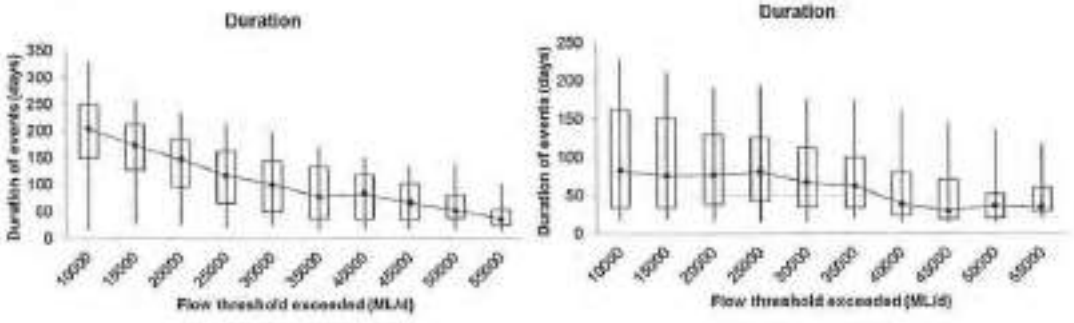


Figure 7-4: Duration of River Murray flow events at Barham for natural and current conditions.

7.3.3 Timing

The date at which flow events in the River Murray commence has low variability and is similar under all scenarios. Under current conditions flood events are now occurring later (about 4 weeks) compared to natural conditions,

especially for the larger flood events which now have a median start date at the start of spring rather than mid-winter (Gippel 2014).

7.3.4 Event interval

Under current conditions the median interval between events is significantly longer, by about two to three months, than under natural conditions across the entire discharge range (Gippel 2014).

Under the proposed 2750 GL Basin Plan the variability and magnitude of intervals is reduced when compared to current conditions (Gippel 2014).

7.3.5 Summary

The spells analysis undertaken demonstrates that current conditions have substantially departed from natural (Table 7-3). For flow events of 35,000 ML/day to 50,000 ML/day the most significant departure from the natural flow regime occurs in frequency, followed by duration. Changes to the flooding regime of the upper Gunbower Forest suggest the hydrological requirements of the upper Gunbower Forest ecosystem are not currently being met. Closing the gap between the current flooding regime and what the forest ecosystem requires is critical to maintaining the health of the Gunbower National Park.

Table 7-2: Evaluation of mean daily flow series from Torrumbarry 1895-2009

Flow threshold exceeded (ML/day)	Natural conditions			Current conditions *			Short fall from natural to current conditions	
	Mean frequency (events/100yrs)	Median duration (days)	Median start date	Mean frequency (events/100yrs)	Median duration (days)	Median start date	Mean frequency (events/100yrs)	Median duration (days)
>35,000	80	79	Mid July	37	63	Late July	43	16
>45,000	61	68	Late July	31	30	Mid August	30	38
>50,000	52	53	Late July	25	37	Early September	27	30

Source: Gippel (2014). * Benchmark conditions (model run 6575). Figures rounded to the nearest whole number.

7.4 Proposed Hydrology

Regulation of the River Murray has significantly altered the flooding regime of the Gunbower National Park, reducing the frequency and duration of inflows. The gap between current and natural flows for the priority water regime classes (at most relevant flow thresholds) are presented in Table 7-3 and Table 7-4.

The *Gunbower National Park Environmental Works Project* will mimic a natural flood event of up to 50,000 ML/day within the upper section (hydraulic zone 2) and up to 45,000 ML/day in the central section (hydraulic Zone 3) across 500 ha of the Gunbower National Park. It will do this by delivering environmental water to the forest through two new supply inlets:

1. Camerons Creek supply inlet - upgrading the natural connection of Camerons Creek to the River Murray, mimicking a natural flood event of up to 50,000 ML/day; and

2. Old Cohuna Main Channel supply inlet –constructing a new connection to the existing irrigation system, mimicking a natural flood event of 45,000 ML/day.

Table 7-3: Frequency and duration of events for 50,000 ML/day flow events in the River Murray

50,000 ML/day River Murray flow	Natural conditions	Current conditions *	Basin Plan (2750 GL)
Frequency (No. peaks per 100 yrs)	52	25	28
Mean duration (days)	53	37	50

Table 7-4: Frequency and duration of events for 45,000 ML/day flow events in the River Murray

45,000 ML/day River Murray flow	Natural conditions	Current conditions *	Basin Plan (2750 GL)
Frequency (No. peaks per 100 yrs)	61	31	34
Mean duration (days)	68	30	55

The inundation extent and area resulting from watering of the Gunbower National Park, through this supply measure, are presented in Table 7-5. Further information on the area to be inundated, the types of habitat and vegetation watered, and the net volume of water used at each site, accounting for return flows to the River Murray, is described further below for each of the supply inlets.

A description of the hydraulic models developed to inform the Project and the associated calibration/validation results, and assumptions, is provided in Appendix 5. Section 8.2 provides further detail on the range of scenarios in which watering of the forest will occur.

Table 7-5: Areas of WRCs to be watered in the Gunbower National Park

	Camerons Creek supply inlet		Old Cohuna Main Channel supply inlet		Total project area		
Water Regime Class	Area (ha) flooded	% of mapped WRCs	Area (ha) flooded	% of WRCs	Total area flooded (ha)*	Total area mapped (ha)	% of total WRC*
Permanent Wetlands	76	45	-	-	**76**	171	45
Temporary Wetlands	5	2	122	45	**127**	271	47
Red Gum with flood-dependent understorey	133	11	116	9	**250**	1253	20
Box Woodlands	31	3	17	2	**48**	1082	5
Total	**245**	8.11%	**255**	8	**500**	3025	17

* Total area not flooded by any other infrastructure

The Project will meet the watering requirements of approximately 500 ha of the Gunbower National Park. This includes almost half of permanent and temporary wetlands (45 and 47% respectively). Twenty per cent (250 ha) of the River Red Gum with flood dependent understorey will also be flooded. These water regime classes have the greatest deficit in their flooding regime.

7.4.2 Camerons Creek and Black Charlie Lagoon

The proposal for the Camerons Creek supply inlet is to mimic the inundation extent, frequency, duration and timing resulting from flows in the River Murray of up to, and including, 50,000 ML/day across the Project area (Figure 7-5). Flow events of 50,000 ML/day would have occurred approximately 52 in 100 years for 53 days prior to river regulation, and now occur about 25 in 100 years for 37 days (median duration) (Gippel 2014). Events of this magnitude would have resulted in the inundation of all wetlands and most of the River Red Gum with flood dependent understorey in the upper Gunbower Forest (Ecological Associates 2014).

Camerons Creek Regulator (upstream) (Photo G.Smith)

Inflows will be delivered via Camerons Creek. Once Black Charlie Lagoon is filled, water will spill towards the Baggots Creek area. Flows will be delivered at up to 20 ML/day and continued for approximately 14 days to achieve an inundation extent equivalent to that of a 50,000 ML/day River Murray flow across the area (Figure 7-5). Once the maximum desired extent is achieved, the Camerons Creek inlet regulator will be closed or have flow reduced to match upstream irrigation demand.

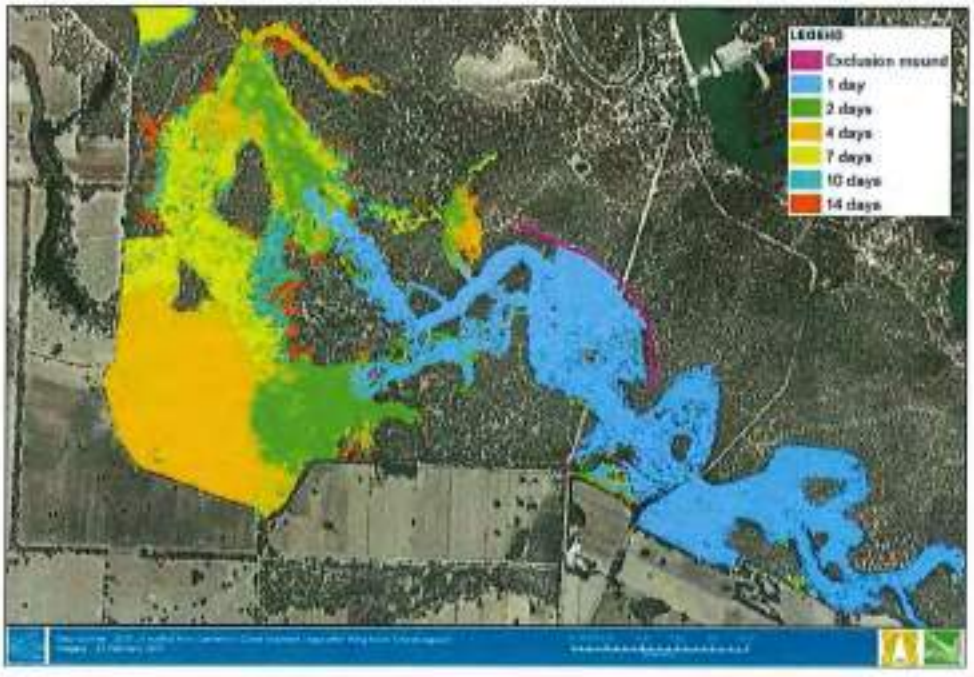


Figure 7-5: Flood extents after filling of Black Charlie lagoon for inflow rate of 20 ML/day (source Water Technology 2014)

7.4.3 Central Forest Floodplain

The proposal for the Old Cohuna Main Channel supply inlet is to mimic the inundation extent, frequency, duration and timing resulting from flows in the River Murray of up to, and including, 45,000 ML/day. Flow events of 45,000 ML/day would have occurred approximately 61 in 100 years for 68 days prior to river regulation, and now occur about 31 in 100 years for 30 days (median duration) (Gippel 2014).

Inflows will be delivered via an existing irrigation channel within the TIA (see Section 11.3). Flows will be delivered at up to 50 ML/day. After 14 days the maximum extent is achieved upstream of Deep Creek achieving an inundation extent equivalent to that of a 45,000 ML/day flooding event. Inflows can be continued for a further approximately 40 days allowing water to continue to spill downstream of Deep Creek (refer Figure 7-6) creating flow and inundation within the confined waterways and some spread onto the floodplain.

Figure 7-6: 50 ML/day inflow from Old Cohuna Main Channel to Spur Creek Island

7.6 Water use

There is no return of water to the River Murray or Gunbower Creek under the proposed operating scenarios (Section 8.2) for the Gunbower National Park. Irrigation water introduced into the forest from the Old Cohuna Main Channel will continue to flow down into the lower Gunbower Forest. The proposed watering event of a few months is not expected to be sufficient for return flows from the forest to the River Murray. However a watering event combined with Hipwell Road would return flows lower down the forest. Once the desired period of the watering event inflow has been achieved, inflows will cease and environmental water will be retained within the forest above Deep Creek before gradually infiltrating and evaporating. Downstream of Deep Creek water will continue to move down into the lower Gunbower Forest and gradually infiltrate and evaporate. The water use for each operating scenario is therefore calculated by the inflow volume (Table 7-6).

Table 7-6: Estimated water use under the proposed operating scenarios

Scenario	Inflow volume (ML)
Camerons Creek supply inlet	
Black Charlie Lagoon fill (from dry)	300
Black Charlie and Baggots creek	580
Old Cohuna Main Channel supply inlet	
Upstream of Deep Creek flooding (14 days)	700
Upstream and downstream of Deep Creek flooding (40 days)	2000

8 Environmental water requirements

8.1 Water requirements

The environmental water requirements for Gunbower National Park have been defined according to modelled natural conditions and referenced with the hydrological requirements of the ecological values present.

The primary ecological objectives for Gunbower National Park (Section 4) are:

- River Red Gum: Restore the health of River Red Gum forest with flood dependent understorey (including temporary wetlands).
- Native fauna in wetlands: Provide drought refuge habitat for fauna (particularly small-bodied native fish) through restoration of Black Charlie Lagoon.
- Waterbirds: Restore a healthy wetland bird community through improved access to food and habitat that promotes breeding and recruitment.

The indicative hydrological requirements for each ecological component described through the objectives are shown in Table 8-1. The justification for the hydrological requirements is based on a substantial (scientific based) literature review as well as input by expert ecologists. Refer to the *Ecological Objectives and Hydrological Requirements Justification Paper 2014* for Gunbower National Park for details on the scientific evidence supporting the environmental water requirements outlined below.

Black Charlie Lagoon, 2008 (before floods)
(Photo H. Kleinert)

Black Charlie Lagoon, 2011 (after floods)
(Photo North Central CMA)

Table 8-1: Indicative hydrological requirements to achieve ecological objectives (North Central CMA 2014b)

Ecological Objective	Hydrological Objectives										Relevant water regime class (*equivalent River Murray flow threshold*)
	Recommended number of events in 10 years			Tolerable interval between events once wetland is dry (months)			Duration of ponding (months)			Preferred timing of inflows	Depth (m)	
	Min	Opt	Max	Min	Opt	Max	Min	Opt	Max			
Healthy River Red Gum forests F0.1 (temporary wetlands)	5	6	6	3yrs	-	4yrs	1	-	6	Winter/ spring	Variable. Some understorey sp. prefer shallow depths <10cm during active growth but can tolerate deeper immersion for short periods.	River Red Gum forests *45,000ML/day Central forest floodplain* *50,000 ML/day Baggots Creek area*
Drought refuge habitat provided for fauna (particularly small bodied native fish) in Black Charlie Lagoon	8	10	10	0	0	0	12	12	12	Winter/ spring	Variable. Black Charlie Lagoon is 3m deep in parts Fluctuation in depth over time required to promote wetland productivity	Permanent wetlands *25,000 to 30,000 ML/day for flows into Black Charlie Lagoon*
Healthy wetland bird community through improved access to food and habitat that promotes breeding and recruitment.	3	5	10	6	12	24	4	6	12	Late winter/ spring/ early summer	Maximise area up to 30cm deep. Fluctuation in depth over time required to promote wetland productivity	River Red Gum forests *45,000 ML/day Central forest floodplain* *50,000 ML/day Baggots Creek area*

8.2 Hydrological gaps to be addressed

Modelling suggests that hydrological requirements will not be met under the Basin Plan (2750 GL) conditions (Run 6761 BP2750 daily flow time series) (Gippel 2014). This information has guided the operating regime for the supply measure (discussed in the next section), so that the hydrological deficits are addressed and the ecological objectives can be realised.

Table 8-2: Hydrological gaps in achieving the project's ecological objectives under the Basin Plan

Equivalent River Murray flow threshold	Water regime parameter	Optimum for water regime class	Basin Plan (2750ML)	Deficit to be addressed by project
25,000 ML/day	Frequency (mean)	9.5 in 10 yrs	7 in 10 yrs	2.5 in 10 yrs
	Duration (median)	253 days	76 days	177 days
	Timing (month of median event start date)	Winter/spring	July	-
45,000 ML/day	Frequency (mean)	6 in 10 yrs	3 in 10 yrs	3 in 10 yrs
	Duration (median)	68 days	55 days	13 days
	Timing (month of median event start date)	Winter/spring	July	-
50,000 ML/day	Frequency (mean)	6 in 10 yrs	3 in 10 yrs	3 in 10 yrs
	Duration (median)	62 days[1]	35 days	27 days
	Timing (month of median event start date)	Winter/spring	August	-

Source: Gippel (2014) – based on Run 6761 BP2750 daily flow time series, downstream of Torrumbarry data.

Note 1: Two month optimum duration chosen (in the interim) as this achieves the duration requirement of as many of the EVCs within the River Red Gum forest with flood dependent understorey water regime class as possible. See *Ecological Objectives and Hydrological Requirements Justification Paper 2014* for Gunbower National Park.

9 Operating regime

9.1 Overview

The Project proposes to reinstate a more natural flooding regime for the Gunbower National Park in order to support and enhance the site's significant environmental values. This will be achieved by constructing infrastructure that will enable the delivery of water, under a range of scenarios, from the River Murray and the Torrumbarry Irrigation Area into the forest. The water will be used to meet the current deficit in the flooding regime of the forest, and component water regime classes. In summary the operating regime for the Gunbower National Park package of works has been designed to:

- Increase the frequency of inundation by watering in years when there are no natural events, filling the floodplains from a dry state;
- Increase the extent and duration of inundation by complementing flooding from natural events;
- Meet the specific watering requirements of the priority ecological communities/water regime classes;
- mimic a 50,000 ML/day flood event in the Camerons Creek, Black Charlie Lagoon and Baggots Creek area, which would have occurred about 50 times per 100 years prior to river regulation and now occurs about 25 times per 100 years (Gippel 2014);
- allow managed flood events in the central forest floodplain (the central part of the upper forest) using the Old Cohuna Main Channel (officially the 2/4/1 Channel) to operate as a through-flow system that mimics the forest's natural hydrology equivalent of up to a 50,000 ML/day flood event;
- build on natural flooding through 'hybrid' watering events that add to the extent and duration of natural events;
- provide foraging areas to support large waterbird breeding events that occur in the lower forest;
- provide drought refuge areas in the upper forest to improve the security of permanent aquatic habitat availability in response to dry climate scenarios; and
- provide operational flexibility to meet the various water requirements of the flora and fauna communities.

This section outlines the proposed operating scenarios, designed to meet the hydrological requirements of the ecological objectives, and the role of operating infrastructure in implementation of the different scenarios.

9.2 Operating scenarios

Two separate, parallel scenarios have been developed. These have been designed to meet the ecological objectives of different aspects of the upper forest. The use of multiple pathways allows the Project to target specific outcomes at the same time as minimising costs, impacts and potential adverse ecological effects. The two operating scenarios are:

- Permanent wetland watering (Camerons Creek and Black Charlie Lagoon)
- Forest floodplain watering (River Red Gum and temporary wetlands)

Table 9-1presents a summary of operating scenarios and the ability to meet the flooding regime requirements of each water regime class.

Table 9-1: Overview of scenarios and their ability to meet the flooding regime requirements of the water regime classes.

SCENARIO	Permanent Wetland watering			River Red Gum watering		
Water regime class	*Frequency*	*Duration*	*Timing*	*Frequency*	*Duration*	*Timing*
River Red Gum FDU						
Permanent Wetlands						

The operating scenarios can be delivered either as stand alone watering events (into a dry forest) or as 'hybrid events', enhancing the inflow rate or duration of unregulated flows. The combined use of natural with introduced inflows generates multiple benefits (North Central CMA 2010b) such as:

- Maximising the chance of successful wetland bird breeding events by making use of climatic cues;
- Greater floodplain inundation, creating a greater food resource for waterbirds;
- Enabling use of the floodplain by native fish – an outcome that is limited through artificial delivery via the irrigation system; and
- Greater connectivity between the forest and River Murray – important for maximising ecosystem functions.

The relationship between the scenarios and the ecological objectives is outlined in Table 9-2.

Table 9-2: Summary of operating scenarios and their link to the ecological objectives

Ecological objective	Operating scenario	
	Permanent wetland watering	Forest floodplain watering
River Red Gum with flood dependent understorey		
Overarching: Healthy River Red Gum forests with flood dependent understorey (temporary wetlands).		
Achieve an appropriate cover and diversity of species characteristic of the plant functional groups found in the River Red Gum FDU.		
Maximise the proportion of trees with healthy canopy condition in the River Red Gum FDU.		
Maintain and where possible increase the current diversity of threatened flora species.		
Reduce the area of high threat weed species.		
Native fish in wetlands		
Overarching: Drought refuge habitat provided for fauna (particularly small-bodied native fish) in Gunbower National Park through Black Charlie Lagoon.		
Maintain and where possible improve the current diversity of the small-bodied native fish community in Black Charlie Lagoon.		
Promote recruitment of small-bodied native fish in Black Charlie Lagoon.		
Native birds		
Overarching: Healthy wetland bird community through improved access to food and habitat that promotes breeding and recruitment.		
Contribute to the colonial nesting waterbird community in the lower Gunbower Forest by providing foraging areas in Gunbower National Park.		
Provide suitable habitat for the threatened (EPBC-listed) Australasian Bittern in the Gunbower National Park.		
Maintain and where possible increase the current diversity of threatened wetland bird species		

9.2.1 Permanent wetland watering

Water will be delivered to Black Charlie Lagoon via Camerons Creek using the new regulator and irrigation weir. Delivery will continue until the level within Black Charlie Lagoon reaches 85.05 mAHD, to achieve the required inundation extent (16 ha). Seventy two hectares of Camerons Creek will also be watered as part of this operating scenario (Water Technology 2014a).

In summary, the indicative inflow pattern will be:

- Filling at peak flows of 20 ML/day for 15 days to fill Camerons Creek downstream of the regulator and inundate Black Charlie Lagoon to Full Supply Level (85.05mAHD).
- Closing the regulator and ponding water for at least 12 months.
- Delivering top-up flows if required.

Table 9-3 below summarises the proposed infrastructure operation to deliver water to Black Charlie Lagoon under this scenario. This represents filling from dry to full supply level – the maximum watering option except for when greater

flows and water depths/inundation areas are required to water the Baggots Creek area. Less water will be required for wetland topping up.

Table 9-3: Operating plan summary for permanent wetland watering scenario

Component	Permanent wetland watering scenario (Black Charlie Lagoon)
Frequency of delivery	10 years in 10 (no natural flooding expected)
Timing	Winter/spring
Inundated area	16 ha at FSL 85.05m (Water Technology 2014a)
Peak inflow rate	20 ML/day (Water Technology 2014a)[1]
Delivery time (days to fill from dry)	Approx. 15 days (Water Technology 2014a)
Drying time (days to dry for wetland once inflows cease)	12 months (Water Technology 2014a)
Desired duration of inundation (from hydrological requirements)	365 days (i.e. 12 mths)
Estimated total water inflow (ML) (excluding ramp up, ramp down and contingencies)	300 ML[2] (Watering from dry. Topping up if required will require less water each year)

Note 1: Accurate levels for Black Charlie Lagoon are not available. Capacity has been estimated from an average depth of 1.5 m (it is understood to be 2-3 m deep in parts) with an area of 16 ha. This is greater than the Water Technology (2014a) estimate. Field observations and local knowledge indicate that the 2-3 m depth is more realistic. Bathymetric surveys of the wetland will be required to refine this figure.

Note 2: A volume of 40 ML is estimated to be required for charging the creek downstream of the regulating structure, before water enters Black Charlie Lagoon.

9.2.2 Forest floodplain watering

The forest floodplain watering scenario aims to reinstate a more natural flooding regime for the River Red Gum FDU, including those areas supporting temporary wetlands. This scenario will contribute towards achievement of the Project's ecological objectives for the River Red Gum vegetation communities and native birds.

Water will be delivered to meet the shortfall in frequency and duration of natural flooding, and to target the water requirements of the River Red Gum FDU in two main locations:

- Central forest floodplain – 255 ha in the vicinity of the Old Cohuna Main Channel, spanning from the Munzel Road area in the south to Monro Track (Red Rise area) in the north.
- Baggots Creek area – 154 ha immediately downstream of Black Charlie Lagoon.

These locations were chosen as they contain flood dependent values over a relatively large area and can be targeted for environmental watering through minor infrastructure works.

The scenario relates to watering the forest floodplain from dry in order to achieve the desired frequency (and duration) of watering in addition to that supplied by natural events. The flooding will mimic an event up to approximately 50,000 ML/day at both locations.

Baggots Creek, exit from forest (Photo: North Central CMA)

Forest lining waterway between Black Charlie Lagoon and billabong south of Baggots Creek Track. (Photo: North Central CMA)

9.3 Infrastructure operation (from dry)

9.3.1 Central forest floodplain

Water will be delivered to the central forest floodplain by the Old Cohuna Main Channel (officially known as the 2/4/1 Channel), which is supplied off the National Channel and crosses over Gunbower Creek through a 70 m long flume. Whilst the 2/4/1 Channel capacity itself has a large cross section and high capacity, the capacity of the flume and a number of other farm/road vehicle crossing points is a constraint on water delivery into the forest from this location. Works will be required to achieve the desired flow rates of 50 ML/day.

Water will spread north and south from the Old Cohuna Main Channel inlet point, following the lower lying areas of the forest supporting temporary wetlands and River Red Gum FDU. Water flow is slowed by the banks of Deep Creek and results in upstream ponding. This inundation pattern mimics the pattern of water distribution that occurs from natural River Murray inflows. Water will continue downstream through the natural braided system that occurs to the north of Deep Creek. Downstream flow will depend on the duration of a given watering event. Within two to three days, flows will reach Spur Creek Island, and then into the lower Gunbower Forest, to the same areas as watered by TLM Hipwell Road infrastructure.

Once inflows cease, water will continue draining through the floodplain system, with some water ponding in the lower lying sections (i.e. temporary wetland environments) before being lost to evaporation and seepage.

A summary of the proposed infrastructure operation to deliver water to the central forest floodplain of Gunbower National Park under this scenario is presented in Table 9-4 and Figure 9-1. This represents the maximum use of the infrastructure i.e. water delivery to a dry forest with the aim of creating the maximum flood extent within the River Red Gum FDU.

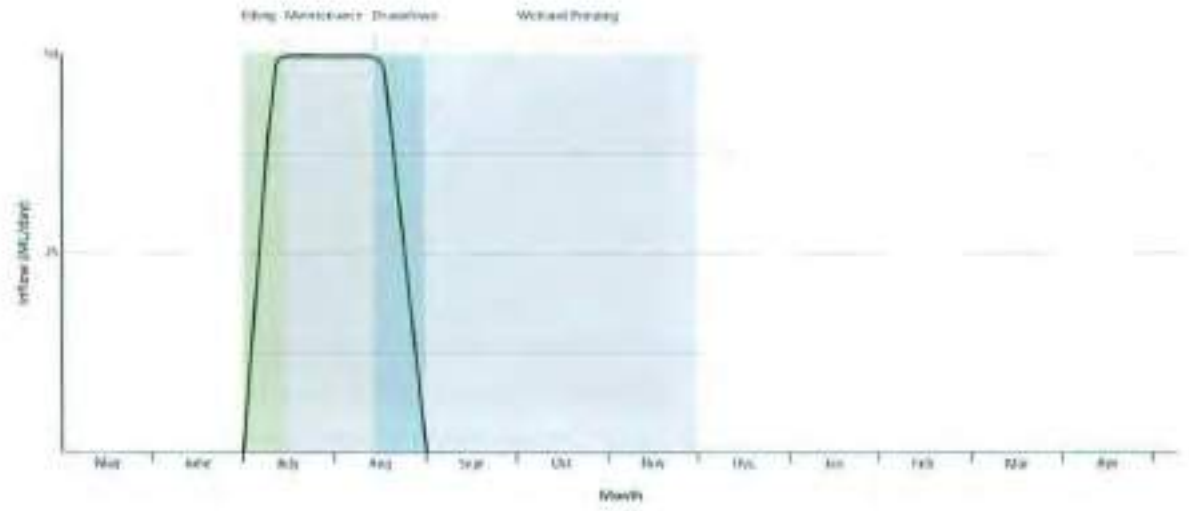


Figure 9-1: Central forest floodplain watering scenario

Table 9-4: Operating plan summary for central forest floodplain watering scenario

Component	Forest floodplain watering scenario
Frequency of delivery	3 years in 10 (inundation in other years provided through natural flooding to achieve the 6 in 10 flooding frequency)
Timing	Winter
Delivery time (days to fill from dry)	14 days (Water Technology 2014a)
Peak inflow rate (ML/day)	50 ML/day
Inundated area (ha)	175 ha – upstream of Deep Creek (Water Technology 2014a) 80 ha – downstream of Deep Creek (Water Technology 2014a)
Total water inflow (ML)	2,250 ML (45 days x 50 ML/day)
Duration of delivery once floodplain full (days)	31 days (Water Technology 2014a)
Drainage time (days to dry from full)	2 weeks to 3 months (Water Technology 2014, C. Corr pers. comm, 29 November 2014a).
Total duration of ponding (days) i.e. total length of event	90 (i.e. 3 mths approx.)

9.3.2 Baggots Creek area

Water will be delivered to River Red Gum in the Baggots Creek area immediately downstream of Black Charlie Lagoon from Camerons Creek. Inflows will be provided to achieve the maximum inundation of the River Red Gum communities, while minimising watering of the Black Box community (Riverine Chenopod Woodland).

A summary of the proposed infrastructure operation to deliver water to the River Red Gum forests in the Baggots Creek area is presented in

Table 9-5. This represents the maximum use of the infrastructure i.e. water delivery to a dry forest with the aim of creating the maximum flood extent in the River Red Gum FDU.

Table 9-5: Operating plan summary for the Baggots Creek area floodplain watering scenario

Component	Baggots Creek floodplain watering scenario
Frequency of delivery	3 years in 10 (inundation in other years provided through natural flooding to achieve the 6 in 10 flooding frequency)
Timing	Winter
Delivery time (days to fill from dry)	14 days (Water Technology 2014a) – from when Black Charlie Lagoon full
Peak inflow rate (ML/day)	20 ML/day (Water Technology 2014a)
Inundated area (ha)	76 ha – Black Charlie Lagoon and Camerons Creek (Water Technology 2014a) 170 ha – Black Charlie Lagoon and Camerons Creek (Water Technology 2014a) 245 ha total
Total water inflow (ML)	540 ML
Duration of delivery once floodplain full (days)	6 days at approximately 10 ML/day
Drainage time (days to dry from full)	40 days (Water Technology 2014a). i.e. 1.5 mths approx.
Total duration of ponding (days) i.e. total length of event	60 days (i.e. 2 mths approx.)

9.3.3 Hybrid scenario

The Hybrid operating scenario will supplement natural inflows that enter the forest from the River Murray. All opportunities to use natural inflows will be sought as they are likely to result in a greater environmental benefit compared to fully managed events. Benefits of using natural inflows include (North Central CMA 2010b):

- Maximising the chance of successful bird breeding events by making use of climatic cues;
- Greater floodplain inundation, creating a greater food resource for waterbirds;
- Enabling use of the floodplain by native fish – an outcome that is limited through artificial delivery via the irrigation system;
- Use of less environmental water allocation volume to achieve ecological outcomes; and
- Greater connectivity between the forest and River Murray – important for maximising ecosystem functions.

Extending forest floodplain inundation: Under natural conditions, inflows of 35,000 ML/day (Ecological Associates 2014) would have occurred in eight in ten years, with events lasting about 80 days on average, ranging from one to 4.5 months (interquartile range) (Gippel 2014). Under current conditions (benchmark model run 6575), flows of this size last about 63 days on average and range from one to 3.5 months (interquartile range) (Gippel 2014). The central forest floodplain ponds water for about 2.5 months on average.

- Baggots Creek area: Inflows of 50,000 ML/day are needed to achieve River Red Gum inundation in the Baggots Creek area due to regulation and effluent blockages (Ecological Associates 2014). Under current conditions (benchmark model run 6575), flows of this size last about 37 days on average for approximately 1.5 months (interquartile range) (Gippel 2014).
- Some natural floods will require intervention to extend the effective duration of flooding if the forest floodplain vegetation in the central part of the Gunbower National Park is to achieve its hydrological requirements.

  For the central forest floodplain, a continuous inflow via the irrigation system of 50 ML/day would maintain the inundation extent (Water Technology 2014a) after a late winter/ spring natural overbank flow (Gippel 2014). In practice, the delivery rate and timing would be adapted to meet the needs of each individual situation including changes in evaporation over time.

  In the Baggots Creek area, a minimum inflow of approximately 2.7 ML/day would maintain the inundation extent in this part of the forest (Water Technology 2014a) after a late winter/ spring natural overbank flow (Gippel 2014).

9.3.4 Discussion

The Old Cohuna Main Channel and Camerons Creek will be operated to mimic a variable flooding regime for River Red Gums, in terms of flood extent, timing and number of flood peaks.

A 50 ML/day inflow through the Old Cohuna Main Channel and a 20 ML/day inflow through Camerons Creek will mimic up to a 50,000 ML/day River Murray inflow, which would have naturally occurred in approximately five out of ten years.

9.4 Role of operating structures

The role of each engineering structure required for the operating scenarios is outlined below (Table 9-6).

Table 9-6: Role of structures in the operation of the project

Operating structure	Role in operations	Operating scenario(s)
Camerons Creek		
Camerons Creek Irrigation Weir and Regulator	Enables accurately controlled releases of water further down Camerons Creek to supply environmental water to Camerons Creek, Black Charlie Lagoon and the Baggots Creek area. Provides operational flexibility for permanent wetland watering and River Red Gum watering. Prevents downstream leakage of water thus removing the overwatering of vegetation as presently occurs. Enables continued water delivery to the irrigators accessing the diversions from the Torrumbarry Weir.	Permanent wetland watering River Red Gum watering Hybrid watering
Torrumbarry Weir Road weir and water level monitoring	Enables automatic control of the Camerons Creek Irrigation Weir and Regulator based on water level to provide downstream flows to Black Charlie Lagoon and Baggots Creek area.	Permanent wetland watering River Red Gum watering Hybrid watering
Black Charlie Lagoon water level monitoring	Enables automatic and remote monitoring and control of water inflows to Black Charlie Lagoon by controlling the Camerons Creek Irrigation Weir and Regulator and thus the flow of the Torrumbarry Weir Road weir.	Permanent wetland watering River Red Gum watering Hybrid watering

Operating structure	Role in operations	Operating scenario(s)
Old Cohuna Main Channel		
Farm Crossing Replacements	Enables a greater water delivery rate down the restricted Old Cohuna Main Channel to maximise flows to the central forest floodplain (River Red Gum forests).	River Red Gum watering Hybrid watering
OCMC Irrigation Forest Supply Regulator	Enables control of water outflows from the Old Cohuna Main Channel and into the central forest floodplain (River Red Gum forests).	River Red Gum watering Hybrid watering
OCMC Flood Regulator	Controls outflows from the floodplain during a major river caused flood. This regulator is located within the existing Gunbower National Park flood protection levee.	

9.6 Operational considerations

The *Gunbower National Park Environmental Works Project* proposes to supply water to the forest via Camerons Creek and the Old Cohuna Main Channel, which are used to supply irrigation water to local irrigators. Camerons Creek diverters are private diverters and take water directly off the Torrumbarry Weir pool. The Old Cohuna Main Channel is part of the Torrumbarry Irrigation Area. The successful implementation of operating scenarios therefore depends on the physical capacity of the system to deliver the required flows at a particular time of year while meeting the demand from other customers.

In Victoria, environmental water can currently access the irrigation network via the following means:

Delivery Share: Entitles the holder to a 1 ML/day share of the channel system capacity during the irrigation season (15 August to 15 May). Priority access is given to delivery share holders.

Casual User: A guaranteed supply once order is placed. First to lose access if water restrictions or demand from delivery share holders.

Interruptible Supply: Lowest level of security with access only available once other customers' demands met.

Note: this is the current framework for delivery of water within Victoria and is subject to change. Under current operational conditions, it is proposed that the majority of water delivered to the Gunbower National Park would be provided as interruptible supply. The following section discusses this in more detail.

9.6.1 Torrumbarry Irrigation Area

The Torrumbarry Irrigation Area covers 167,000 ha in northern Victoria and extends along the River Murray from Gunbower in the east to Nyah in the west and includes the towns of Koondrook, Cohuna, Kerang and Swan Hill (G-MW 2009). It is managed by GMW and consists of a complex distribution network of natural waterways and 1400 km of manmade irrigation channels.

The district originates from Torrumbarry Weir where water from the River Murray is diverted through the National Channel Offtake into the National Channel. The National Channel (approximately 4,000 ML/day capacity) is a straightened and enlarged section of what was originally Gunbower Creek. Water can either be diverted into Gunbower Creek at Gunbower Weir, or continue down Taylor's Creek to supply the Number 1 and 2 channel systems, or enter into storage at Kow Swamp. Gunbower Creek has a number of weirs and regulators that feed irrigation channels and supply wetlands in the Gunbower Forest (e.g. Reedy Lagoon and Black Swamp) (North Central CMA 2010b).

9.6.2 Old Cohuna Main Channel

Delivery to the central forest floodplain is constrained by the 50 ML/day capacity of the existing flume over Gunbower Creek. Given this flume is required to supply irrigators, the ability to deliver the full capacity of the flume (50 ML/day) into the forest to achieve the desired inundation extent, is restricted to the irrigation off-season (May to August).

It is intended that environmental water deliveries to the River Red Gum areas of the central forest will occur on average three years in ten under Basin Plan (2750 GL) conditions. More frequent watering may be required in the absence of natural floods (e.g. during drought periods). With ongoing communication, it is expected the three year in ten delivery schedule will result in few conflicts with GMW's channel maintenance/capital works program that occurs

over winter. However, it is important to note that capacity availability has not been modelled and will require confirmation prior to implementation of the Project.

9.6.3 Camerons Creek

Camerons Creek is currently used by eight surface water diversion customers as a source of irrigation supply to their properties. The required capacity at the offtake for Camerons Creek and the diverters channel has been estimated on the basis of the Rural Water Commission's method of equivalent outlets at 50 ML/day (GJM Civil 2014). The hydraulic modelling undertaken estimated the Camerons Creek capacity at 180 ML/day (Water Technology, 2014a).

While operation of Camerons Creek is linked to River Murray operations, given the inflow volumes are small and required for short periods in winter, capacity constraints are not an issue for environmental water delivery to the Baggots Creek area. Camerons Creek is used by regulated River Murray diversion customers. However, environmental watering will pose no impact to the ability of these irrigators to access their entitlements.

10 Socio-economic impacts from operation

The methodology for assessing the risks has been briefly outlined in Section 6 and further information is provided in the Project's *Risk Management Strategy*. Potential adverse ecological impacts are discussed in Section **Error! Reference source not found.** and the Project development and construction risks are discussed in Section **Error! Reference source not found.**.

This section describes the potential adverse impacts that may result from operation of the supply measure on:

- socio-economic values and
- cultural heritage values.

10.1 Overview

Gunbower National Park is a multi-use site with a range of social and economic values and benefits for local and regional communities. Commercial uses include apiculture (bee keeping) and tourism. A social impact assessment study undertaken in 2009 identified that the level of expenditure in local shops increased by 33% in busy holiday periods from visitors to the forest (SKM 2007). The creation of the National Park in 2010, excluded previous, higher impact economic uses of the forest including grazing, hunting and timber harvesting.

Social and recreational uses include low impact activities such as camping, fishing, swimming, boating and horse-riding.

The results of the risk assessment to social and economic values of the forests are shown in Table 10.1.

Table 10-1: Priority socio-economic risks

Risks	Initial risk			Residual risk		
	Likelihood	Consequence	Rating	Likelihood	Consequence	Rating
Loss of access for recreation	Likely	Moderate	High	Possible	Minor	Moderate
Loss of cultural heritage	Possible	Major	High	Rare	Major	Moderate
Negative impacts of flooding on apiary	Likely	Moderate	High	Possible	Minor	Moderate
Damage to relationships with Aboriginal stakeholders	Possible	Major	High	Unlikely	Moderate	Moderate
Third party flooding	Likely	Moderate	High	Unlikely	Minor	Moderate

Environmental watering in the upper forest will temporarily reduce access in years when watering is taking place, as would be the case when natural flooding occurs. This will restrict social and economic uses of the forest which are dependent on access to these resources. The social benefits of flooding, such as increased opportunities for recreational uses and improved aesthetics of the forest, will offset some of the potential impacts.

The Project overall will help to restore and maintain socio-economic recreational and tourist values - albeit at the risk of limiting access for periods of time. The cost benefit assessment in Section 13.8 confirms the major potential benefits from enhanced watering for recreation and the regional economy. The mitigation controls involve a number of elements described in further detail below.

10.2 Loss of access

Rights of access to the forests to manage beehives are subject to licences. Standard licence conditions include that the licensee may be required to remove bee hives from, or not place bee hives within, the licence area to allow the public land manager to conduct management operations (DEPI, 2014b). Early warnings to bee-keeping licence holders before watering commences will allow time to adjust operations. For example, bee hives may be placed on the outer edge of the flooding extent, and the bees can still use the forest, which is likely to have more flowering as a result of the flooding. With these controls in place the residual risks for apiculture is deemed to be 'possible' with a 'minor impact' generating an overall risk rating of 'Moderate'.

The *Stakeholder Management Strategy* (discussed in Section 13) will be updated following approval to proceed with the Project. Key engagement and communication activities will be informed by the particular phase of the Project and the individual needs of the key stakeholders. Clear and timely communication of planned watering activities will be a key component of this. Engagement with tourist information centres to ensure that visitors have appropriate and up-to date information will be one tool utilised to ensure the impacts of flooding of the national park is reduced.

The North Central CMA prepares annual seasonal watering proposals for all sites that are to receive environmental water, under Victoria's environmental water allocation framework. Developing the proposals involves consultation and engagement with environmental water advisory groups, comprised of interested community members and stakeholders. This process ensures that all parties' interests are considered in planning and implementing any watering event.

The Project overall will help to restore and maintain socio-economic recreational and tourist values - albeit at the risk of limiting access for periods of time. The cost benefit assessment in Section **Error! Reference source not found.** confirms the major potential benefits from enhanced watering for recreation and the regional economy.

10.3 Cultural Heritage

Flooding of the Gunbower National Park has the potential to impact on cultural heritage sites by inundating areas of cultural sensitivity. The cultural heritage management plan, in development for the Project, will ensure that these impacts are considered in the implementation and operation phases. In addition, the North Central CMA is undertaking project work with Gunbower Forest's Traditional Owners to progress the development of meaningful cultural flow objectives to enhance and complement the ecological objectives for forest.

10.4 Third party flooding

The Upper Gunbower forest is bordered to the south by agricultural land. Historically, this agricultural land would have formed part of the Gunbower Forest. The cleared agricultural land however is now protected by a system of levees to provide protection from natural flood events. There is a risk of third party impacts associated with private land flooding should the levees fail.

In order to demonstrate that this risk can be adequately mitigated for this proposed supply measure, an informed risk assessment was undertaken (Water Technology 2014a), accompanied by the development of a comprehensive suite of potential risk mitigation options. This assessment was underpinned by scenario-based hydraulic modelling (DHI 2014, Water Technology 2014a) and levee condition assessments (DHI 2014; Water Technology 2014a). The hydraulic modelling reports and the risk assessment were reviewed by the Expert Review Panel for Victorian supply measure business cases, who determined the process and work undertaken to be 'fit for purpose' (see *Summary Report of Expert Peer Review Panel Outcomes* in the supporting documents).

The risk assessment (Water Technology 2014a) indicated that the risk of levee failure varied considerably depending on location. Potential mitigation options are aimed at both reducing the likelihood of levee failure/overtopping and minimising consequences or avoiding litigation if a levee failure/overtopping did occur. Table 10-2 provides a summary of the mitigation options that will be further investigated for their implementation viability during the detailed design phase (i.e. post-business case submission). It is anticipated that potential mitigation options will be assigned to each risk category (e.g. low/moderate/high/extreme) at this time.

Table 10-2: Potentially Viable Mitigation Measures for Further Consideration.

Option Aim	Mitigation Options
To reduce the likelihood of failure/overtopping	• Levee upgrades • Levee maintenance* • Monitoring levee condition • Manage rates of rise /drawdown during watering
Minimise consequences if failure/overtopping occurs	• Emergency response procedure • Communications plan • Upgrade existing management to provide mitigation • Raise access roads and tracks
Avoid litigation if failure/overtopping occurs	• Landholder agreements • Floodway easements

*Note that levee maintenance can be enabled in a variety of ways however all require permits under relevant legislation.

In presenting the risk assessment in this business case, it is noted that key policy matters that will inform the final risk management strategy for this proposed supply measure cannot be formally determined at this time. This includes any final decision-making on which mitigation options will be selected for implementation, including who owns and maintains the levees.

DEPI will be in a position to provide more formal advice on the state's preferred long-term risk mitigation arrangements for this supply measure once the full suite of Victorian proposals under the SDL adjustment mechanism has been more definitely scoped. This will occur as early as possible in 2015.

11 Technical feasibility and fitness for purpose

11.1 Overview

This section of the Business Case provides an overview of the technical feasibility of the Project's infrastructure package. It outlines the options analysis, design criteria and the location and features of the infrastructure. The information presented is a summary from the *Concept Design Report* for Gunbower National Park, which includes the concept design report, design drawings, and construction cost estimates (URS 2014).

11.2 Options analysis

A number of background investigations and studies were undertaken to inform and support the selection of an infrastructure package for the Project. Alternative options were assessed on their benefit, feasibility, cost and risk and included significant input from partner agencies and the Expert Review Panel. A summary of the design principles and options assessment is provided below.

11.2.1 Design principles

A suite of principles were applied to guide the development of cost effective and appropriate engineering solutions to meet the flooding requirements of the Gunbower National Park. These were:

- Natural patterns: Build on and mimic natural flows and flow paths
- Targeted: focus on the specific watering requirements of priority ecological vegetation classes
- Minimum impact:
    - Low intrusion footprint: build assets in already disturbed areas or outside the National Park
    - Minimise adverse impacts on the forest and risks of overwatering of other EVCs
    - Minimise impacts on third parties, e.g. an inundation pattern to minimise pressure on levee banks
- Effective: robust simple assets that will be effective and resilient over time
- Flexible: capable of adaptive management to respond to the outcomes of the monitoring program to meet the various water requirements of the flora and fauna communities and to respond to climate change.
- Low cost: to construct and operate.

11.2.2 Options assessment

The Phase 1 Feasibility Study proposed a large-scale engineering solution to the inundation deficit in the upper forest. This involved the construction of a major channel to convey environmental water from the Torrumbarry Weir pool into the forest. The channel proposed was 280 m in length, 30 m in width and supplied through three overshot flume gates, each 2.3 m wide and 2.2 m high.

In Phase 2, further investigation of this option revealed that the channel option did not meet the design principles. Construction of the channel would have required significant native vegetation removal, adversely impacting on a high value area of the forest. A lack of operational flexibility and control would also have resulted in over watering of terrestrial vegetation communities - Box woodlands - causing damage to the ecological integrity of the site. The

option was therefore rejected and alternative infrastructure options were scoped. These alternative options focussed on delivering water to meet the specific flooding regime requirements of the water dependent vegetation communities in the upper forest, while avoiding inundation of the less flood tolerant communities.

The resulting options were to deliver water through:

- Camerons Creek into the high value permanent wetland - Black Charlie Lagoon - and provide watering to River Red Gum surrounding the wetland in the upper part of the forest.
- Old Cohuna Main Channel to provide broad scale inundation of River Red Gum, in the middle and lower parts of the forest.

11.2.3 Camerons Creek and Black Charlie Lagoon

Black Charlie Lagoon is the only permanent wetland in the Gunbower National Park and is the deepest wetland in Gunbower Forest. Supplying environmental water to Black Charlie Lagoon will enable the provision of permanent refuge habitat, which is particularly important during dry conditions. The proposed works involve enhancing the natural connection between Black Charlie Lagoon/Camerons Creek and the River Murray.

Flows into Camerons Creek from the Torrumbarry Weir pool are controlled by a regulator which supplies an irrigation channel used by six irrigators. A further two irrigators pump directly off Camerons Creek downstream of the regulator, although the marshy nature of the creek and channels in this location means their water supply can be intermittent and substandard (Corr, C 2014, personal communication, 22 September) (Figure 11-1).

Figure 11-1: Schematic of existing Camerons Creek infrastructure (URS 2014)

The regulator on Camerons Creek leaks resulting in water inflowing into the downstream Black Charlie Lagoon throughout the year, and overflowing into the Baggots Creek area of the upper forest. This leakage causes unseasonal ponding in the Baggots Creek area. This has caused degradation of the local vegetation community (Frood & Bennetts 2014).

The proposal for Camerons Creek involves establishing better controls on inflows to provide operational flexibility and mimic flows of up to 50,000 ML/day, while maintaining the supply of irrigation water to the diverters (GJM Civil 2014).

Options assessed ranged in price from $2.56 million to $7.21 million (Table 11-1). These involved combinations of weirs, regulators, channels and pipelines.

Table 11-1: Options assessed for Camerons Creek works

#	Option	Description	Cost ($m)
1	Standard engineering	Proceed with traditional engineering solution	$7.21
2	Share the creek	Improve the creek to enhance flow	$3.50
3a	Weir & pipeline	New inline weir - reinforced concrete pipeline	$5.87
3b	Weir & channel	New inline weir and earthen channel	$5.18
4a	Pump and pipeline	Pump station, reinforced concrete pipeline	$3.84
4b	Pump and channel	Pump station and earthen channel	$4.03
5	Structural adjustment	Buy out diversion licences, decommission assets	$2.56

Source GIM Civil (2014)

The preferred option that is cost effective and will generate minimum disruption is Option 2.

11.2.4 Central Forest floodplain

The central forest floodplain within Gunbower Forest includes significant areas of River Red Gum forests with shallow wetlands. Watering this area will contribute towards the Project's ecological objectives and targets for River Red Gums and native birds.

A number of design flows, 50 ML/day to 200 ML/day, were modelled and the associated infrastructure costed, to determine the most effective infrastructure option. Flows above 50 ML/day increased infrastructure costs significantly as an upgrade of the existing flume and an increase to the capacity of farm crossing culverts as well as larger regulating structures, would be required. Increasing inflows to the central forest above 50 ML/day inundated only a small additional area of floodplain. Therefore, the utilisation of the existing capacity within the irrigation system, while accommodating irrigation demand, was identified as the preferred option. The flooding extent resulting from inflows is presented in Figure 7-6.

11.2.5 Baggots Creek area

Water currently ponds in the Baggots Creek area for an extended period due to leakage from Camerons Creek and the restriction of flows by the perimeter levees. A number of options were considered for this area including:

- Maintaining flows to the Baggots Creek area but providing permanent drainage to alleviate extended ponding against the levee and prevent further degradation of the local vegetation community. This would result in about 5-10 hectares of terrestrial Grey Box (EPBC-listed Plains Woodland) being inundated. This was considered to be an unacceptable impact. This was also a high cost and high risk activity given the proximity of private land.
- Reduce flow rates and rely on temporary pumping to remove ponded water (from natural and environmental watering) from Baggots Creek to an area in the forest 2 km downstream with a higher dependency on water. Temporary pumping represented a lower cost option compared to the higher cost of permanent drainage works at Baggots Creek but still risked inundating Grey Box woodland.
- Limit flows through Black Charlie Lagoon to restrict inundation to a smaller area of River Red Gum with flood dependent understorey. This approach reflects the most recent understanding of the flooding requirements of

the relevant EVCs in the Baggots Creek area. This option minimise risks of over-watering or the potential for inundation of private land.

The third option was identified as the preferred option, as it generated the best environmental outcomes in line with the Project objectives and targets, at least cost and risk.

11.2.6 Other options

A number of additional options were considered and discarded as they did not meet the design principles or make a significant contribution to the overall project objectives.

Forest inflows via Old Straight Cut Channel through Pig Swamp

This option involved delivering flows to the lower forest from the Old Straight Cut Channel through Pig Swamp. In order to transfer the flows downstream into the forest it would have been necessary to construct a channel between 50 m and 120 m wide.

This option was discarded as it required extensive, intrusive, high cost works that would impact on the forest. The EVC in the vicinity of the required channel to the north of Pig Swamp is Riverine Chenopod Woodland (EVC 103), which is endangered in the Murray Fans Bioregion.

Forest inflows via Deep Creek

An alternative option for watering the lower forest was to source water from Deep Creek. However, irrigators in this location pump water from the irrigation system, indicating there is insufficient hydraulic head to support a gravity flow (Lacy, P 2014, personal communication, 4 September). Delivery of environmental water into the forest floodplain via Deep Creek would therefore require pumping, which would require a new pump station and potentially dredging and replacement of crossings.

This option was less appealing than other gravity fed options (Old Straight Cut Channel, Old Cohuna Main Channel) due to the need for pumping and the higher operational costs associated with pumping options (RMCG 2014). In addition Deep Creek is downstream in the floodplain, limiting the area upstream that can be effectively flooded.

11.3 Proposed package of works

The location of works to deliver the required inundation outcomes in Gunbower National Park are shown in Figure 11-2. Refer to the *Concept Design Report* which includes the brief and design drawings (URS 2014).

Camerons Creek Regulator: Construction of a new irrigation weir and regulator structure to provide controlled environmental flows from upper reaches of Camerons Creek, connected to the Torrumbarry weir pool, into the lower reaches of Camerons Creek and Black Charlie Lagoon and beyond to the Baggots Creek area. The same regulator will also provide irrigation supply to two current Camerons Creek diverters via irrigation supply works required approximately 1.5 km downstream of the new irrigation weir regulator.

Baggots Area Temporary Pumping: Provision of works to facilitate temporary pumping to drain the low lying Baggots area where it is contained by surrounding levees and pump water some 2 km further down the forest.

Old Cohuna Main Channel (OCMC): Enhancements to the OCMC (2/4/1 Channel) to enable inflows to the lower half of the Gunbower National Park. Works include construction of a regulating structure to control flows and a flood control regulator to retain flooding within the forest from high river flows.

The above package of works will enable the provision of water to approximately 500 ha of Gunbower National Park currently unable to be watered by any other infrastructure.

11.4 Project design criteria

The development of concept designs for the engineering works, required to deliver environmental water to the upper forest, were guided by the following overall design criteria:

- Facilitation of forest or targeted wetland watering/flooding from the River Murray via Camerons Creek and/or Torrumbarry Irrigation District via the Old Cohuna Main Channel (2/4/1/ Channel).
- Provision of the following design inflows:
    - up to 50 ML/day via Camerons Creek from the River Murray.
    - 50 to 100 ML/day via Old Cohuna Main Channel from the No.1 Channel and the National Channel.
- Fully automated operation of inflow control structures.
- Access to each structure at all times during watering events and in forest floods, by use of the existing public roads, forest tracks and / or new access tracks.
- Containment of water within the forest.
- Drainage of ecologically sensitive forest areas to prevent overwatering by natural river floods including the Baggots area.
- Provision of safe downstream fish passage for small bodied fish through all new regulating structures.
- Provision of carp / large bodied fish screens to prevent large fish entering the floodplain.
- Provision of erosion protection works.
- Maintenance of the existing level of flood protection of private land from inundation events where new infrastructure is to be introduced.
- Consideration of environmental and cultural heritage impacts.
- Incorporation of Safety in Design principles.
- Minimisation of operation and maintenance costs.

Figure 11-2: Package of works – Gunbower National Park (URS 2014)

11.5 Key design features

11.5.1 Camerons Creek regulator

An existing regulator sits within a weir embankment at the site and is dilapidated and in disrepair. The existing regulator has manually removable drop boards and leaks extensively both through and around the structure.

It is proposed to construct a new regulating structure within a new embankment, immediately downstream of the existing installation. The regulator will consist of concrete (precast) box culverts containing flume gates, and include a walkway for maintenance access over the regulator Figure 11-3.

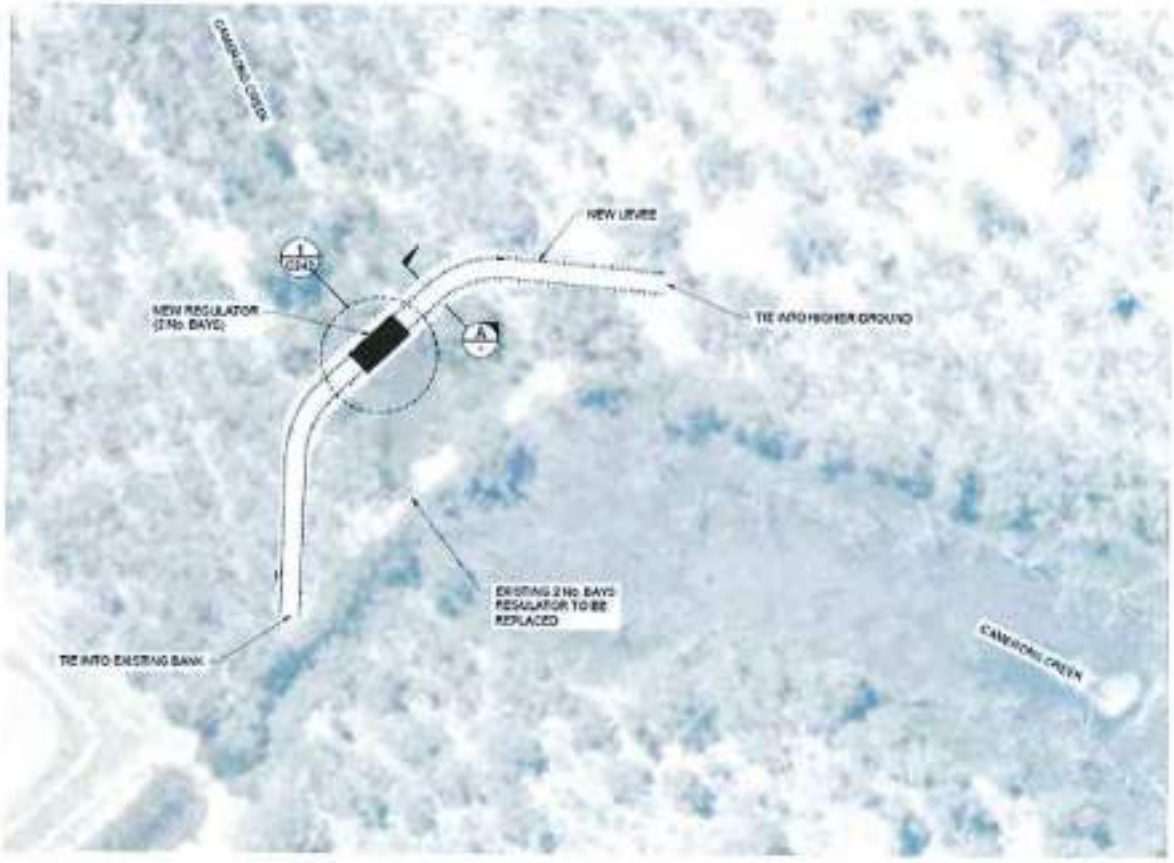


Figure 11-3: Location of Camerons Creek Regulator Irrigation Supply works (URS 2014)

Upstream and downstream key walls have been included along with rip rap and a carp screen to achieve plunge pool type conditions permitting safe passage for small fish downstream through the structure. Upstream and downstream rock beaching has been designed to minimise erosion and scour around the structure. To prevent piping failure, it is anticipated that a sheet pile cut-off wall will be required directly below the regulator and extend to a depth of at least 5 m. A secondary row of sheet piles is also likely to be required to a similar depth along the downstream aspect of the regulator base slab.

A two bay regulating structure containing flume gates (FGB-1675-0674) is proposed, each gate with a flow area of 1.8 m width and a height of 0.8 m. The structure is expected to pass up to a total of 134 ML/day with the two gates which surpasses the design criteria of 50 ML/day. Two gates are proposed so that, in the case of the failure of one of the gates, the structure can continue to regulate flow. This provides structure redundancy and future operational flexibility, if in practice a higher regulated flow is required. Additionally this regulator will essentially operate throughout all of the year so a level of redundancy is considered appropriate.

It is anticipated that the existing weir embankment will act as a coffer dam during construction and assist with dewatering of the new structure downstream.

Estimated costs for these structures are provided in Section 13 with further detail in the *Concept Design Report*.

11.5.2 Irrigation supply works

About 1.5 km downstream from where the new regulator is proposed on Camerons Creek, infrastructure works will be required to maintain irrigation supply for two irrigation diversion customers and allow for environmental watering of Black Charlie Lagoon, lower Camerons Creek and the Baggots Creek area.

A small diversion bank and weir will be constructed on Camerons Creek to divert low flows into an irrigation channel adjacent to Torrumbarry Weir Road to enable a pumping supply rate of 25 ML/day at a new combined offtake (sump) location for the two irrigation diversion customers. From the sump, a pump hardstand, power supply and rising main will be required to reinstate irrigation supply to one of the irrigation diversion customers Figure 11-4. Overtopping of the fixed crest weir will provide a measurable capacity of up to 20 ML/day to enter Black Charlie Lagoon and the Baggots Creek area to meet environmental water requirements.

Figure 11-4: Location of Camerons Creek Irrigation Supply works (URS 2014)

Estimated costs for these structures are provided in Section 13 with further detail in the *Concept Design Report*.

11.5.3 Baggots Creek area drainage/pumping

The perimeter levee bank around the Baggots Creek area provides protection to private land against risks of inundation. However, the levee results in pooling of flood waters, and presently water from the leaking Camerons Creek regulator, leading to inappropriate watering and degradation of the vegetation communities.

The package of works (Refer to Figure 11-5) involves the provision of temporary pumps and piping to transfer this artificial pooled water from the Baggots area to a location further down the forest. Given the occasional and opportunistic basis for the pumping, the concept design is based on the provision of temporary infrastructure to reduce the footprint in the forest. This will require the construction of an access road, sump, and pump slab.

The costs do not include works required to remove trees within the construction footprint or to provide access along the levee crest to lay the temporary piping when required. An alternative alignment that could be further investigated during detailed design would be to align the temporary pipeline within farmland immediately outside the forest.

Estimated costs for these structures are provided in Section 13 with further detail in the *Concept Design Report*.

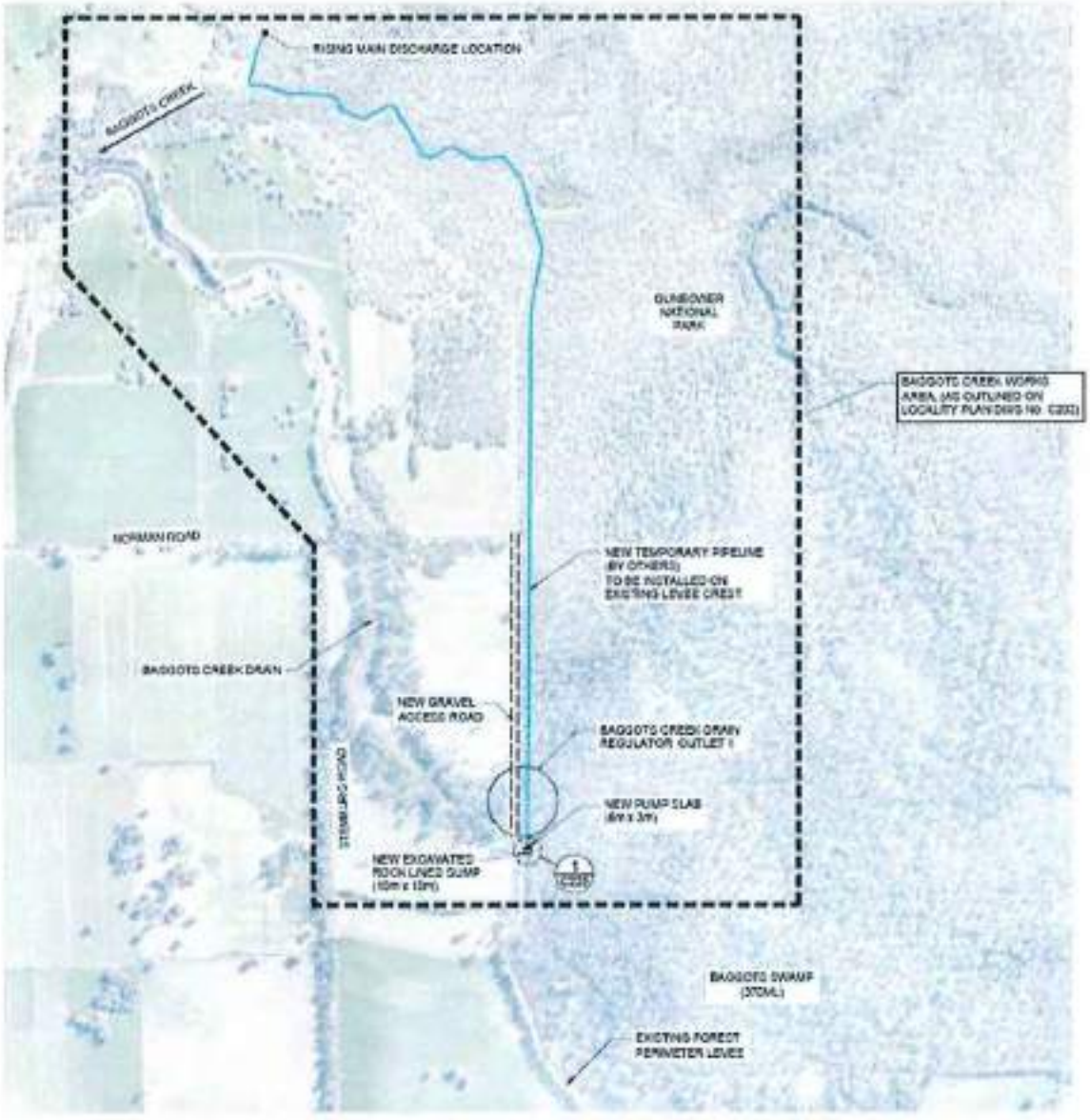


Figure 11-5: Baggots Area Temporary Pumping (URS 2014)

11.5.4 Old Cohuna Main Channel

The Old Cohuna Main Channel (2/4/1 Channel) provides a supply mechanism to enable effective inundation of the central forest floodplain both upstream and downstream of the channel Figure 11-6. The works involve a number of elements including:

- Replacement and upgrading of three farm crossing culverts to achieve 50 ML/day.
- Offtake and outlet (Flood Protection) regulators

- The offtake regulator at the end of the channel backbone will have cast in situ guide walls designed to support the proposed flume gates (three of FGB 1675-1437) and facilitate bulk heads for maintenance dewatering.
- The outlet regulator will be located within the flood protection levee where a stopbank currently exists within the channel with the channel continuing into the forest. Box culverts will be designed to support the two AWMA dual leaf gates.

For both regulators, upstream and downstream key walls have been included along with rip rap to achieve plunge pool type conditions permitting small fish travel and to minimise erosion and scour around the structure. Overshot gates will provide suitable flow conditions for small bodied fish movement. Undershot gates will provide for flow during periods of low head drop across the structure. To prevent against piping failure a sheet pile cut-off wall will be required directly below the regulator and extend to a depth of at least 5 m. A secondary row of sheet piles is also likely to be required to a similar depth along the downstream aspect of the regulator base slab. A grated steel walkway including handrails has been included to provide maintenance access over the regulator, along with access to the bulkheads and flume gates.

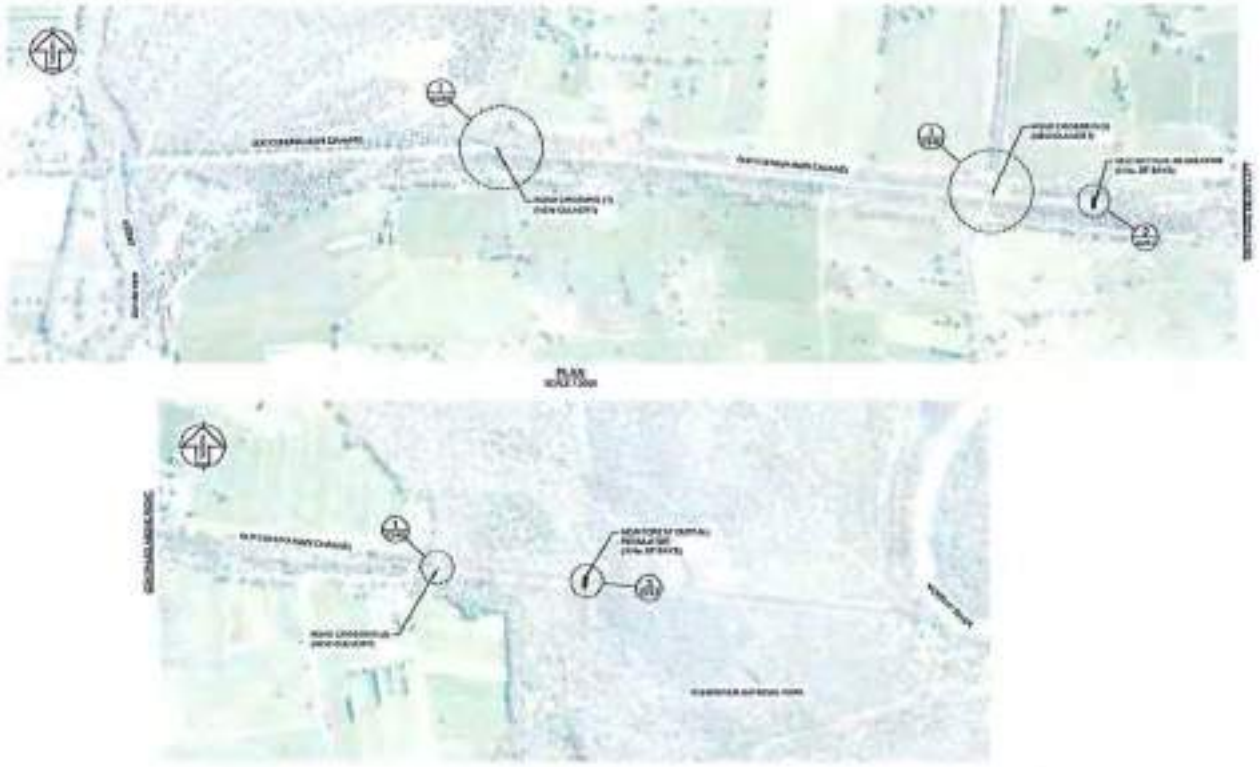


Figure 11-6: Old Cohuna Main Channel – Central forest floodplain watering (URS 2014)

The existing flood protection levee will require repair work at specified points (Water Technology 2014b) and a new levee access track will be required for ongoing monitoring and maintenance of the levee.

In addition to structural levee repair, at project construction, the levees will be inspected by an experienced engineer and arborist and all vegetation removed from the levee and its immediate surrounds either side of the toe of the levee where in the professional opinion the risk to the levee will be reduced by its removal. This process would potentially result in further minor points of weakness being identified and rectified where necessary.

Inspections and maintenance will be conducted to prevent inappropriate vegetation growth and the ongoing condition of the levee monitored and repaired where necessary. With ongoing inspections and maintenance, this low risk profile is considered manageable.

Estimated costs for these structures are provided in Section 13 with further detail in the *Concept Design Report*.

11.5.5 Ancillary works

A number of complementary ancillary works have been identified to enhance the effectiveness of environmental watering events. In addition, ancillary works have been identified to assist with maintenance of existing perimeter levees. It should be noted that cost allowance estimates only have been developed. No design and only limited on site verification of these works has been undertaken.

Remedial/bank works along northeast side of Black Charlie Lagoon and Camerons Creek

These works are designed to avoid flooding of Black Box (Riverine Chenopod Woodlands) during watering events from Camerons Creek regulator.

The short mound to the south will be approximately 50 m long and average 200 mm high (the 200 mm will act as freeboard). The long mounds to the north will consist of two mounds: the mound to the west will be approximately 350 m long and the mound to the east will be approximately 50 m long.

Both mounds will have an average height of 400 mm with approximately 200 mm of freeboard. All mounds will be approximately 1 m wide. A one way flap valve will be included in the western long mound to provide the ability to drain the adjacent woodland area. These works are highlighted in Figure 11-8.

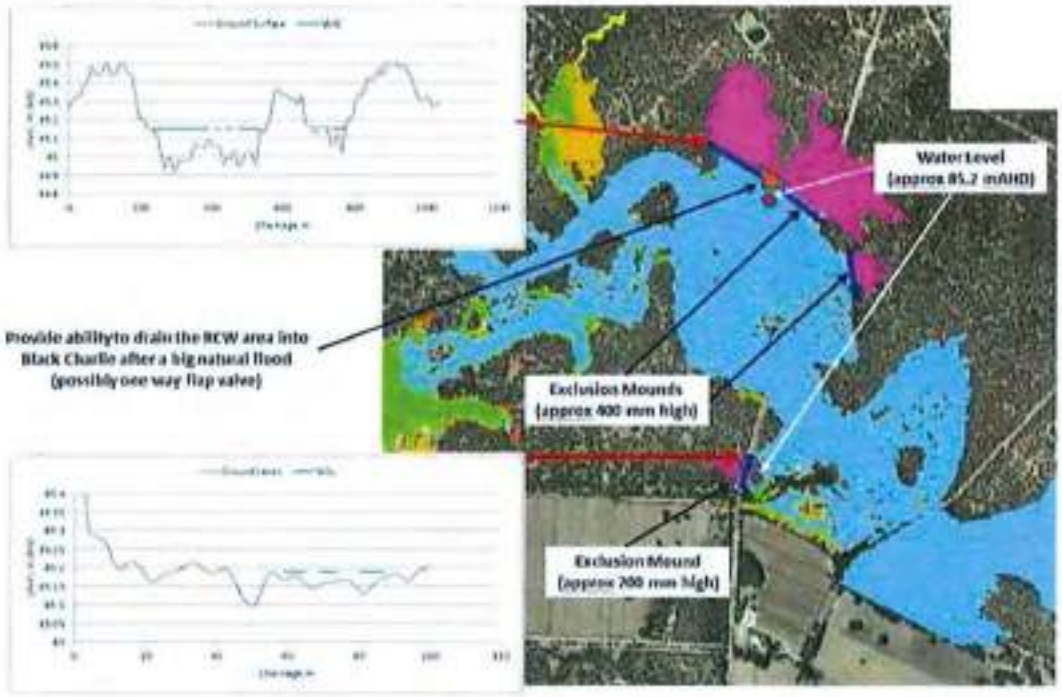


Figure 11-8: Black Charlie Area Exclusion Mounds

Remedial works within Camerons Creek

These works will be between the River Murray and the proposed Camerons Creek Irrigation Weir and Regulator to increase flow rate (if water level / flow drops excessively under required demands). The following remedial works are proposed:

- Minor earthworks, including defouling of the creek from Camerons Bridge at the river forest track to Camerons Creek (a distance of approximately 1 km)

- Remove vegetation within the creek.

In-forest works at Deep Creek

These are works at Deep Creek or other locations to improve hydraulic efficiency and inundation effectiveness of forest environmental watering flows (depending on hydraulic performance). Proposed works include excavation and remove vegetation at various locations at Deep Creek and providing erosion protection at various locations.

New levee access tracks for existing perimeter levee monitoring and maintenance where water touches/pools against the existing levee.

Small bodied fish passage for Camerons Creek regulator site

Different forms of fish passage were considered for Camerons Creek including: Vertical slot Fishway, Denil Fishway, Fishlock, and Rock Ramp Fishway.

Denil fishways are unsuitable for the passage of small fish, and therefore this option was considered unsuitable. A fishlock was considered too complex and expensive for the Camerons Creek site and requirements. A rock ramp fishway option was also considered as unsuitable, as at the location it is required that flows can be variable and fully shut off, a function that rock ramp fishways do not have.

Vertical slot fishways were considered to be the most appropriate option for Camerons Creek, as these:

- Work well with a constant upstream water level
- Work well with variable downstream water levels
- Can be designed to suit the target fish, in this situation only small bodied fish are to be targeted
- Can control flows through the Fishway
- Can be fitted with Carp screens and/or monitoring traps

The regulator concept design indicates a head differential of 0.6 m through the structure with the upstream weir pool connected to the Torrumbarry Weir pool creating a constant upstream water level.

The fishway entrance would be offset a by a minimum 1 m from the regulating structure; this allows fish to enter the fishway without having to travel in the high velocity zone produced around the structure. As the fishway is only required to pass small fish, a single vertical slot entry would be provided.

It is expected that the fishway would consist of 5-7 pools, each having an approximate water depth of 1 m, and dimensions in the order of a length of 1.5 m and width of 1.1 m. Each pool would have a drop in head of approximately 93 mm and each slot entry would be 100 mm wide. This design approach will provide a low energy fishway, with low turbulence zones, suitable for upstream fish passage of small bodied fish.

For Camerons Creek it has been suggested that the existing levee bank and dilapidated regulating structure can be used as a temporary coffer dam and therefore based on the existing information it is suggested that the construction cost of a vertical fishway at Camerons Creek would be between $500,000 and $600,000. However, if the construction of the fishway was to be undertaken concurrently with the regulating structure, then the cost would decrease as items such as mobilisation and dewatering would be shared. As a result, the cost allowance of the fishway would be between $200,000 and $400,000.

Top up low points in existing levee system

This will provide the required level of service as well as maintain a minimum of 200 mm freeboard. This option adopted the recommendations from the *Levee Breach Risk Assessment and Strategy Report* (Water Technology 2014), which determined low points and points of weakness along the levee alignment. Total lengths of levee needing to be raised were adopted from the report.

Water level monitoring devices

Automated gates will operate via real time water level measurement. Functional requirements for the water level sensors include:

- Real time water level measurement
- Capacity to connect to GWM SCADA control system
- Powered by solar panel
- Suitable for installation in semi-permanent wetland locations and channels

11.6 Private land and flood easements

Project implementation will require acquisition of private land and flood easements over private land bordering Camerons Creek and the Baggot Creek areas. The intent is to conduct a voluntary flood easement process, as for TLM *Gunbower Forest – Flooding for Life* project.

Negotiation with the affected landholders was conducted in collaboration with GMW because of their extensive experience in these types of negotiations. The consultation delivered in-principle agreement by all landholders to negotiate flood easements if the Project is funded. Costs to purchase easements are included in Section 13.

Flood easements will be required on three properties covering 20 ha of forested land within the confines of the perimeter levees in the Baggots Creek area. This land is inundated both from natural flooding events and constant leakage from the Camerons Creek regulator, meaning that it is effectively not currently available for productive use.

Two irrigators on Camerons Creek, downstream from where the new regulator is proposed, access water from two sumps fed by channels within the national park. The replacement of the current manually operated regulator with a new automated regulator will create a more even and controlled supply for these two irrigators who would have their pumping points consolidated at the one location to remove a long, heavily vegetated and inefficient channel. However, in order to maintain current supply as per their regulated diversion licences, modifications to their irrigation infrastructure will be required. This will require the creation of a private easement to allow one diverter to place pipework and a pump on a neighbouring private property. The relevant landholders have been consulted and recognise the benefits from the upgrading of the infrastructure, which will provide a more secure and consistent supply. On this basis, the affected landholders have indicated in-principle agreement to the necessary easement.

Camerons Creek is not currently actively used for environmental watering. While the leaky existing regulator does provide some beneficial watering to Black Charlie Lagoon, due to overwatering and the inability to stop inflows, the lagoon is kept permanently full and the Baggots area is also often detrimentally wetted. The proposed works on the creek and the change in supply arrangements will trigger the need for a formal Water Sharing Agreement to document the relative rights of the existing diverters and the environment. The capacity of Camerons Creek and the timing of the environmental water delivery in late winter and early spring are not likely to impact on irrigators. The capacity of the proposed Camerons Creek Irrigator Weir and Regulator has been sized such to allow simultaneous

irrigator pumping and environmental watering. On this basis the affected landholders have indicated in-principle agreement.

The issue of easements was included in the risk assessment process and is reported in Section 17. The relevant landholders have been included as part of the risk management and stakeholder engagement strategies.

Indicative costs are set out in

Table 11-2.

Table 11-2: Gunbower National Park – Private land and flood easement costs

[redacted]

11.7 Reliance on other measures or actions

Interdependencies and complementary actions are detailed in Section 11. However, this project is not reliant on other supply or constraint measures for implementation or operation.

11.8 Geotechnical investigations

Geotechnical investigations are being conducted to inform the detailed design phase. Preliminary results were provided on 19 December 2014 with their completion due in January 2015. Results of these investigations will be utilised to refine the designs.

In the absence of geotechnical results, the concept designs for the Camerons Creek regulator and Old Cohuna Main Channel regulator incorporate extensive sheet-piling which adds approximately $225,000 to the construction cost estimate. Depending upon the outcome of the geotechnical investigations, cost estimates for the regulators may be reduced.

The key objectives of the geotechnical investigations are to provide:

- Geotechnical information at the locations of important infrastructure to assist in progressing the concept designs. The following will be undertaken:
    - Assessment of the presence or otherwise of poor quality materials (e.g. silts and softened soils) and requirements for preparation of suitable foundations for regulating structures, culverts, levees.
    - Requirements for cut-offs of filtering if needed.
    - Design of stable earthfill structures and slopes for new embankments, levees and channels.
    - Assessment of suitability of the excavated materials for re-use in the constructed works.
    - Impact on groundwater on the proposed works and requirements (if needed) for managing groundwater.
- Baseline geotechnical information to assist understanding of the subsurface conditions and importantly to reduce the potential for latent condition claims related to the ground conditions and groundwater.

All proposed infrastructure sites will have borehole drilling and/or test pitting undertaken. Soil samples will be analysed at a laboratory accredited to the National Association of Testing Authorities.

11.9 Ongoing operation, maintenance and management of infrastructure

Refer to Section 13 which outlines the process being taken in Victoria to determine asset ownership, management, operation, and maintenance. Once determined, it will be possible to develop an asset operations and management plan, risk management framework, water accounting arrangements, and ongoing operational monitoring and record keeping arrangements.

12 Complementary actions and interdependencies

The proposed *Gunbower National Park Environmental Works Project* supply measure will affect the Victorian Murray (SS2) surface water SDL water resource unit. This SDL resource unit is anticipated to be affected by this supply measure through an adjustment to the SDL, pending MDBA confirmation of a final off-set amount.

12.1 Interdependencies

Any potential inter-dependencies for this supply measure and its associated SDL resource unit, in terms of other measures, cannot be formally ascertained at this time. This is because such inter-dependencies will be influenced by other factors that may be operating in connection with this site, including other supply/efficiency/constraints measures under the SDL adjustment mechanism, and the total volume of water that is recovered for the environment.

It is expected that all likely linkages and inter-dependencies for this measure and its associated SDL resource unit, particularly with any constraints measures, will become better understood as the full adjustment package is modelled by the MDBA and a final package is agreed to by Basin governments.

Similarly, a fully comprehensive assessment of the likely risks for this supply measure and its SDL resource unit cannot be completed until the full package of adjustment measures has been modelled by the MDBA, and a final package has been agreed between Basin governments.

12.2 Complementary actions

To maximise on the environmental outcomes from implementation of the supply measure, a number of complementary actions have been identified.

12.2.1 Invasive Plants and Animals

Invasive plants and animals threaten biodiversity by competing for natural resources and contributing to habitat and native species loss and displacement. Invasive plants often displace native species and can provide a harbour for invasive animals. Invasive animals such as foxes directly prey on native fauna, and have been identified as a serious risk to freshwater turtle populations. The North Central CMA *Invasive Plants and Animals Strategy 2010* (North Central CMA 2010c) has identified the Gunbower Ramsar Site as having exceptional significance, facing a high IPA threat. The *Gunbower Ramsar Site Key Asset Project* funded by the Australian Government's National Landcare Program is funded until 2018. Activities that enhance the achievement of the ecological objectives include:

Bridal Creeper's climbing stems smother native plants (Photo VicVeg L.Milne)

- Invasive Plant Control –target high threat weeds (e.g. Weeds of National Significance: - Bridal Creeper, Paterson's Curse, African Boxthorn, Blackberry, Bathurst Burr, Prickly Pear) particularly weed infested areas.
- Invasive Animal Management: monitor pest animal activity (e.g. European Fox, Rabbit and Feral Pig).and employ appropriate management techniques (e.g. baiting, fumigation).

12.2.2 Revegetation

Revegetation of threatened species undertaken within the national park will assist in improving the floristic diversity. This will enhance ecological objective R2 (River Red Gum FDU understorey composition).

12.2.3 Cultural Heritage protection

Aboriginal cultural heritage sites are known throughout the forests. Complementary actions include works to isolate and protect areas of cultural heritage to minimise incidental damage from forest users.

12.2.4 Aboriginal engagement

North Central CMA is undertaking project work with Gunbower Forest's traditional owners to progress the development of meaningful cultural flow objectives including:

- Project management of a Cultural Flows project
- Co-ordination of a Project Steering Committee
- Development of a framework to develop cultural flow objectives
- Promoting understanding of the cultural values to forest stakeholders and the broader community
- Communication to stakeholders of project learnings
- Improving annual watering priorities to incorporate social, cultural and spiritual values

The North Central CMA employs an Indigenous Facilitator to share knowledge with Yorta Yorta Traditional Owners and Aboriginal groups aimed to:

- Increase opportunities for Indigenous partnerships in TLM icon site planning, activities and monitoring
- Provide communication and updates on TLM and North Central CMA activities
- Promote the involvement and sustainable use of Aboriginal groups in natural resources.

This process has included ongoing investigation of opportunities for economic and cultural benefit from the provision of cultural services such as tourism. Gunbower Forest has been identified as a potential priority natural asset to utilise in this endeavour for its rich cultural landscape and proximity to the existing tourist market.

12.2.5 Tourism

Environmental watering has the potential to expand the tourism industry and create jobs, boost the local economy and raise the profile of the Gunbower National Park. This is a priority for the Campaspe Shire Council (Campaspe Shire Council Environment Strategy, 2012).

The Campaspe Shire Council is committed to the delivery of a sustainable future for its communities to assist in the delivery of environmental, economic and social outcomes. The Council has been proactive in establishing a framework for activity and investment in the environment through the adoption of its *Environment Strategy 2012 – 2015* that aims to manage threats to biodiversity and develop the eco-tourism market. Targeting pest plants and animals, the Council partners with other government agencies (DEPI, Parks Victoria, CMAs) and other groups (i.e. Landcare) to collaborate on specific initiatives and programs to prevent the growth and spread of weeds and rabbits that will enhance the value and effectiveness of environmental watering. Bird watching, bike riding, bush walking and canoe trails would be tourism opportunities arising from the environmental watering of the Gunbower National Park.

Canoeing on Gunbower Creek (Photo: S.Volk)

Tents beside Gunbower Creek (at Tree Tops camping area) (Photo: MDBA, D. Kleinert)

12.2.6 Integration

The package of works developed under the Project is designed to operate in conjunction with the forest's existing water delivery infrastructure, downstream of the national park including the:

- Hipwell Road Channel – delivers water to the mid-forest via Spur Creek, inundating River Red Gum forest floodplain and associated permanent and semi-permanent wetlands across the mid and lower forest. Large waterbird breeding events can be supported through Hipwell Road Channel deliveries.
- Lower Landscape regulators – deliver targeted flows to priority wetlands in the lower part of the forest.

Hipwell Road Channel (Photo: A.Chatfield)

This will ensure synergies from conjunctive operation with inflows to the upper Gunbower Forest contributing to mid-forest inundation, and providing foraging sites in the River Red Gum FDU to support colonial bird-breeding in the lower forest.

Operating scenarios for the Lower Landscape Regulators and Hipwell Road Channel are described in detail in the relevant Investment Proposals (North Central CMA 2009; North Central CMA 2010b) and *the Flooding Enhancement of Gunbower Forest Interim Operating Plan* (North Central CMA 2013a).

13 Costs, Benefits and Funding Arrangements

13.1 Overview

This section of the Business Case details the estimated financial costs of the Project, separated into the following key Project areas and components:

- Detailed design: design and approval;
- Capital costs;
    - Construction: on-ground water delivery infrastructure works and capital asset items
    - Risk management: costs incurred to minimise potential risks from operation
    - Contingency: provision for uncertainty around construction costs
- Operation and maintenance;
- Co-contributions; and
- Project benefits: benefits and costs that support a compelling case for investment.

This business case presents the cost to fully deliver the Project (i.e. until all infrastructure is constructed, commissioned and operational), including contingencies. *Cost estimates for all components in this proposal are based on current costs, with no calculation of cost escalations either accounting for the time taken from estimating the cost to the time for construction to commence or for escalation during execution of the Project.*

To ensure sufficient funding will be available to deliver the Project in the event that it is approved by the MDB Ministerial Council for inclusion in its approved SDL Adjustment Package to be submitted to the MDBA by 30 June 2016, cost escalations will be determined in an agreed manner between the proponent and the investor as part of negotiating an investment agreement for this project.

13.2 Total capital costs

Although significant work has been undertaken to develop cost estimates, including peer and expert panel review, information gaps, uncertainties and options remain. Further investigation in the next phase of the Project will provide greater certainty for refinement of the costs. The cost estimates as presented, reflect the uncertainties for the current stage of development of the Project. During the detailed design phase as the designs are refined and contingency reduced, costs may decrease.

The total capital cost estimate to design, construct and commission the works at Gunbower National Park (excluding GST) is **$12,838,185** (at upper cost estimate) (see **Error! Reference source not found.**).

Table 13-1: Gunbower National Park – Estimated capital costs

Across the upper and lower cost estimates, costs for items relating to quantities, task duration and rates are unchanged, except as noted below in Table 13-2.

Table 13-2: Gunbower National Park – Allowances

13.2.1 Assumptions

The following assumptions were made during the preparation of the construction cost estimates:

- Rates for items mentioned in the cost estimates are based on locally available material
- It is assumed that earthworks are carried out in the dry season
- Geotechnical investigation and analysis have not been estimated in the cost estimates provided
- Tree cutting at each site is based on desk top analysis and engineering judgement from available aerial photographs
- Top soil cannot be used as backfill material
- Backfilling of soil includes a 10% bulking factor and

- Given that many of the structures have no existing road access, mobilisation and demobilisation costs have been included with each individual structure.

Costs associated with further geotechnical investigations have been included in the detailed design costs.

13.2.2 Exclusions

Construction contract costs do not include the following:

- All costs are excluding GST;
- Allowances for detailed design, investigations, superintendence, project management and construction support;
- Obtaining (planning) approvals and permits;
- Native vegetation offsets;
- Cultural heritage and environmental studies;
- Preparation of maintenance programs and operations manuals;
- Landowner consultation and land acquisition (except as specified);
- Disposal of contaminated material to an approved site; and
- Testing and commissioning of regulators and fishways.

These costs are included in the detailed design and construction ancillary costs. The approach being taken by Victoria with native vegetation offsets is explained in Section 16.

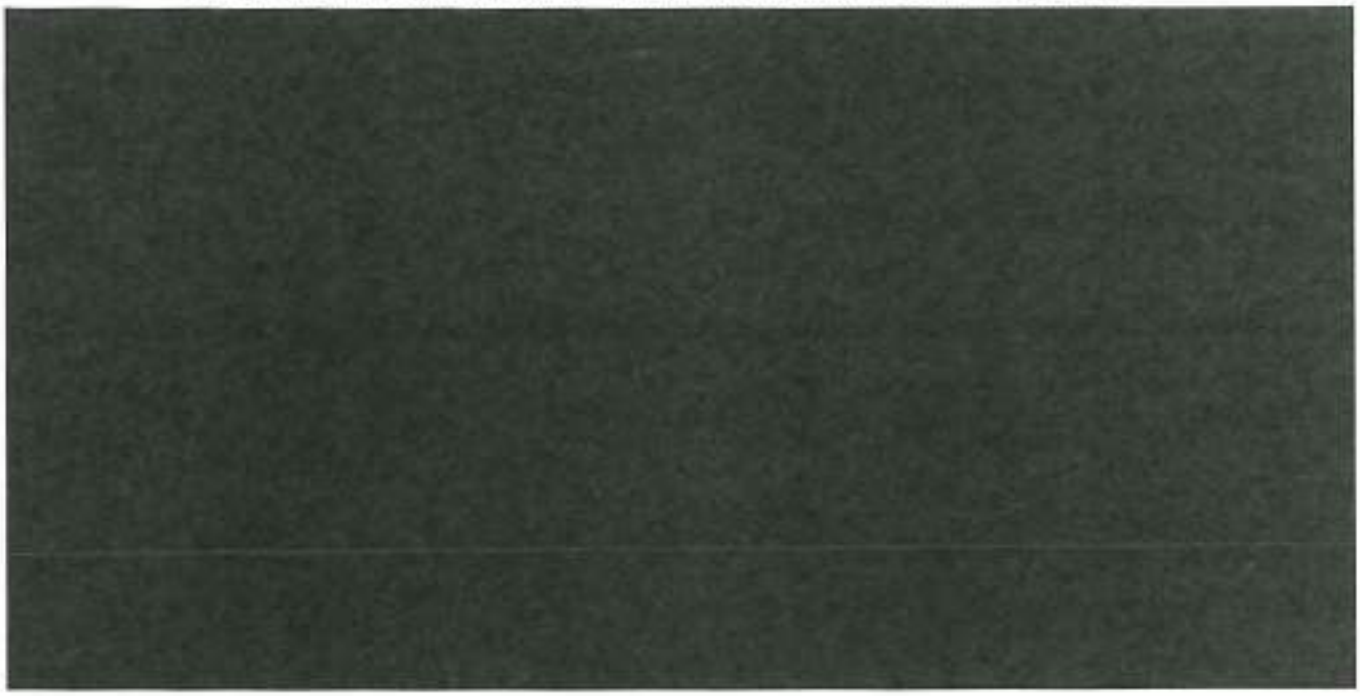
13.3 Detailed design and approvals

The cost estimate (excluding GST) for completion of the detailed design and approvals phase for the Project is **$2,358,427**. This includes the completion of technical investigations, detailed design of all structures, and statutory approvals. Table 13-3 below is a summary of the cost estimates.

Management of the detailed designs will take 18 months and be supported by the North Central CMA, DEPI and Parks Victoria for the following key activities:

- Investigations
    - Further geotechnical investigations, hydraulic modelling and field inspections, land feature and level surveys, to refine designs
    - Water sharing arrangements (with Camerons Creek irrigation diverters)
    - Water delivery cost arrangements
    - Irrigation system capacity review
- Statutory approvals – includes preparation of permit applications, referrals and assessment (refer to Section 16 for the list of regulatory approvals anticipated for the Project)
- Ongoing stakeholder engagement and communications
- Resolution of delivery costs
- Development of the construction proposal.

Table 13-3: Gunbower National Park – Costs associated with the detailed design phase



13.4 Capital Costs

The capital costs has been packaged into three separate sections (construction, risk management and contingency) to better present the differing range of costs associated with the supply measure.

13.4.1 Construction Costs

A detailed construction cost estimate is provided in the *Concept Design Report*. Table 13-4 below is a summary of that estimate. Only forward looking costs have been included.

The total construction cost estimate (excluding GST) is **$4,773,993** (at upper cost estimate).

The concept designs for the Camerons Creek regulator and Old Cohuna Main Channel regulator incorporate extensive sheet-piling as they have been developed in the absence of geotechnical information. This additional sheet-piling adds approximately [redacted] to the construction cost estimate. Geotechnical investigations are currently underway to inform the detailed design phase. Depending upon the outcome of these investigations, due for completion in early 2015, cost estimates for the regulators may decrease.

Table 13-4: Gunbower National Park – Estimated construction costs for works

[redacted]

13.4.2 Ancillary costs

The estimated ancillary costs for construction are provided in Table 13-5 below. Project delivery will be a partnership between the North Central CMA, the constructing authority (TBC), DEPI and Parks Victoria. [redacted]

Table 13-5: Gunbower National Park – Estimated ancillary costs for construction

[redacted]

13.4.3 Risk management

The risks to the Project development and delivery are explained in Section 17, the risk register in Appendix 4 and in the Project's *Risk Management Strategy*. Costs have been estimated for flooding delays, wet weather delays, approvals delay and contingency.

Flooding delay

An assessment has been made (URS, 2014) on the potential cost impact at each of the sites if they are inundated by a 1 in 2 year frequency river flow event during the construction period. The cost allowance for flood risk is [redacted] for the higher cost estimation.

For regulator and irrigation works, a three month construction period has been assumed. For levee systems, a six month construction period has been assumed. The intention is to build these structures during the dry period of each year.

The cost of rework and clean-up of the site following a flood including delay costs is assessed as follows (see Table 13-6 and Table 13-7):

- A greater than 20,000 ML/d flow based on Torrumbarry Weir records occurs on average once every two years
- This represents a 50% chance of it occurring in any one year at any time as the records did not show a bias towards one seasonal period compared to another
- The Construction cost (excluding Contingency and Profit) of the component of the works at risk is determined and divided by the construction period
- It is assessed that the site would be out of action and / or being reinstated over a 2 week period following the event. (1 week for the event to recede, 1 week to reinstate)
- Therefore the cost of the flood event is two weeks of cash flow for the site
- The probability of this occurring is 50% hence the contingency allowance is the two week cost multiplied by 0.5
- This is then expressed as a % of the raw construction cost (excluding profit and contingency).

Table 13-6: Camerons Creek Regulator flooding delay costs

For the Old Cohuna Main Channel area only the outfall regulator is considered to be at risk from flooding and its raw construction cost has determined to assess flood risk contingency costs.

Table 13-7: Gunbower National Park – Flood Risk Contingency Cost Allowance Estimates

Wet weather delay

A 3% allowance for wet weather delay is included in the contingency costs. This contingency will be transferred to the construction contractor, with as stated relief on the basis of time extensions at no extra cost. Due to the remote access and the difficulty in getting materials to site, most work will be done in the dry period and potentially programmed over a number of seasons. This will reduce the risk of wet weather delay. 3% is allocated for wet weather delay.

Approvals delay

The *Regulatory Approvals Strategy* (DEPI 2014c) has identified the approvals, permits or licences likely to be required prior to the commencement of construction. This strategy includes an indicative program for effecting regulatory approvals that predicts a minimum 31 week period to obtain all required approvals. However, delays can come from a number of sources including:

- Delays in preparing applications including supporting documentation;
- Delay in assessment of submissions by agencies;
- Request by agencies for further studies/investigations/specific management plans creating a time delay;
- Lack of direction with regards to policy or change in policy; and
- The Project triggers an EES or assessed as a controlled action under the *EPBC Act* (1999).

No construction work will be tendered until all approvals have been granted or will be staggered at different sites depending on expected timeframes and ease of obtaining for approvals. Based on experience from TLM program, and advice from GMW and URS, a 20% contingency has been included on top of the existing approvals cost estimate of [redacted] is estimated for approvals delay.

Project contingency

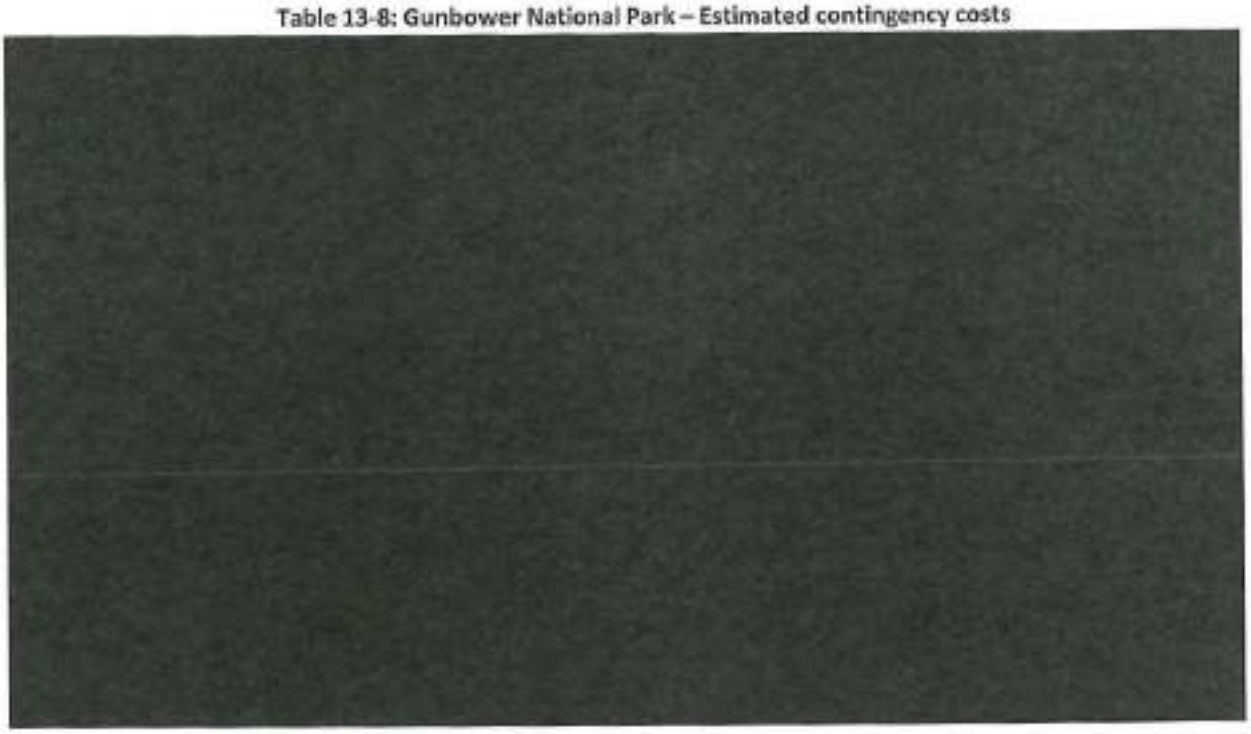
Contingency as applied in an engineering cost estimate is defined as the cost assigned to uncertainties in the definition of the project. The major sources of uncertainty that have influenced the degree of contingency include:

- Insufficient geology and geotechnical information, i.e. upon later investigation, geological conditions found to be worse than reasonably anticipated during concept design;
- Design changes, including changes in the level of design definition, i.e. as more detailed hydrology, topography and site conditions become available alterations to the design criteria for a given regulator structure result in larger capacity requirements;
- Quantity variations include potential changes initiated by design alterations or site conditions;
- Variation in site conditions, including unanticipated permit restrictions, seasonal limitations or environmental conditions;
- Price variations including escalations, and variations in labour rate and commodity prices; and
- Schedule risks, include unforseen delays due to weather effects i.e. projects with seasonal window restrictions are particularly vulnerable to schedule delay risks since relatively short delays can result in having to move construction windows to the following season.

A 40% contingency has been applied to the design given the level of uncertainty. A lower 20% contingency was also considered. However, with a 20% contingency, there are no allowances for changes in design. The degree of

contingency will reduce over time as further investigations, planning and detailed designs are completed during the Project implementation phase. Contingency costs are outlined below in Table 13-8.

Table 13-8: Gunbower National Park – Estimated contingency costs



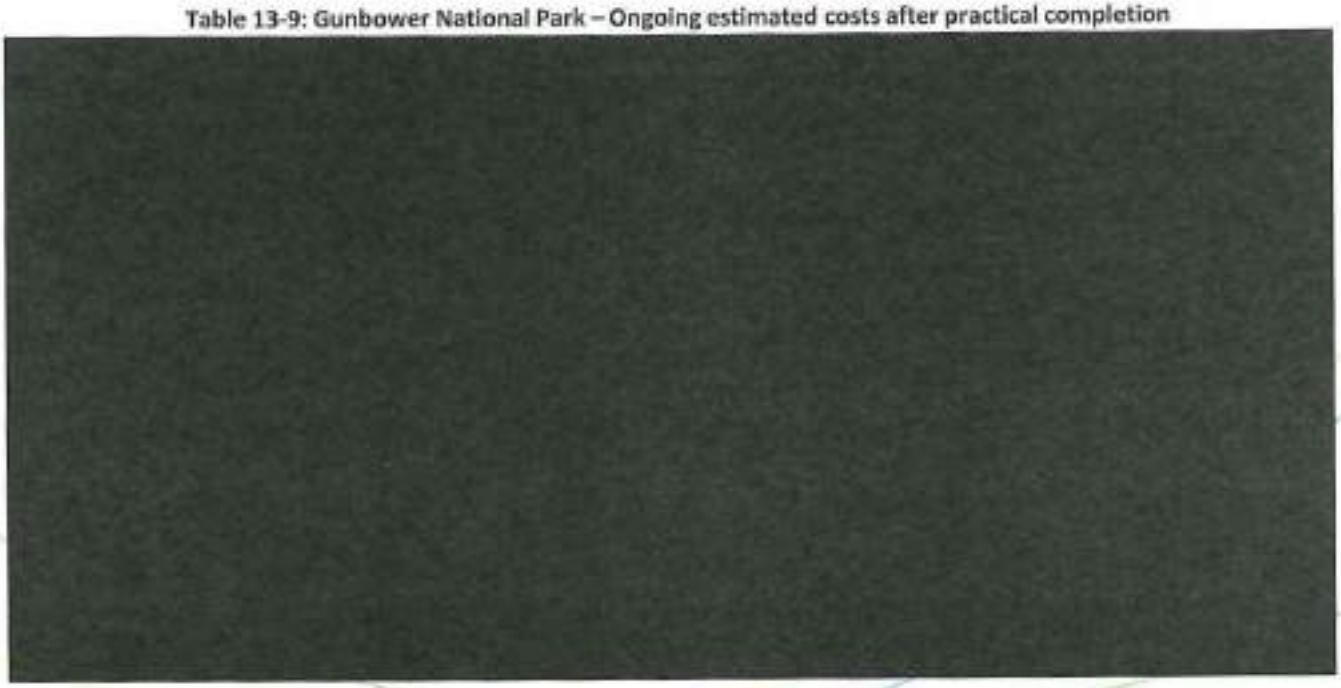
Construction cost estimates specific for specific infrastructure is presented in the *Concept Design Report*.

13.5 Ongoing operating and maintenance costs

Asset renewal costs have not been included in the calculation of operation and maintenance costs.

Table 13-9 outlines the projected costs (in current dollars) for system operation and maintenance. These are averaged between years to take account of the variation in levels of activity. These do not form part of the construction budget but are to be considered in future budget planning.

Table 13-9: Gunbower National Park – Ongoing estimated costs after practical completion



13.6 Co-contributions

No co-contributions are provided for project capital costs.

13.7 Proposed financial responsibility for ongoing costs

The Department of Environment and Primary Industries (DEPI) convened a workshop with the key delivery partners for Victoria's proposed supply measures to inform a decision on proposed financial responsibility for ongoing asset ownership costs. Attendees at the workshop included representatives from the Mallee and North Central CMAs, DEPI, Parks Victoria and Goulburn Murray Water. The workshop identified a set of criteria required by an agency to own, operate and maintain an asset like those proposed by this supply measure. These were:

- Access to capability to perform the required functions, either directly or under contract;
- Access to suitable resources which can be deployed in a timely, efficient manner;
- Sufficient powers conferred under legislation to enable services to be provided;
- Demonstrable benefit or linkage to primary business mission or activities;
- Ability to collaborate and co-ordinate effectively with multiple parties; and
- Risks are allocated to those best placed to manage them.

Although the criteria have been identified, the delegation of asset ownership and operation, including any associated proposed financial responsibility, cannot be formally ascertained at this time. Such decisions are generally whole-of-Victorian Government, and sufficient information is not currently available to enable a formal position on this matter to be clarified.

In line with good financial practice, any long-term arrangements for asset ownership, operation and maintenance should maximise cost-efficiencies where they can be found. This includes options to 'package up' ongoing ownership, operation and maintenance where this is deemed the most cost-effective approach.

DEPI will be in a position to provide more formal advice on the state's preferred long-term arrangements for this supply measure, once the full suite of Victorian proposals under the SDL adjustment mechanism has been more definitely scoped. This is anticipated to occur during the course of 2015, pending receipt of advice from the MDBA on likely adjustment.

13.8 Cost benefit analysis

The primary purpose of the *Gunbower National Park Environmental Works Project* is to achieve environmental benefits and water efficiencies (refer to Section 4). However, the delivery of this project will provide other benefits that depend on condition of the site, such as supporting social and cultural values.

A formal cost benefit analysis has not been undertaken as part of this business case, because the main benefit of the project (the SDL adjustment) cannot be reliably estimated at this stage in the planning cycle. This approach is consistent with the guidance given on page 26 of the *Phase 2 Assessment Guidelines for Supply and Constraint Measure Business Cases*.

However, from a qualitative perspective, Victoria considers that, on balance, the benefits of this project will significantly outweigh its costs. The rationale for this assertion is that a broad range of enduring social, economic and environmental benefits can be assumed to arise from this project.

13.8.1 Cultural heritage

Traditionally, Indigenous people have a strong affinity with waterways and wetlands, as a vital source for food, water and camping. The Gunbower National Park is part of the lands of the Yorta Yorta people. The cultural heritage sites are an important component of the forest values. Improved flooding will result in the enhancement of the ecological values of the site, with the opportunity to maximize on cultural flows if relevant, in the future.

13.8.2 Licensed forest use

Apiary licences allow access to the Gunbower National Park for honey production. The bee hives depend on seasonal flowering of River Red Gums, which will increase in regularity and reliability due to the Project. This should provide opportunities to increase the number of active sites and hives at each site.

13.8.3 Economic benefit to local communities

Previous analysis by Dyack et al. (2007) has calculated the economic value of additional visitation days to the Barmah Forest based on the travel cost method. Given the proximity and similarities between the Barmah Forest and Gunbower National Park, this is a useful source study for transferring values to the current site. Dyack et al. (2007) found that each additional day of visitation had an economic value of $135.50 per day. Adjusting for CPI from 2007 to 2014 produces a current value of $161.80 per day.

Applying this economic value to the number of visitor days to the forests as estimated by Parks Victoria, gives a total economic value of visitation as per Table 13-10.

Table 13-10: Annual visitor days to Gunbower National Park

Type	Visitor days*	Economic value per day**	Value
Over night	29,000	$161.80	$4,692,200
Day visitors	15,000	$161.80	$2,427,000
Total	44,000	$161.80	**$7,119,200**

*Wehner, B 2014, personal communication, October.

**Tourism Research Australia, Regional Tourism Profile for Central Murray 2012/13

13.8.4 Balancing benefits and dis-benefits

There will be some dis-benefits from the proposed Project, but these are expected to be minor and transient. Construction will involve some physical disturbance which has the potential to impact on native vegetation and wildlife. These impacts will be minimised by careful planning and adherence to relevant state and Commonwealth legislation, regulations and guidelines. Any unavoidable impacts will be minimised through the implementation of a rigorous environmental management framework during construction.

Access will also be restricted to some extent during the construction phase, but this will be temporary. Given the relative remoteness of the site from populated areas, there is unlikely to be any significant loss of social amenity to surrounding communities due to the noise and nuisance that will be encountered during construction.

Access to the forests will also be restricted during managed flooding events. This will impact on recreational activities and licence holders. The public will still have some access to River Murray frontage during delivery of environmental water, which will limit dis-benefit during delivery and drying out phases provided the watering schedule is well publicised. This restriction on access would also occur during natural floods.

Over the long term, the local and regional communities located close to this site will significantly benefit from the environmental amenity dividend generated by this project over its lifetime.

13.9 Project seeking Commonwealth funding

Victoria will be seeking 100% of Project funding for this supply measure proposal from the Commonwealth. The funding requested will ensure the proposed supply measure is construction ready, built in accordance with all regulatory approval requirements and conditions, and fully commissioned once construction is completed.

14 Stakeholder management strategy

The *North Central CMA SDL Offset Projects Stakeholder Management Strategy 2014d* (the Strategy) was prepared to guide engagement and communication activities for the *Gunbower National Park Environmental Works Project*. The Strategy clarifies project specific communication and engagement objectives, key messages and target audiences to ensure clear, transparent and thorough communication to all identified stakeholders.

An overview of the Strategy and the outcomes from the Business Case phase is provided in the following sections.

The North Central CMA uses the International Association for Public Participation's (IAP2) spectrum for effective engagement in strategic planning. The spectrum guides the approach to identifying activities at the project level that will see interaction with community members and stakeholders in ways that inform, consult, involve, collaborate and ultimately empower them (North Central CMA 2013b).

14.1 Project phases

Four project phases have been identified for the Project's engagement with stakeholders. These are:

- Phase 1: Business case development
- Phase 2: Approvals and detailed design
- Phase 3: Construction
- Phase 4: Operation

The various phases of the Project will require different approaches to engagement with the various stakeholders. There will be overlap as the Project moves into different phases; and adaptive management as new learnings on the Project and the needs of stakeholders are gleaned.

14.2 Key stakeholders

The proposed supply measure has engaged a similar 'community of interest' to The Living Murray *Gunbower Forest – Flooding for Life* project. The North Central CMA has been able to draw on the extensive consultation and engagement activities undertaken for that Project and experience gained. These existing channels of communication, and the benefits of prior significant work to assess issues and develop effective solutions, have provided a solid basis for the development and implementation of the Strategy for this Project.

Stakeholders have been characterised into four groups relating to their interest and influence on the project outcomes (refer Table 14-1). Relative to each other, Stakeholder Group 1 has a higher level of interest in, and influence on the Project outcomes, with Stakeholder Group 4 having the lowest level. A more detailed analysis of the project stakeholders is provided in the Strategy.

Table 14-1: Stakeholders of the Gunbower National Park Environmental Works Project.

Stakeholder group	Stakeholder
Group 1: Project partners (Collaborate)	1. Department of Environment and Primary Industries (DEPI) 2. Goulburn Murray Water (GMW) 3. Parks Victoria (PV) 4. Commonwealth Department of the Environment (DoE) 5. Murray Darling Basin Authority (MDBA) 6. Commonwealth Environmental Water Holder (CEWH) 7. Victorian Environmental Water Holder (VEWH)
Group 2 (Involve)	1. Irrigators / Adjacent freehold landholders (Diversion, Gravity and Groundwater) • GMW customers • Torrumbarry Water Services Committee (a GMW Committee) 2. Traditional Owners: Yorta Yorta Nation Aboriginal Corporation 3. NCCMA Community Committees: Portfolio Group, Natural Resource Management Committee (NRMC)
Group 3 (Consult)	1. Local Government: Campaspe Shire Council 2. Local community: townships of Torrumbarry, Gunbower and Cohuna 3. Environmental / Technical Expert organisations: Murray Darling Freshwater Research Centre, Murray Darling Association, Environment Victoria, Australian Conservation Foundation, Victorian National Parks Association • Community groups: Cohuna and District Historical Society, Cohuna and District Progress Association • Industry (businesses and services): tourism businesses, licence holders (apiary) • Special Interest Groups: Field and Game Australia, Victorian Farmers Federation, angling clubs, VR Fish, Heritage Victoria
Group 4 (Inform)	1. Recreational users: campers, fishing and boating users, 4WD motorists, field and game hunting enthusiasts, day visitors, eco-tourists, bush walkers, bird watchers 2. Wider community: local retailers, North Central region, Victoria, Murray Darling Basin 3. Local schools

The aims and approaches for engaging with each of key stakeholders were identified to ensure that each stakeholder's expectations and needs were met. These approaches (summarised below) have been applied consistently for all engagement and communication activities during the Business Case phase. They will form the basis for future phases of the Project but will be adapted to reflect the activities and needs of a particular phase.

Stakeholder Group 1: Collaborate - involves an extended level of consultation to formulate solutions and requires a targeted and tailored approach to meet the needs of each individual stakeholder.

Stakeholder Group 2: Involve - aims to ensure that issues and concerns are understood and are considered as part of the process. It involves working directly with stakeholders and informing them in a timely manner of any planned works or major decisions related to the project.

Stakeholder Group 3: Consult - aims to increase understanding and awareness through sourcing feedback on analysis, alternatives or decisions. It is more generic in nature in comparison to Stakeholder Group 1.

Stakeholder Group 4: Inform - stakeholders are informed about the project and/or decisions that have already been made through a variety of mediums that may include information dissemination and responding to enquiries.

14.3 Phase 1 stakeholder group engagement

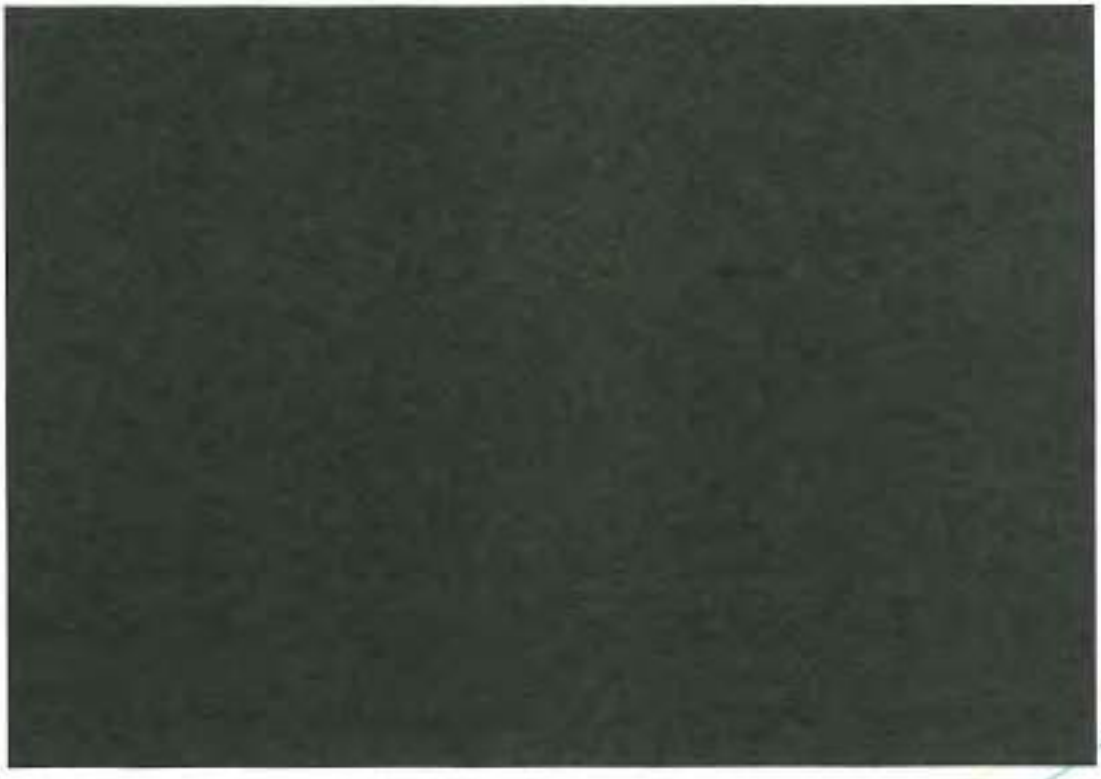
A stakeholder reference group (project partners) was established and existing groups utilised for community consultation.

North Central CMA groups: Engagement with the local community has been complemented by engaging established groups such as the North Central CMA Board, North Central CMA Natural Resource Management Committee (NRMC), and the Campaspe Shire Council. Field trips and presentations have been used to connect with these groups and disseminate information to the local community about the project.

Stakeholder Reference Group (SRG): this group was established to provide a forum for inter-agency collaboration to facilitate the successful development and implementation of Project. The success of the Project depends on the support and involvement of the various agencies – DEPI, Parks Victoria, GMW and Campaspe Shire Council. These organisations have been involved, throughout the Project, through representation on the Project's SRG. Local staff have provided key information to support the development of concept designs, operating scenarios and risk assessments. Staff have also reviewed concept designs and their comprehensive knowledge of the forest ecology and flooding patterns has been invaluable in the development of the package of works.

Gunbower Island Community Reference Group (CRG): The CRG was established in 2006 as a requirement of The Living Murray Business Plan. For this proposed supply measure, the CRG has provided a platform to seek advice built on extensive experience, knowledge and understanding of the local area. It has also provided a community perspective on the project communication and engagement activities. This has ensured that project development and implementation has been undertaken with consideration of local knowledge and issues to achieve the desired environmental outcomes. Membership of the group is shown in Table 14-2.

Table 14-2: Membership of the Gunbower Island CRG.



Adjacent Landholders: Letters were sent to all 25 landholders adjacent to the Project site in February 2014. North Central CMA contacted 25 landholders by phone with a follow up email. Face-to-face meetings were then held with 11

of these landholders who were interested in further discussion. That has ensured close, personal contact with key affected parties to explain the proposed Project and understand landholders' concerns.

Traditional Owners: The Traditional Owners of Gunbower National Park are the Yorta Yorta Nation Aboriginal Corporation (YYNAC), a Registered Aboriginal Party under the *Aboriginal Heritage Act 2006*.

In accordance with the Victorian *Aboriginal Heritage Act 2006*, a Cultural Heritage Management Plan (CHMP) is being developed for the package of works. The YYNAC were engaged from inception of the CHMP (Table 14-3 below).

The development of the CHMP will be used as the key vehicle for ongoing engagement with the YYNAC. With assistance from the North Central CMA Indigenous Facilitator, written and face-to-face briefings, phone conversations and site tours will continue to be used to maintain open communication channels with the YYNAC.

Table 14-3: North Central CMA engagement with YYNAC

Date	Event
May 2014	YYNAC consultation on drafting the RFQ and involvement in the tender assessments
June 2014	YYNAC provide comment/feedback on the Aboriginal Cultural Heritage desktop assessment
June 2014	Inception meeting and Gunbower field visit
July 2014	YYNAC evaluate the Notice of Intent to prepare a Cultural Heritage Management Plan
August 2014	YYNAC participating in surveying for cultural heritage material
September 2014	Post survey meeting with YYNAC and provide comment/feedback on the standard survey report

Licence holders: Letters were sent to commercial forest users (i.e. honey production and tourist operators), informing them about the projects and their benefits.

Public Information: FAQs, fact sheets, a media release, introductory letters to licensees, an introductory email to other project stakeholders, and project update emails have been prepared and released about the project. A project page is available on the North Central CMA website. The fact sheets were attached to letters and emails introducing/explaining the projects and their progress, displayed at the North Central CMA office, attached to the project page on the North Central CMA website, and provided at a stand at the Murrabit Markets on 4 October 2014.

Stakeholder engagement and communication activities undertaken to date are shown in Table 14-4.

Table 14-4: Stakeholder engagement and communication activity log

Date	Event	Target Audience
February 2014	Project introductory letters	Landholders with property adjoining project site
April 2014	Project update presentation and field visit	SRG
May 2014	Project update presentation and field visit	SRG
June-August 2014	One-on-One meetings	Landholders with property adjoining project site
July 2014	Project update presentation and field visit	SRG
July 2014	Project update presentation	CRG
August 2014	Project update email	Landholders with property adjoining project site
August 2014	Project update presentation and field visit	SRG

Date	Event	Target Audience
August 2014	Council meeting	Campaspe Shire Councillors
August 2014	Field visit	North Central CMA NRMC
August 2014	Project update presentation and field visit	CRG
September 2014	Project introductory email	Stakeholder groups
September 2014	Project update presentation and field visit	SRG
October 2014	Project update email	Landholders and Stakeholder groups
October 2014	Project introductory letters	Licensees (apiary, tourism operators)
October 2014	A project information stall at the Elmore Field Days	Community members and industry
October 2014	A project information stall at the Murrabit Markets	Community members
October 2014	Project update presentation	North Central CMA NRMC
October 2014	Presentation to Torrumbarry Water Services Committee	Irrigators' committee

14.4 Outcomes

The main outcomes from stakeholder engagement for Phase 1 are provided in Appendix 7. For all activities undertaken, the North Central CMA has documented the: consultation parties; type and degree of impact; extent of support for the Project; and how consultation outcomes have been considered and responded to by the North Central CMA.

In summary, a wide spectrum of groups and individuals, with differing levels of interest and impact, were engaged. The main findings that demonstrate broad community support are:

- There is recognition of the importance of the health of the forest for environmental, social and economic values
- There is broad support to increase the frequency of flooding as this is considered the best way to restore and enhance forest health
- There is recognition that the Project will increase the health and vitality of the Gunbower National Park and so support social and economic uses as well as ecosystem health.

Some concerns and interests raised by the community, through engagement activities, are outlined below. These have been addressed through the risk assessment process.

- Unplanned inundation: risk of flooding to inundate private land. The risk management sections confirm the comprehensive program in place to reduce risks to an overall rating of "Low".
- Blackwater: risks of blackwater entering and affecting water quality in the River Murray. The operating regime is designed to minimize this risk. Increasing the watering frequency should also reduce the build-up of organic material that can feed such events.
- Access: reduced access for recreation, timber harvesting, grazing and honey production. There will be restricted but overall benefits are recognized.
- Fire: risk of greater understorey growth increasing wildfire risk. There was also an acknowledgment that greater inundation will reduce the frequency and severity of such risks.

14.5 Proposed consultation for implementation phase

Further engagement activities and implementation of the Strategy will continue in the next phases of the Project if it is approved. The cost of these engagement and communication activities is estimated at $129,258 (refer to Section 13 for detailed costings).

The Strategy will be updated and revised for subsequent phases. An overview of the proposed approach is provided in Table 14-5.

Table 14-5: Consultation strategy for the implementation phase

Stakeholder group	Consultation approach	IAP2 level of engagement	Number / Timing
Group 1 Project partners	Intensive engagement through: • Steering Committee (6 weekly meetings) • Construction progress meetings	Collaborate	Ongoing
Group 2	• Irrigator / Adjacent landholder meetings (face-to-face) • Special events – site tours (e.g. funding announcement, commencement of construction)	Involve	Funding announcement/ commencement of construction 2016 Contact and organise meetings with all interested irrigators / adjacent landholders 2016 Site tours 2017
Group 3	• Teleconference briefing sessions with North Central CMA	Consult	One during 2016
	• Presentations conducted by North Central CMA	Consult	One during 2016
	• Special events – site tours (e.g. funding announcement, commencement of construction)	Consult	Site tours 2017
Group 4	• Information accessed through the North Central CMA website	Inform	Accessible in 2016
All stakeholders	• Information package accessed on the North Central CMA website (fact sheets, photos, contact information)	Inform	Accessible in 2016 (as soon as possible after funding is confirmed)
	• Project updates accessed through the North Central CMA website and social media (e.g. newsletter, Twitter, Facebook)	Inform	Regularly during 2016
	• Project update emails	Inform	One during detailed design, two during construction, and one associated with each watering event. Coincide with media releases
	• Media communication (e.g. media releases, newspaper articles, radio interviews, television interviews)	Inform	Media releases – one during detailed design, two during construction, one associated with each watering event. Coincide with project update emails

15 Legal and statutory requirements

15.1 Regulatory approvals

A Regulatory Governance Group (RGG) is supporting the delivery of business case requirements by providing a mechanism, through high-level engagement with responsible agencies, to streamline the regulatory approvals process. The RGG provides advice to the Project Control Board (PCB) regarding the regulatory approvals needed for Victorian projects, the resolution of associated issues and the development of a program-level strategy to obtain approvals.

The term 'approvals' refers to all environmental and planning consents, endorsements and agreements required from government agencies by legislative or other statutory obligations to conduct works (DEPI 2014c). The approvals required for the Project are listed in Table 15-1.

The *Regulatory Approvals Strategy* (DEPI 2014c) has identified the approvals, permits or licences likely to be required prior to the commencement of construction. An assessment of the likely impacts of the proposed works, based on preliminary construction footprints confirms the need to obtain a number of local government, State and Commonwealth approvals.

The following supporting documents will be required and are likely to be requested through referral decisions or planning permit conditions (DEPI 2014c):

- An offset strategy for native vegetation losses (see below)
- An environmental management framework
- A threatened species management plan, and
- A cultural heritage management plan.

Any vegetation losses will be offset in line with current state policy. A program-level approach to offsetting is currently being developed, where the primary offsetting mechanism will be the gains in vegetation condition within the areas watered by the various Victorian works-based supply measures. An assessment of vegetation offset requirements based on preliminary construction footprints indicates that the offsets for this proposed supply measure can be met using this approach.

The application process for each approval, the responsible agency, timing of submissions and timeframe for decisions are outlined in the *Regulatory Approvals Strategy* (DEPI 2014c). The Strategy includes an indicative program for effecting regulatory approvals that predicts a minimum 31-week period to obtain all required approvals. This timeframe assumes that an Environmental Effects Statement is not required, all applications (including supporting documentation) are already prepared and that there are no significant delays during the assessment process. The Strategy also notes that there are a number of linkages and dependencies between approvals, where for example, some approvals cannot be issued until another is approved e.g. a planning permit cannot be granted until there is an approved cultural heritage management plan.

Table 15-1: Regulatory approvals anticipated for Gunbower National Park (DEPI 2014c)

Approvals required	Description
Commonwealth legislation	
Environmental Protection & Biodiversity Conservation Act 1999 • Referral	A number of potentially affected "matters of national environmental significance" (MNES) are present in the forests: • Wetlands of international importance (Ramsar-listed wetlands) • Migratory waterbird species (JAMBA, CAMBA, ROKAMBA) • Nationally threatened species or communities e.g. Western Water-starwort (*Callitriche cyclocarpa*)
Victorian legislation	
Environmental Effects Act 1978 • Referral	Relevant to two of the six referral criteria for individual potential effects i.e. • Potential long-term change to the ecological character of a wetland listed under the Ramsar Convention or in 'A Directory of Important Wetlands in Australia' • Potential extensive or major effects on the health or biodiversity of aquatic, estuarine or marine ecosystems, over the long term
Planning & Environment Act 1987 • Planning permit • Public Land Managers Consent	Applicant to request permission from public land manager to apply for a planning permit for works on public land A planning permit application is then submitted with supporting documentation: likely to include an offset plan, threatened species management plan Local Council refers applications and plans to appropriate authorities for advice
Aboriginal Heritage Act 2006 • Cultural Heritage Management Plan	A CHMP is required when a listed high impact activity will cause significant ground disturbance and is in an area of cultural heritage sensitivity as defined by the *Aboriginal Heritage Regulations 2007* (Part 2, Division 5) To be prepared by an approved Cultural Heritage Advisor
Water Act 1989 • Works on waterways permit	Application for a licence to construct and operate works on a waterway.
National Parks Act 1975 • Section 27 consent	Approval for a public authority to carry out its functions in a national park.
Flora & Fauna Guarantee Act 1988 • Protected flora licence or permit	Application for approval to remove protected flora within public land for non-commercial purposes. • Will need to include targeted surveys for threatened/protected species considered likely to be present at the site and impacted by proposed works

15.2 Legislative and policy amendments and Inter-jurisdictional agreements

At the state level, a legislative change may be needed to address the requirement to secure native vegetation offsets prior to clearing. As the primary offsetting mechanism is expected to be the gains in vegetation condition within the areas watered by the various Victorian works-based supply measures, (i.e. the outcomes of the measures once operational), this requirement cannot be met. DEPI will investigate a suite of options to address this issue during the detailed design for this measure, including the potential for a planning scheme amendment. Note that the other options to be investigated do not require legislative changes.

Matters related to other regulatory approvals necessary for the implementation of this supply measure are discussed elsewhere in this business case.

No other amendments to state legislation or policy are anticipated. This includes any formal amendments to state water sharing frameworks, or river operations rules or practices. Further to this, no changes to the Murray-Darling Basin Agreement 2008 are required to implement this measure, nor do any new agreements need to be created either with other jurisdictions or water holders in the Basin.

State policy on water tariffs, associated with use of the irrigation system, is currently being reviewed. This will influence the costs associated with delivery of environmental water but not the feasibility of delivery.

15.3 Cultural heritage assessment

Initial assessments have been conducted both for Aboriginal and European cultural heritage. 248 sites on Gunbower Island are recorded in the Aboriginal Cultural Heritage Register Information System (ACHRIS) (Colin Pardoe Bio-Anthropology & Archaeology). The upper forest is within an area of Cultural Heritage Sensitivity as defined under the Aboriginal Heritage Act (2006).

The North Central CMA has engaged the Traditional Owners, identified as the as the Yorta Yorta Nations Aboriginal Corporation (YYNAC), a Registered Aboriginal Party, in the development of a Cultural Heritage Management Plan (CHMP), under the Aboriginal Heritage Regulations 2007 (Part 2, Division 5). The YYNAC were engaged from project inception.

16 Governance and project management

Appropriate governance and project management arrangements have been put in place to minimise risks to investors and other parties from the proposed supply measure. The sections below describe the governance arrangements during business case development and proposed arrangements during project implementation.

16.1 Governance arrangements during business case development

DEPI convened a Project Control Board (PCB) to oversee the development of business cases for the nine Victorian works-based supply measures. The PCB is comprised of senior executives from DEPI, the North Central and Mallee CMAs, GMW and Parks Victoria. This has ensured high level engagement of responsible agencies and has assisted in identifying and resolving program-level issues during development of business cases. The PCB's role has been to ensure that:

- All business cases meet the requirements set out in the Phase 2 Guidelines (reference)
- All business cases are of a high and consistent standard, and delivered within specified timelines
- The technical basis of each business case is robust, credible and fit for purpose
- That appropriate consultation with stakeholder agencies, affected persons and the community was carried out during business case development.

The PCB has been supported by an Expert Review Panel and Regulatory Governance Group, and project-specific governance arrangements set up by the North Central and Mallee CMAs (Figure 16-1).

Figure 16-1: Governance arrangements during business case development

The *Gunbower National Park Environmental Works Project* business case has been endorsed by the PCB as part of the final package of Victorian business cases to be submitted for assessment under Phase 2 of the SDL adjustment mechanism.

16.1.1 Expert review panel

An Expert Review Panel ('the Panel') was established to examine the critical elements of each business case at key stages and assess quality, credibility and whether the element is fit for purpose. The Panel was chaired by David Dole

and comprised of experts in engineering (including geotechnical, structural, hydraulic and water system operations), hydrology and ecology. Its members include:

- Phillip Cummins (engineering)
- Shane McGrath (engineering)
- Dr Chris Gippel (hydrology)
- Andrew Telfer (salinity)
- Professor Terry Hillman (ecology)

The following evaluations were carried out during the development of this business case:

- Engineering: Review of concept engineering designs (hydraulics and structures), the scoping of geotechnical investigations to support water management structure design and construction costs
- Hydrology: Review of hydrodynamic and hydrological models, data, modelled scenarios and outputs
- Salinity: review of assessments of potential salinity impacts of works and measures projects
- Ecology: Review of the descriptions of ecological values, the ecological objectives and targets, and environmental water requirements, and the descriptions of anticipated ecological outcomes and environmental water requirements

The expert review process has led to the conclusion that the underlying feasibility and outcome investigations have effectively provided a soundly based proposal that is fit for purpose. See the *Summary Report of Expert Peer Review Panel Outcomes* for further detail.

16.1.2 Regulatory Governance Group

The Regulatory Governance Group (RGG) was established to support the delivery of business case requirements related to regulatory approvals. The RGG was comprised of relevant staff from Victorian approvals agencies, including DEPI, Parks Victoria and Aboriginal Affairs Victoria. The RGG provided advice to the PCB regarding the regulatory approvals needed for Victorian projects, the resolution of associated issues and to develop a program-level strategy to obtain approvals (provided with this business case as a supporting document).

Setting up the RGG has provided a mechanism for high-level engagement with responsible agencies at an early stage to streamline the regulatory approvals process for proposed supply measures. While the RGG ceased operation when all business cases were finalised for submission (December 2014), the Group may be reconvened by the PCB as required.

16.1.3 Stakeholder Reference Group (Project partners)

At the project level, development of the business case for the *Gunbower National Park Environmental Works Project* was overseen by the Stakeholder Reference Group (North Central CMA, 2014e). The group's role was to ensure the business cases developed for these sites are of a high quality, consistent standard, and that they meet the requirements of the Commonwealth.

The Stakeholder Reference Group was comprised of members representing North Central CMA, PV, DEPI, GMW, MDBA, DoE, Gannawarra Shire Council and Campaspe Shire Council (North Central CMA, 2014e).

Specifically the group was responsible for the following functions in the development and delivery of the relevant project business cases (North Central CMA, 2014e):

- Advising on the development and proposed delivery of the projects from a technical perspective
- Ensuring projects developed and the supporting business cases produced are technically rigorous and sound
- Guiding and advising on statutory and policy issues, including the identification of any constraints or issues that may impede the success of the projects
- Advising on interpretation of policy and legislation relevant to their agency
- Advising on processes to resolve issues relative to their agency
- Identifying any issues associated with the proposed works that may impact upon project implementation, including any policy changes
- Monitoring the development of business cases to ensure a consistent approach and that required information is provided, in accordance with the Phase 2 Guidelines (reference).
- Disseminating information within their respective agencies regarding project progress and issues.

16.2 Governance arrangements during project implementation

To ensure that this proposed supply measure is delivered on time, arrangements will be put in place that will ensure appropriate senior oversight of project governance and delivery. This will allow for the successful completion and operation of the measure as part of the SDL adjustment mechanism.

These arrangements will be predominantly based around those that were used to deliver the three TLM projects within Victoria, complemented with existing state government frameworks, which together will underpin a set of robust and thorough processes for procurement and project management. Key aspects of the proposed governance and project management for this supply measure are explained below.

16.2.1 Project management structure and team

The project management structure and team will be overseen by the project owner, currently anticipated to be the DEPI. In line with the governance arrangements that have underpinned Business Case preparation for this proposed supply measure, DEPI will be supported by a Project Control Board (PCB), comprised of senior executives from DEPI, the relevant Victorian Catchment Management Authorities (CMAs), the relevant constructing authority (e.g. Goulburn Murray Water, SA Water) and Parks Victoria.

It is expected that the PCB will be comprise appropriate senior management representation from each of the participating agencies, who will have the required decision-making authority to oversee all elements of implementation. In line with the successful governance arrangements utilised during the Living Murray EWMP and the outcomes of the workshop on ongoing asset management arrangements (see Section 13.7), the relevant constructing authority would be well placed to undertake the construction of the supply measure, supported by the relevant CMA.

16.2.2 Procurement strategy

As the primary delivery agency, the relevant constructing authority could manage procurement during the construction of the supply measure, operating under the high-level oversight of the PCB. Supporting this, North Central CMA will play a critical role by assisting in the development of a procurement strategy, which would be approved by the PCB. More specific details of the preferred approach for procurement will be detailed in the construction proposal.

16.2.3 Project Steering Committees or related governance mechanisms

In line with good governance practice, and again drawing on the experience of the *Living Murray*, it is expected that the PCB would meet regularly throughout the construction of this proposed supply measure to ensure that milestones and timelines are met, and to resolve any potential arising issues.

The PCB members would have the required decision-making authority to address any emerging risks, including the following:

- Identifying and resolving issues, including those that might impact timelines/budget
- Providing guidance to resolve project-specific issues
- Ensuring appropriate consultation with key stakeholder agencies and the community
- Closely monitoring implementation to ensure timelines and budgets are met
- Making recommendations to DEPI on any issues that may arise during construction

16.2.4 Monitoring and reporting during implementation

The PCB would be the key conduit for monitoring and reporting during the implementation of this proposed supply measure. This would include:

- North Central CMA providing regular implementation updates at each PCB meeting
- Consideration of any milestone or payment reporting that is likely to be required under all contractual funding arrangements associated with this supply measure

16.2.5 Design and implementation plan with timelines

The PCB will meet regularly throughout the construction phase of this proposed supply measure to ensure milestones and timelines are met, to review designs, and to resolve any arising issues. North Central CMA will play a critical supporting role by assisting with statutory approvals and the development of the construction proposal, as well as managing discrete projects to support detailed designs and the implementation/ construction of the supply measure.

North Central CMA has a proven track record in the design and over-sight of project delivery for major environmental works measures, such as the TLM investment in the lower Gunbower Forest.

A detailed work plan will document the key tasks and the agency responsible, associated resources and timelines for the implementation of the supply measure. An overall timeframe for the completion of construction is shown in Table 16-1.

Table 16-1: Milestones and timelines for construction

Stages	Year 1	Year 2	Year 3	Year 4
Planning/Detailed design				
Approvals				
Procurement				
Works				
Commissioning				

16.2.6 Reference Group

A Reference Group will be established to assist and advise on the commissioning and operation of this proposed supply measure. This group will provide a forum to involve project partners in the decision-making process, to consider broader system operations (e.g. of the River Murray and other environmental watering events) during planning and operations, and to inform stakeholders of operations and progress.

For the upper Gunbower National Park, the Reference Group membership will consist of partners and stakeholders, including the MDBA, DEPI, GMW, NSW Office of Water, Lower Murray Water, Parks Victoria, the Commonwealth Environmental Water Holder and the Victorian Environmental Water Holder. Other agencies and organisations may be invited to participate as guests or observers.

The Reference Group's key responsibilities will be to ensure the necessary planning, monitoring, communication and reporting arrangements are established prior to and during events and to identify and monitor any event risks or issues. This allows for safe and effective operation of the works, real time response and adaptive management when necessary.

16.3 Governance expertise of partner agencies

Implementation of the Project in the upper Gunbower National Park will be a partnership between four agencies: North Central CMA, DEPI, PV and GMW.

16.3.1 North Central CMA

The North Central CMA's primary responsibility is to ensure that natural resources in the region are managed in an integrated and ecologically sustainable way. North Central CMA's work is based on rigorous science and delivered through meaningful partnerships with government agencies, industry, environmental organisations, private land managers, Indigenous stakeholders and the broader community. All delivery arrangements are formalised through a range of mechanisms including operating agreements, service level agreements and landholder incentive / tender management agreements, the application of comprehensive MERI frameworks; and the application and interpretation of complex spatial data.

The North Central CMA has a proven track record in successfully delivering a range of environmental projects which have varied in complexity, monetary value (up to multi-million dollar projects) and in spatial extent (from concentrated focal points to landscape-scale programs).

Operating within policies and controls approved and overseen by the North Central CMA Board ensures transparent and accountable governance systems that embody performance and continuous improvement. These governance arrangements include a quality management approach to project management, with policies and procedures for

project management, contractual arrangements, procurement and risk management. The North Central CMA's risk management approach covers strategic, operational, financial and compliance risks.

The North Central CMA was recognised in 2014 by the Australian Organisational Excellence Foundation with a Bronze Award for its achievements utilising business excellence principles, thereby demonstrating a commitment to sustainable performance, stakeholder value, quality and service, philanthropic ideals, ethical behaviour and environmentalsustainability.

16.3.2 DEPI

DEPI's primary responsibility in regard to this project is to act as its sponsor through the project assessment process established by the Intergovernmental Agreement on Murray-Darling Basin Water Reform 2014 (IGA). As part of this process, DEPI will represent the State of Victoria in negotiations with Commonwealth Government agencies to secure funding for the project, consistent with the commitments and arrangements outlined in the above mentioned IGA.

Once a funding agreement is reached for this project, DEPI will then assume an oversight role for the rollout of the project consistent with the terms of the funding agreement. As indicated previously, this oversight will be applied through the establishment of a PCB for the purposes of this project and any others that secure Commonwealth Government funding. It is envisaged that DEPI will chair and operate this PCB. Its primary focus will be to ensure that milestones and timelines are met and where necessary, to resolve any emerging issues that present a material risk to the conduct and/or completion of this project.

Over the past decade, DEPI has had considerable experience in undertaking such oversight roles to a high standard for major Commonwealth funded water infrastructure projects in Victoria. Notable examples in this regard include *The Living Murray* Environmental Works and Measures projects at Gunbower, Hattah Lakes, Mulcra and Lindsay Islands, the GMW Connections Program and the Lake Mokoan project.

16.3.3 Parks Victoria

Parks Victoria is a statutory authority, created by the *Parks Victoria Act 1998* and reporting to the Minister for Environment, Climate Change and Water.

Parks Victoria is responsible for managing an expanding and diverse estate covering more than 4 million hectares, or about 17 per cent, of Victoria.

Parks Victoria is committed to delivering works on the ground across Victoria's parks network to protect and enhance park values. Parks Victoria's primary responsibility is to ensure parks are healthy and resilient for current and future generations and to manage parks in the context of their surrounding landscape and in partnership with Traditional Owners.

Parks Victoria works in partnership with other government and non-government organisations and community groups such as DEPI, catchment management authorities, private land owners, friends groups, volunteers, licensed tour operators, lessees, research institutes and the broader community.

Healthy Parks Healthy People is at the core of everything Parks Victoria does. Parks and nature are an important part of improving and maintaining health, both for individuals and the community. Parks Victoria has a clear role to play in connecting people and communities with parks.

16.3.4 GMW

GMW provides rural water and drainage services in northern Victoria. GMW is the Victorian State Constructing Authority (SCA) for the MDBA, and the Victorian Murray Resource Manager, with responsibilities for water accounting and liaison with the MDBA on planned and actual diversion operations. GMW manages $4 billion of its own assets and a further $2 billion of MDBA assets to fulfil its functions. As SCA, GMW was the delivery authority for the Gunbower and Hattah *Living Murray* Projects in Victoria. GMW has the asset management and design and construction policies and controls in place to deliver against a large capital works program. These policies and controls will direct GMW's activities for the delivery of those SDL Offset projects for which it is assigned responsibility.

17 Risk assessment of project development and construction

The Project's approach to assessing risks has been outlined briefly in Section 7 and is further detailed in the *Risk Management Strategy* and the *Risk Register*.

Section 6 deals with potential adverse ecological impacts and Section 11 with potential adverse social and economic impacts, from operation of the measure. This section reviews the potential risks related to the successful completion of the Project, including its construction and delivery. There is some inevitable overlap with the earlier risk assessment sections.

17.1 Construction risks

Construction of the infrastructure required to deliver the watering activities has the potential to have impacts. These include adverse environmental impacts, fire, damage to cultural heritage and/or European historical assets, injury or loss of life, and socio-economic impacts including disruption to local amenities or economic activities. Table 17-1 provides a listing of the risks which scored an overall risk rating of either 'Very High' or 'High'.

17.2 Process

Risk mitigation and management of construction activities involve a standard set of well-established legislated controls outlined below:

- The project proponent applies for a planning permit to undertake the works
- The application triggers referrals to multiple agencies
- The agencies impose conditions on the planning permit
- That permit requires the development and implementation of standard controls including:
  - Public Land Manager or Land Owner consent
  - An Environmental Management Framework
  - An Offset Strategy
  - Threatened Species Management Plan
  - A Cultural Heritage Management Plan (see below)
  - Installation and site plans
  - A traffic management plan
  - A fire management plan
  - An Occupational Health and Safety plan
  - A rehabilitation plan
- The relevant construction contractor is responsible for developing and implementing these plans, subject to over-sight by the relevant managing authority.
- Approvals under other legislation (refer Section 16) will be required as part of the development and delivery of the Project. The implementation of these legislated mitigation controls will reduce the risks in Table 18-1 to a 'Moderate' rating.

Table 17-1: Priority construction impact risks

Risks	Initial risk			Residual risk		
	Likelihood	Consequence	Rating	Likelihood	Consequence	Rating
Machinery may start a fire, causing loss of biodiversity within the National Park and human and/or property damage.	Possible	Extreme Harm	Very High	Unlikely	Major Harm	High
Construction activities may cause injury to workers or community members	Unlikely	Major Harm	High	Unlikely	Moderate Harm	Moderate
Construction machinery or vehicles may be involved in traffic incidents or accidents, causing injury and damages.	Unlikely	Major Harm	High	Unlikely	Moderate Harm	Moderate
Relevant landholders are not engaged and supportive then project unable to acquire land required for channel supply	Possible	Major Harm	High	Unlikely	Moderate Harm	Moderate
Flooding of work areas through abnormal weather may prevent access causing delays	Possible	Major Harm	High	Possible	Minor Harm	Moderate
Poor quality control compromise the functionality and durability of the infrastructure	Possible	Major Harm	High	Unlikely	Moderate Harm	Moderate
Bushfire impact on construction site	Unlikely	Major Harm	High	Unlikely	Moderate Harm	Moderate
Wet weather delays	Likely	Moderate Harm	High	likely	Minor Harm	Moderate
Approval delays	Possible	Major Harm	High	Unlikely	Moderate Harm	Moderate
Change in staff lead to delays in project due to loss or corporate knowledge	Possible	Major Harm	High	Unlikely	Moderate Harm	Moderate

Further detail on the risks and associated mitigation controls is provided below.

17.2.1 Environment

To identify potential risks of construction to significant, threatened or listed species or communities of environmental significance, a flora and fauna assessment of proposed work sites was undertaken (Biosis 2014). The study identified the following relevant matters listed under relevant legislation:

- *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)
    - Potential habitat for EPBC-listed species - River Swamp Wallaby-grass, Winged Peppercress, Stiff Groundsel, Growling Grass Frog and Superb Parrot.
    - Listed Grey Box woodland community.
- *Victorian Flora and Fauna Guarantee Act 1988* (FFG Act)
    - Study recorded presence of Broad-shelled Turtle and habitat for a number of listed species. Numerous protected flora species were recorded.

The results of this assessment were incorporated into the Project design and options investigated to retain as much of the mapped vegetation/habitats as possible. Priority was given to the highest value areas and retaining as many large trees as possible. As a result of the above investigation, the design and construction of the required infrastructure will minimise removal of native vegetation and terrestrial and aquatic habitat. i.e. the construction focused adverse ecological impacts are negligible.

In addition, the following will be undertaken by North Central CMA prior to any works:

- Prepare a referral to the Commonwealth Environment Minister to determine if the project needs to be formally assessed under the *EPBC Act* (1999) for potential impacts to Matters of National Environmental Significance (MNES)
- Prepare a referral under the *Environment Effects Act 1978* to determine if the project needs to be formally assessed.
- Prepare an offset strategy to meet the required offsets for the permitted clearance of native vegetation and threatened species habitat.
- Obtain permits required by policy and legislation.
- Prepare relevant management plans such as a Construction Environment Management Plan (CEMP) and a Threatened Species Management Plan (TSMP) that will identify activities required during construction to avoid or minimise impacts on significant, threatened or listed species or communities of environmental significance.

17.2.2 Physical Injury

The residual risk for physical injury, from construction vehicles and construction activities, is considered to be moderate. A Construction Management Plan will be developed that will prescribe responsibilities under the *Occupational Health and Safety Act 1994* to ensure safe practices for all activities on site and related to the construction work.

17.2.3 Community unsupportive

Community support is an important part of implementing and operating environmental watering projects. The North Central CMA has developed the *Stakeholder Management Strategy* (North Central CMA 2014c) to guide engagement activities for the Project and mitigate the potential risks associated with a lack of community support. This is reported

on more fully in Section 14. Targeted engagement of adjacent landholders has been a key activity for the business case development phase of the Project. The residual risk for this risk is considered to be moderate. Ongoing engagement and communication activities will be critical to ensure this risk is mitigated.

17.2.4 Cultural Heritage

Construction of the works and operation of the proposed watering regime has the potential to impact on sites of cultural heritage significance. The proposed construction works in Gunbower National Park will require the preparation of a Cultural Heritage Management Plan (CHMP) for indigenous cultural heritage as these are high impact activities within an area of Cultural Heritage Sensitivity as defined under the *Aboriginal Heritage Act 2006* (Benchmark Heritage Management. 2014).

The CHMP will be the primary mitigation control to protect cultural heritage values from harm during construction. The CHMP will set out the actions required to minimise potential impacts and manage any residual risks. The major mitigation strategy will be to relocate works and activities away from locations with an existing record of significance. This will reduce both the likelihood and severity of any risk. However, it is recognised that the register of aboriginal sites and artefacts is only a partial record of all potential sites. Therefore, any work activities will also need to include systems to identify assets and respond to them as construction is undertaken.

The North Central CMA has an existing relationship with the Traditional Owners, the Yorta Yorta Nation Aboriginal Corporation, through its indigenous facilitator and project staff. The preliminary cultural heritage assessment was undertaken with Yorta Yorta Traditional Owners (Benchmark Heritage Management. 2014). If significant assets are identified during construction, the CMA will work closely with Yorta Yorta Traditional Owners to reach an agreed response, as well as adhering to the legal requirements. It is also worth noting that the Traditional Owners place considerable value on the health of the wetlands and forests.

A preliminary European cultural heritage study (Kaufman & Ballinger 2014) identified a number of cultural heritage sites of local significance. The study concluded that there are no historic heritage compliance issues arising from the *Heritage Act 1995* or the *Planning and Environment Act 1987* associated with the impacts outlined above and no action is required of the North Central CMA or its contractors in carrying out the proposed works. Given these established controls and protocols, it is judged that the residual risk is 'likely' to occur but could cause 'minor harm' - resulting in an overall risk rating of 'Moderate'.

17.2.5 Fire

Fire has a residual risk rating of high due to the consequences of a fire e.g. property damage, loss of life. The likelihood of the event is considered to be 'Unlikely', but the consequence of any such event would still be 'Major Harm' and so triggers a Category B 'High' risk rating.

17.2.6 Poor workmanship

If poor quality controls are in place, the functionality and durability of the infrastructure will be compromised, impacting on the desired operational outcomes, future maintenance and operational costs and safety. The detailed design and construction process will engage suitably qualified and experienced personnel, with a peer review process to ensure that appropriate quality assurance and quality controls are in place. The residual risk is considered to be moderate with a probability of 'unlikely'.

17.2.7 Flooding and adverse weather

If flooding of work areas or abnormal weather conditions prevent access to the site, this could result in delays and costs for de-mobilisation and re-mobilisation of workforce. Ensuring appropriate contractor contract and management arrangements will be critical to ensure that cost escalation, insurance considerations and liability are agreed up front. With this mitigation control in place, the residual risk was assessed as 'possible' and 'minor' generating an overall risk rating of 'Minor'. Costs for this risk have been accounted for in the construction costs (refer Section 13.2.1). The residual risk is considered to be moderate.

17.3 Project management

There are risks arising from the project management aspect of the implementation phase as outlined below. These risks could be from a number of sources, which will trigger a range of different risk mitigation strategies and controls.

17.3.1 Approval delays

The *Regulatory Approvals Strategy* (DEPI 2014c) provides a detailed review of the approvals required for implementation of the Project. The Project plan will outline proposed timelines with appropriate contingencies to account for potential delays. DEPI will also provide statewide oversight on the approvals process on behalf of Victoria.

17.3.2 Loss of staff capacity

Effective and efficient project management requires skilled and experienced staff, particularly for projects that are multidisciplinary involving ecological, hydrological and engineering relationships. The time lag between submission of business cases for assessment by the Australian Government and notification of approval poses a risk that key staff involved in planning and development of the Project will no longer be available for the implementation phase. This risk will be mitigated through collaborative statewide and Basin wide approaches to skill resourcing and development. The residual risk is considered to be 'moderate' as there is limited control over the availability of funding to retain staff during this key period.

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Appendix 1: Species lists

Table 1 Flora species found in Gunbower National Park (DSE 2010; Biosis 2014; Bennetts 2014a; Bennetts 2014b; Frood & Bennetts 2014; Bennetts & Jolly 2013)

Species Name	Common Name	EPBC	VIC	FFG
Acacia acinacea	Gold-dust Wattle			
Acacia brachybotrya	Grey Mulga			
Acacia dealbata subsp. dealbata	Silver Wattle			
Alisma plantago-aquatica	Water Plantain			
Alternanthera denticulata	Lesser Joyweed			
Alternanthera nodiflora	Common Joyweed		k	
Alternanthera sp. 1 (Plains)	Plains Joyweed		k	
Amphibromus fluitans	River Swamp Wallaby-grass	V	X	
Amphibromus nervosus	Common Swamp Wallaby-grass			
Amphibromus spp.	Swamp Wallaby-grass			
Amyema miquelii	Box Mistletoe			
Anthosachne scabra s.l.	Common Wheat-grass			
Aphanes australiana	Australian Piert			
Arthropodium fimbriatum	Nodding Chocolate Lily			
Arthropodium minus	Small Vanilla-lily			
Atriplex eardleyae	Small Saltbush			
Atriplex leptocarpa	Slender-fruit Saltbush			
Atriplex nummularia subsp. nummularia	Old-man Saltbush			
Atriplex pseudocampanulata	Mealy Saltbush		r	
Atriplex pumilio	Mat Saltbush			
Atriplex semibaccata	Berry Saltbush			
Atriplex suberecta	Sprawling Saltbush			
Austrostipa elegantissima	Feather Spear-grass			
Austrostipa nodosa	Knotty Spear-grass			
Austrostipa scabra	Rough Spear-grass			
Austrostipa scabra subsp. falcata	Rough Spear-grass			
Austrostipa spp.	Spear-grass			
Azolla filiculoides	Pacific Azolla			
Azolla pinnata	Ferny Azolla			
Azolla spp.	Azolla			
Boerhavia dominii	Tah-vine			
Bolboschoenus medianus	Marsh Club-sedge			
Brachyscome basaltica var. gracilis	Woodland Swamp-daisy			
Brachyscome ciliaris var. brachyglottis	Variable Daisy			
Brachyscome diversifolia	Tall Daisy			
Brachyscome readeri	Reader's Daisy		r	
Bulbine semibarbata	Leek Lily			
Calandrinia calyptrata	Pink Purslane			
Calandrinia spp.	Purslane			
Callitriche sonderi	Matted Water-starwort			
Callitriche spp.	Water-starwort			
Callitriche umbonata	Western Water-starwort		r	X
Calocephalus sonderi	Pale Beauty-heads			
Calotis cuneifolia	Blue Burr-daisy		r	
Calotis hispidula	Hairy Burr-daisy			
Calotis scabiosifolia var. scabiosifolia	Rough Burr-daisy			
Calotis scapigera	Tufted Burr-daisy			
Cardamine moirensis	Riverina Bitter-cress		R	
Carex inversa	Knob Sedge			
Carex tereticaulis	Poong'ort			
Cassinia arcuata	Drooping Cassinia			

Species Name	Common Name	EPBC	VIC	FFG
Centella cordifolia	*Centella*			
Centipeda cunninghamii	Common Sneezeweed			
Centipeda minima subsp. minima s.s.	Spreading Sneezeweed			
Ceratophyllum demersum	Hornwort		k	
Chamaesyce drummondii	Flat Spurge			
CHARACEAE spp.	Stonewort			
Chenopodium desertorum subsp desertorum	Frosted Goosefoot		r	
Chenopodium desertorum subsp. microphyllum	Small-leaf Goosefoot			
Chenopodium desertorum subsp. rectum	Frosted Goosefoot		v	v
Chenopodium pumilio	Clammy Goosefoot			
Chloris spp.	Windmill Grass			
Chloris truncata	Windmill Grass			
Cotula australis	Common Cotula			
Craspedia paludicola	Swamp Billy-buttons			
Crassula colorata	Dense Crassula			
Crassula decumbens var. decumbens	Spreading Crassula			
Crassula helmsii	Swamp Crassula			
Crassula peduncularis	Purple Crassula			
Crassula sieberiana	Sieber Crassula			
Cymbonotus preisianus	Austral Bear's-ear			
Cynodon dactylon var. pulchellus	Native Couch			k
Cyperus difformis	Variable Flat-sedge			
Cyperus exaltatus	Tall Flat-sedge			
Cyperus gunnii subsp. gunnii	Flecked Flat-sedge			
Cyperus spp.	Flat Sedge			
Damasonium minus	Star Fruit			
Daucus glochidiatus	Australian Carrot			
Deyeuxia quadriseta	Reed Bent-grass			
Dianella admixta	Black-anther Flax-lily			
Dianella spp. aff. longifolia (Riverina)	Pale Flax-lily		v	
Dichondra repens	Kidney-weed			
Dillwynia cinerascens	Grey Parrot-pea			
Dysphania glomulifera subsp. glomulifera	Globular Pigweed			
Dysphania pumilio	Clammy Goosefoot			
Eclipta platyglossa	Yellow Twin-heads			
Einadia hastata	Saloop			
Einadia nutans subsp. nutans	Nodding Saltbush			
Einadia trigonos subsp. trigonos	Lax Goosefoot			
Elatine gratioloides	Waterwort			
Eleocharis acuta	Common Spike-sedge			
Eleocharis pallens	Pale Spike-sedge		k	
Eleocharis pusilla	Small Spike-sedge			
Eleocharis sphacelata	Tall Spike-sedge			
Elymus scaber var. scaber	Common Wheat-grass			
Enchylaena tomentosa var. tomentosa	Ruby Saltbush			
Enteropogon acicularis	Spider Grass			
Epilobium billardierianum	Variable Willow-herb			
Epilobium billardierianum subsp. Billardierianum	Smooth Willow-herb			
Epilobium billardierianum subsp. cinereum	Grey Willow-herb			
Epilobium hirtigerum	Hairy Willow-herb			
Eragrostis infecunda	Southern Cane-grass			
Erodium crinitum	Blue Heron's-bill			
Eryngium paludosum	Long Eryngium		v	
Eucalyptus camaldulensis	River red-gum			
Eucalyptus largiflorens	Black box			
Eucalyptus microcarpa	Grey box			
Euchiton collinus	Creeping Cudweed			
Euchiton involucratus s.l.	Common cudweed			
Euchiton involucratus s.s.	Star Cudweed			
Euchiton sphaericus	Annual Cudweed			

Species Name	Common Name	EPBC	VIC	FFG
Eulalia aurea	Silky Browntop			
Euphorbia drummondii	Flat Spurge			
Eutaxia microphylla var. diffusa	Spreading Eutaxia			
Eutaxia microphylla var. microphylla	Common Eutaxia			
Exocarpos cupressiformis	Cherry Ballart			
Exocarpos strictus	Pale-fruit Ballart			
Galium gaudichaudii	Rough Bedstraw			
Geococcus pusillus	Earth Cress			
Geranium sp.	Crane's Bill			
Geranium sp. 2	Variable Crane's-bill			
Geranium sp. 5	Naked Crane's-bill			
Glinus lotoides	Hairy Carpet-weed			
Glinus oppositifolius	Slender Carpet-weed			
Gnaphalium polycaulon	Indian Cudweed			
Gnaphalium sp.	Cudweed			
Goodenia fascicularis	Silky Goodenia			
Goodenia glauca	Pale Goodenia			
Goodenia gracilis	Slender Goodenia			
Goodenia heteromera	Spreading Goodenia			
Goodenia pinnatifida	Cut-leaf Goodenia			
Goodenia pusilliflora	Small-flower Goodenia			
Gratiola pumila	Dwarf Brooklime		r	
Haloragis aspera	Rough Raspwort			
Haloragis heterophylla	Varied Raspwort			
Helichrysum luteoalbum	Jersey Cudweed			
Helichrysum rutidolepis	Pale Everlasting			
Hypoxis glabella var. glabella	Tiny Star			
Isolepis spp.	Club sedge			
Juncus amabilis	Hollow Rush			
Juncus aridicola	Tussock Rush			
Juncus australis	Austral Rsuh			
Juncus flavidus	Gold Rush			
Juncus holoschaenus	Joint-leaf Rush			
Juncus ingens	Giant Rush			
Juncus pallidus	Pale Rush			
Juncus subsecundus	Finger Rush			
Juncus usitatus	Billabong Rush			
Lachnagrostis filiformis s.s.	Common Blown-grass			
Landoltia punctata	Thin Duckweed			
Lemna disperma	Common Duckweed			
Lepidium pseudohyssopifolium	Native Peppercress		k	
Limosella australis	Austral Mudwort			
Linum marginale	Native Flax			
Lobelia concolor	Poison Pratia			
Lobelia pratioides	Poison Lobelia			
Ludwigia peploides subsp. montevidensis	Clove-strip			
Lycopus australis	Australian Gipsywort			
Lythrum hyssopifolia	Small Loosestrife			
Lythrum salicaria	Purple Loosestrife			
Maireana brevifolia	Short-leaf Bluebush			
Maireana decalvans	Black Cotton-bush			
Maireana enchylaenoides	Wingless Bluebush			
Maireana humillima	Dwarf Bluebush			
Malva spp.	Mallow			
Marsilea costulifera	Narrow-leaf Nardoo			
Marsilea drummondii	Common Nardoo			
Marsilea hirsuta	Short-fruit Nardoo			
Marsilea spp.	Nardoo			
Melaleuca lanceolata subsp. lacelata	Moonah			
Mentha australis	River Mint			

Species Name	Common Name	EPBC	VIC	FFG
Mimulus gracilis	Slender Monkey-flower			
Minuria integerrima	Smooth Minuria		r	
Muehlenbeckia florulenta	Tangled Lignum			
Myosurus australis	Mousetail			
Myriophyllum caput-medusae	Coarse Water-milfoil			
Myriophyllum crispatum	Upright Water-milfoil			
Myriophyllum papillosum	Robust Water-milfoil			
Myriophyllum spp.	Water-milfoil			
Myriophyllum verrucosum	Red Water-milfoil			
Najas tenuifolia	Water Nymph		r	
Nitella spp.	Stonewort			
Nymphoides crenata	Wavy Marshwort		v	L
Olearia pimeleoides	Pimelea Daisy-bush			
Ophioglossum lusitanicum	Austral Adder's-tongue			
Ottelia ovalifolia subsp. ovalifolia	Swamp Lily			
Oxalis perennans	Grassland Wood-sorrel			
Parietaria debilis s.s.	Shade Pellitory			
Paspalidium jubiflorum	Warrego Summer-grass			
Paspalum distichum	Water Couch			
Persicaria decipiens	Slender Knotweed			
Persicaria hydropiper	Water Pepper			
Persicaria lapathifolia	Pale Knotweed			
Persicaria prostrata	Creeping Knotweed			
Phragmites australis	Common Reed			
Picris spp.	Picris			
Pittosporum angustifolium	Weeping Pittosporum			
Plantago cunninghamii	Clay Plantain			
Plantago drummondii	Dark Plantain			
Plantago gaudichaudii	Narrow Plantain			
Plantago turrifera	Crowned Plantain			
Plantago varia	Variable Plantain			
Poa labillardierei var. labillardierei	Common Tussock-grass			
Polygonum aviculare	Prostrate Knotweed			
Polygonum plebeium	Small Knotweed			
Potamogeton cheesemanii	Red Pondweed			
Potamogeton ochreatus	Blunt Pondweed			
Potamogeton spp.	Pondweed			
Potamogeton sulcatus	Furrowed Pondweed			
Potamogeton tricarinatus	Floating Pondweed			
Pseudognaphalium luteoalbum	Jersey Cudweed			
Pseudoraphis spinescens	Spiny Mud-grass			
Ptilotus spathulatus f. spathulatus	Pussy Tails			
Ranunculus inundatus	River Buttercup			
Ranunculus lappaceus	Australian buttercup			
Ranunculus pumilio	Ferny Small-flower Buttercup			
Ranunculus sessiliflorus subsp. sessiliflorus	Annual Buttercup			
Rhagodia spinescens	Hedge Saltbush			
Riccia duplex	Floating Crystalwort			
Ricciocarpos natans	Fringed Heartwort			
Rorippa eustylis	Dwarf Bitter-cress		r	
Rorippa laciniata	Jagged Bitter-cress			
Rumex bidens	Mud Dock			
Rumex brownii	Slender Dock			
Rumex crispus	Curled Dock			
Rumex dumosus	Wiry Dock			
Rumex tenax	Narrow-leaf Dock			
Rytidosperma caespitosum	Common Wallaby-grass			
Rytidosperma duttonianum	Brown-back Wallaby-grass			
Rytidosperma erianthum	Hill Wallaby-grass			
Rytidosperma fulvum	Copper-awned Wallaby-grass			

Species Name	Common Name	EPBC	VIC	FFG
Rytidosperma racemosum var. racemosum	Slender Wallaby-grass			
Rytidosperma setaceum var. setaceum	Bristly Wallaby-grass			
Rytidosperma spp.	Wallaby-grass			
Salsola tragus	Prickly Saltwort			
Salsola tragus subsp. tragus	Prickly Saltwort			
Sclerolaena diacantha	Grey Copperburr			
Sclerolaena muricata	Black Roly-poly			
Sclerolaena muricata var. semiglabra	Dark Roly-poly			
Sclerolaena uniflora	Two-spined Copperburr			
Senecio campylocarpus	Floodplain Fireweed		r	
Senecio cunninghamii var. cunninghamii	Branching Groundsel			
Senecio quadridentatus	Cotton Fireweed			
Senecio runcinifolius	Tall Fireweed			
Senna artemisioides spp. agg.	Desert Cassia			
Sida corrugata	Variable Sida			
Sigesbeckia orientalis subsp. orientalis	Indian Weed			
Solanum esuriale	Quena			
Solanum spp.	Nightshade			
Solenogyne dominii	Smooth Solenogyne			
Spergularia marina	Salt Sand-spurrey			
Spirodela spp.	Duckweed			
Stellaria angustifolia	Swamp Starwort			
Stellaria caespitosa	Matted Starwort			
Stemodia florulenta	Blue Rod			
Stemodia glabella s.s.	Smooth Blue-rod		k	
Stuartina muelleri	Spoon cudweed			
Swainsona procumbens	Broughton Pea			
Teucrium racemosum	Grey Germander			
Themada triandra	Kangaroo Grass			
Triglochin multifructa	Northern Water-ribbons			
Triglochin procera	Water Ribbons			
Triglochin spp.	-			
Typha domingensis	Narrow-leaf Cumbungi			
Typha orientalis	Broad-leaf Cumbungi			
Typha spp.	Cumbunghi			
Urtica incisa	Scrub Nettle			
Utricularia australis	Yellow Bladderwort			
Vallisneria americana var. americana	Eel Grass			
Verbena litoralis	Verbena			
Vittadinia cervicularis var. cervicularis	Annual New Holland Daisy			
Vittadinia condyloides	Club-hair New Holland Daisy			
Vittadinia cuneata	Fuzzy New Holland Daisy			
Vittadinia cuneata var. cuneata	Fuzzy New Holland Daisy			
Vittadinia gracilis	Woolly New Holland Daisy			
Vittadinia spp.	New Holland Daisy			
Wahlenbergia communis s.s.	Tufted Bluebell			
Wahlenbergia fluminalis	River Bluebell			
Wahlenbergia gracilis	Sprawling Bluebell			
Wahlenbergia luteola	Bronze Bluebell			
Wurmbea dioica subsp. dioica	Common Early Nancy			
Xerochrysum bracteatum	Golden Everlasting			
Zygophyllum glaucum	Pale Twin-leaf			

Table 2: Threatened species likely to occur in the project area

Species Name	Common Name	EPBC	VIC	FFG	IUCN
Lepidium monoplocoides	Winged Peppercress	EN	e	L	
Senecio behrianus	Stiff Groundsel	EN	e	L	

Table 3. Fauna species found in Gunbower National Park (SKM 2007; Bennetts 2014; Biosis 2014a, 2014b; DSE 2010)

Species Name	Common Name	EPBC	VIC	FFG
Acanthiza chrysorrhoa	Yellow-rumped Thornbill			
Acanthiza lineata	Striated Thornbill			
Acanthiza nana	Yellow Thornbill			
Acanthiza pusilla	Brown Thornbill			
Acanthiza reguloides	Buff-rumped Thornbill			
Acanthiza uropygialis	Chestnut-rumped Thornbill			
Accipiter cirrhocephalus	Collared Sparrowhark			
Accipiter fasciatus	Brown Goshawk			
Acrocephalus australis	Australian Reed-Warbler			
Acrocephalus stentoreus	Calmorous Reed Warbler			
Aegotheles cristatus	Australian Owlet-nightjar			
Anas castanea	Chestnut Teal			
Anas gracilis	Grey Teal			
Anas superciliosa	Pacific Black Duck			
Anhinga novaehollandiae	Darter			
Antechinus flavipes	Yellow-footed Antechinus			
Anthochaera carunculata	Red Wattlebird			
Aphelocephala leucopsis	Southern Whiteface			
Apus pacificus	Fork-tailed Swift			
Aquila audax	Wedge-tailed Eagle			
Ardea alba	Eastern Great Egret		vu	L
Ardea ibis	Cattle Egret			
Ardea intermedia	Intermediate Egret		en	L
Ardea pacifica	White-necked Heron			
Artamus cyanopterus	Dusky Woodswallow			
Artamus leucorynchus	White-brested Woodswallow			
Artamus personatus	Masked Woodswallow			
Artamus superciliosus	White-browed Woodswallow			
Aythya australis	Hardhead		vu	
Barnardius zonarius	Australian Ringneck			
Biziura lobata	Musk Duck		vu	
Botaurus poiciloptilus	Australasian Bittern	EN	en	L
Cacatua galerita	Sulphur-crested Cockatoo			
Cacatua sanguinea	Little Corella			
Cacatua tenuirostris	Long-billed Corella			
Cacomantis flabelliformis	Fan-tailed Cuckoo			
Cacomantis pallidus	Pallid Cuckoo			
Carduelis Carduelis	European Goldfinch			
Ceyx azureus	Azure Kingfisher		nt	
Chalcites basalis	Horsfield's Bronze-Cuckoo			
Chalinolobus gouldii	Gould's Wattled Bat			
Chalinolobus morio	Chocolate Wattled Bat			
Chelodina expansa	Broad-shelled Turtle		en	L
Chelodina longicollis	Common Long-necked Turtle		dd	
Chenonetta jubata	Australian Wood Duck			
Cheramoeca leucosterna	White-backed Swallow			

Species Name	Common Name	EPBC	VIC	FFG
Chlidonias hybridus javanicus	Whiskered Tern		nt	
Christinus marmoratus	Marbled Gecko			
Chrysococcyx basalis	Horsfield's Bronze-cuckoo			
Chrysococcyx lucidus	Shining Bronze-cuckoo			
Chrysococcyx osculans	Black-eared cuckoo		nt	
Cincloramphus mathewsi	Rufous Songlark			
Circus approximans	Swamp Harrier			
Cisticola exilis	Golden-headed Cisticola			
Climacteris picumnus victoriae	Brown Treecreeper (south-eastern ssp.)		nt	
Colluricincla harmonica	Grey Shrike-thrush			
Columba livia	Rock Dove			
Coracina maxima	Ground Cuckoo-shrike		vu	L
Coracina novaehollandiae	Black-faced Cuckoo-shrike			
Coracina papuensis	White-bellied Cuckoo-shrike			
Corcorax melanorhamphos	White-winged Chough			
Cormobates leucophaea	White-throated Treecreeper			
Corvus coronoides	Australian Raven			
Corvus mellori	Little Raven			
Coturnix ypsilophora	Brown Quail			
Cracticus nigrogularis	Pied Butcherbird			
Cracticus torquatus	Grey Butcherbird			
Cracticus tibicen	Australian Magpie			
Crinia parinsignifera	Plains Froglet			
Crinia signifera	Common Froglet			
Crinia sloanei	Sloane's Froglet			
Cryptoblepharus pannosus	Carnaby's Wall Skink			
Ctenotus robustus	Large Striped Skink			
Cygnus atratus	Black Swan			
Dacelo novaeguineae	Laughing Kookaburra			
Daphoenositta chrysoptera	Varied Sittella			
Dendrocygna eytoni	Plumed Whistling-duck			
Dicaeum hirundinaceum	Mistletoebird			
Diplodactylus tessellatus	Tessellated Gecko			
Diplodactylus vittatus	Wood Gecko			
Dromaius novaehollandiae	Emu		nt	
Egernia striolata	Tree Skink			
Egretta garzetta nigripes	Little Egret		en	L
Egretta novaehollandiae	White-faced Heron			
Elanus axillaris	Black-shouldered Kite			
Elseyornis melanops	Black-fronted Dotterel			
Entomyzon cyanotis	Blue-Faced Honeyeater			
Eolophus roseicapillus	Galah			
Eopsaltria australis	Eastern yellow robin			
Eulamprus heatwolei	Yellow-bellied Water Skink			
Eurystomus orientalis	Dollarbird			
Falco berigora	Brown Falcon			
Falco cenchroides	Nankeen Kestrel			
Falco longipennis	Australian Hobby			
Falco peregrinus	Peregrine Falcon			

Species Name	Common Name	EPBC	VIC	FFG
Falcunculus frontatus	Crested Shrike-tit			
Fulica atra	Eurasian Coot			
Gallinula tenebrosa	Dusky Moorhen			
Geopelia cuneata	Diamond Dove		nt	L
Geopelia striata	Peaceful Dove			
Gerygone fusca	Western Gerygone			
Glossopsitta concinna	Musk Lorikeet			
Grallina cyanoleuca	Magpie-lark			
Haliaeetus leucogaster	White-bellied Sea-Eagle		vu	L
Haliastur sphenurus	Whistling Kite			
Hamirostra melanosternon	Black-breasted Buzzard			
Hieraaetus morphnoides	Little Eagle			
Himantopus himantopus	Black-winged Stilt			
Hirundapus caudacutus	White-throated Needletail		vu	
Hirundo neoxena	Welcome Swallow			
Lalage tricolor	White-winged Triller			
Lampropholis guichenoti	Garden Skink			
Lerista bougainvillii	Bougainville's Skink			
Lichenostomus chrysops	Yellow-faced Honeyeater			
Lichenostomus fuscus	Fuscous Honeyeater			
Lichenostomus penicillatus	White-plumed Honeyeater			
Limnodynastes dumerilii	Southern Bullfrog (ssp. unknown)			
Limnodynastes dumerilii dumerilii	Pobblebonk Frog			
Limnodynastes fletcheri	Barking Marsh Frog			
Limnodynastes interioris	Giant Bullfrog		cr	L
Limnodynastes tasmaniensis	Spotted Marsh Frog (race unknown)			
Limnodynastes tasmaniensis NCR	Spotted Marsh Frog NCR			
Litoria peronii	Peron's Tree Frog			
Lophoictinia isura	Square-tailed Kite		vu	L
Macropus giganteus	Eastern Grey Kangaroo			
Malurus cyaneus	Superb Fairy-wren			
Manorina melanocephala	Noisy Miner			
Megalurus gramineus	Little Grassbird			
Melanodryas cucullata	Hooded Robin		nt	
Melithreptus brevirostris	Brown-headed Honeyeater			
Melithreptus gularis	Black-chinned Honeyeater		nt	
Melithreptus lunatus	White-naped Honeyeater			
Melopsittacus undulatus	Budgerigar			
Merops ornatus	Rainbow Bee-eater			
Microcarbo melanoleucos	Little Pied Cormorant			
Microeca fascinans	Jacky Winter		nt	
Milvus migrans	Black Kite			
Morethia boulengeri	Boulenger's Skink			
Myiagra cyanoleuca	Satin Flycatcher			
Myiagra inquieta	Restless Flycatcher			
Myiagra rubecula	Leaden Flycatcher			
Neochmia temporalis	Red-browed Finch			
Ninox connivens connivens	Barking Owl		en	L
Ninox novaeseelandiae	Southern Boobook			
Notechis scutatus	Tiger Snake			

Species Name	Common Name	EPBC	VIC	FFG
Nycticorax caledonicus	Nankeen Night-Heron		vu	
Nyctophilus geoffroyi	Lesser Long-eared Bat			
Nymphicus hollandicus	Cockatiel			
Ocyphaps lophotes	Crested Pigeon			
Oriolus sagittatus	Olive-backed Oriole			
Pachycephala inornata	Gilbert's Whistler			
Pachycephala pectoralis	Golden Whistler			
Pachycephala rufiventris	Rufous Whistler			
Pardalotus punctatus	Spotted Pardalote			
Pardalotus striatus	Striated Pardalote			
Passer domesticus	House Sparrow			
Pelecanus conspicillatus	Australian Pelican			
Petaurus norfolcensis	Squirrel Glider		en	L
Petrochelidon ariel	Fairy Martin			
Petrochelidon nigricans	Tree Martin			
Petroica goodenovii	Red-capped Robin			
Petroica multicolor	Scarlet Robin			
Petroica phoenicea	Flame Robin			
Phalacrocorax carbo	Great Cormorant			
Phalacrocorax sulcirostris	Little Black Cormorant			
Phalacrocorax varius	Pied Cormorant		nt	
Phaps chalcoptera	Common Bronzewing			
Philemon citreogularis	Little Friarbird			
Philemon corniculatus	Noisy Friarbird			
Platalea flavipes	Yellow-billed Spoonbill			
Platalea regia	Royal Spoonbill		nt	
Platycercus elegans	Crimson Rosella			
Platycercus elegans flaveolus	Yellow Rosella			
Platycercus eximius	Eastern Rosella			
Podargus strigoides	Tawny Frogmouth			
Podiceps cristatus	Great Crested Grebe			
Poliocephalus poliocephalus	Hoary-headed Grebe			
Polytelis swainsonii	Superb Parrot	VU	en	L
Pomatostomus superciliosus	White-browed Babbler			
Pomatostomus temporalis	Grey-crowned babbler		en	L
Porphyrio porphyrio	Purple Swamphen			
Porzana fluminea	Australian Spotted Crake			
Psephotus haematonotus	Red-rumped Parrot			
Pseudechis porphyriacus	Red-bellied Black Snake			
Pseudocheirus peregrinus	Common Ringtail Possum			
Ramphotyphlops bituberculatus	Peter's Blind Snake			
Ramphotyphlops proximus	Woodland Blind Snake		nt	
Rhipidura albiscapa	Grey Fantail			
Rhipidura leucophrys	Willie Wagtail			
Sericornis frontalis	White-browed Scrubwren			
Smicrornis brevirostris	Weebill			
Stagonopleura guttata	Diamond Firetail		nt	L
Strepera graculina	Pied Currawong			
Sturnus vulgaris	Common Starling			
Tachybaptus novaehollandiae	Australasian Grebe			

Species Name	Common Name	EPBC	VIC	FFG
Tadarida australis	White-striped Freetail Bat			
Tachyglossus aculeatus	Short-beaked Echidna			
Tadorna tadornoides	Australian Shelduck			
Taeniopygia guttata	Zebra Finch			
Threskiornis molucca	Australian White Ibis			
Threskiornis spinicollis	Straw-necked Ibis			
Todiramphus sanctus	Sacred Kingfisher			
Tribonyx ventralis	Black-tailed Native-hen			
Trichosurus vulpecula	Common Brushtail Possum			
Turdus merula	Common Blackbird			
Turnix pyrrhothorax	Red-chested Button-quail		vu	L
Turnix varius	Painted Button-quail			
Tyto javanica	Pacific Barn Owl			
Vanellus miles	Masked Lapwing			
Vespadelus regulus	Southern Forest Bat			
Vespadelus vulturnus	Little Forest Bat			
Wallabia bicolor	Black Wallaby			
Zosterops lateralis	Silvereye			

Table 4: Threatened species likely to occur in the project area

Species Name	Common Name	EPBC	VIC	FFG
Burhinus grallarius	Bush Stone-curlew		en	L
Falco subniger	Black Falcon		vu	
Hirundapus caudacutus	White-throated Needletail		vu	
Litoria raniformis	Growling Grass Frog	VU	en	L
Pogona barbata	Bearded Dragon		vu	
Varanus varius	Lace Goanna		en	

Appendix 2: Water Regime Class descriptions

Water Regime Classes (as excerpted from Ecological Associates 2014)

Scroll Bars and Riparian Billabongs (referred to as Permanent Wetlands throughout this business case)

Scroll Bars and Riparian Billabongs represent the low lying meander loops and deep localised depressions mostly occurring along the River Murray, but also Black Charlie Lagoon. This water regime class comprises areas mapped as Floodplain Riparian Woodland and Billabong Wetland Aggregate.

Under natural conditions, with a threshold of 25,000 ML/day, the scroll bars were flooded in 89% of years for 2 to 5 months (interquartile range 66 to 163 days). The deep billabongs retained water on the flood recession and were essentially permanent. Under current conditions the frequency of events has halved to 48% of years and the duration has fallen to 1.5 to 4 months (interquartile range 43 to 125 days). The billabongs now rarely remain flooded for 12 months. Black Charlie Lagoon is an exception: it is maintained as a permanent wetland by water from the Torrumbarry Weir pool.

Seasonally connected permanent billabongs are important to vegetation-dependent fish species such as gudgeon species and river murray rainbowfish. These habitats provide a diverse range of drought refuges during periods of low flow and provide a colony from which fish disperse to the wider forest area during floods. Small permanent wetlands within the forest environment are the favoured breeding habitat for several waterbird species and provide sources of food for piscivorous birds and insectivorous birds and bats.

Seasonal inundation of scroll bars contributes to the habitat requirements of channel-specialist fish species including Murray cod, trout cod and golden perch. These species benefit from access to snaggy habitats that provide diverse hydraulic conditions (deep holes, turbulent water) and abundant macroinvertebrate and small fish prey. Access to this habitat is particularly important during spring to support adults prior to spawning and the development of juveniles.

Under current conditions the billabongs are now intermittently flooded and have limited value as drought refuge or as habitat for small fish. The productivity of scroll bar vegetation has declined with summer-growing grasses becoming more dominant in the understorey than aquatic species that are more productive during flooding in spring.

The ecological objectives for scroll bars and riparian billabongs are to:

- maintain permanent populations of small fish in riparian billabongs
- to support the spawning and juvenile development in channel specialist fish species
- promoting understorey vegetation dominated by seasonally growing aquatic macrophytes

These objectives will be achieved by:

- inundating scroll bars for 3 to 4 months in spring and early summer in 9 years out of 10

Seasonal Swamps (referred to as Temporary Wetlands throughout this business case)

The seasonal swamps of the upper forest are Pig Swamp, Deep Creek Swamp, McGillivray Corner Swamp and Red Rise Swamp. Baggot Creek Swamp is also a seasonal swamp that has been degraded through modifications to Cameron Creek and by the river levee. The swamps are mapped from a variety of EVCs comprising:

- Drainage Line Aggregate
- Riverine Swamp Forest - Floodway Pond Herbland

- Grassy Riverine Forest - Riverine Swamp Forest
- Riverine Swampy Woodland (part)
- Tall Marsh
- Sedgy Riverine Forest - Tall Marsh Complex

Deep Creek Swamp and Red Rise Swamp receive inflows at approximately 30,000 ML/day and would be substantially flooded at flows exceeding 35,000 ML/day. It is interpreted that that Baggot Creek Swamp shared a similar water regime to these wetlands. However inflows to this wetland occur less often due to the effects of the Cameron Bridge regulator and effluent blockages. When it does occur, flooding is longer and deeper because the forest levee prevents outflows to Baggot Creek.

Under natural conditions flows of 35,000 ML/day occurred in 74% of years with a duration of one to four months (interquartile range 38 to 133 days). The swamps retain water to a depth of approximately 1 m and would remain flooded for a further two to four months, providing seasonal flooding of three to eight months. In sequences of wet years the wetlands would remain flooded throughout the year.

These conditions would support an open canopy of river red gum and a diverse and productive understorey of aquatic plants.

Pig Swamp and McGillivray Corner Swamp receive inflows at approximately 50,000 ML/day. Under natural conditions these flows occurred in 48% of years and lasted for 1 to 3 months (interquartile range 38 to 82 days). The wetlands would retain water for about 2 months after filling.

The seasonal swamps would have provided highly productive habitats for vegetation-dependent fish and potentially adults and juveniles of channel-specialist fish that access the forest during floods. The swamps would support dense and diverse aquatic macrophyte vegetation with little open water habitat. The swamps would be productive foraging areas for waterbirds, bats and a source of prey for piscivorous waterbirds and reptiles. Dense wetland vegetation provides shelter for black wallaby and several waterbirds including crakes and bittern.

Under current conditions the frequency of events exceeding 35,000 ML/day has declined to 35% of years and the duration has declined to approximately one to three months (interquartile range 34 to 101 days). The interval between events has increased so that 75% of events are less than 620 days apart but were only 318 days under natural conditions.

The frequency of events exceeding 50,000 ML/day has declined to 20% of years and the duration has declined to 3 to 7.5 weeks (interquartile range 21 to 52 weeks). The interval between events has increased so that 75% of events are less than 1028 days apart but were 615 days apart under natural conditions.

At Deep Creek Swamp and Red Rise Swamp the current flooding regime has promoted the recruitment of river red gum, creating a closed canopy that allows less light to reach the understorey. Reduced flooding and light has reduced the productivity of the understorey and promoted more drought-tolerant aquatic plants such as *Carex tereticaulis* in place of seasonal aquatic species such as *Triglochin procerum*. The swamps provide aquatic habitat less often and for shorter periods. They no longer sustain significant beds of drought-intolerant aquatic plants and are less productive habitats when they are flooded.

The effects of the current water regime are more complex at Pig Swamp, due to a history of excessive and aseasonal flooding, and at Baggot Creek Swamp, due to reduced inflow frequency and increased flood depth and duration. However all seasonal swamps would have shared similar ecological characteristics under natural conditions.

The objectives for seasonal swamps are to:

- maintain extensive beds of aquatic macrophytes dependent on seasonal flooding
- support breeding in 75% of years by vegetation-dependent waterbirds including crake and bittern
- support large populations of vegetation-dependent fish species when flooded
- support large resident populations of frogs
- restore an open or sparse red gum canopy

These objectives will be achieved by:

- inundating seasonal wetlands in 5 to 7.5 years in 10 for 1 to 4 months.

Red Gum Forest and Woodland (referred to as River Red Gum Flood-dependent Understorey throughout this business case)

Red Gum Forest and Woodland is inundated by significant overbank flows that occur when flow in the River Murray exceeds 50,000 ML/day. This water regime class is represented mostly by Grassy Riverine Forest in lower-lying areas. At the upper extent the class is represented by Riverine Swampy Woodland where black box is also present. Lignum Swampy Woodland dominates the understorey in the upstream section near Worthy Bend.

Under natural conditions river discharge exceeded 50,000 ML/day in 48% of years for a duration of one to three months (interquartile range 38 to 82 days). Under current conditions these events occur in only 20% of years and have a median duration of 3 to 7 weeks (interquartile range 21 to 52).

When flooded, the red gum forest and woodland provides an important seasonal floodplain habitat for aquatic fauna such as frogs and small fish which disperse from refuge habitats and breed in large numbers. Waterfowl will breed and wading birds will make use of the abundant prey in flooded understorey. Flooding promotes a range of aquatic plant species and contributes significantly to the plant diversity of the forest.

The understorey plant growth promoted by flooding will persist for several months after flooding and will contribute to the forest productivity in the form of seeds, forage and nectar. Water returning to the river will carry significant loads of organic carbon and contribute to the energy requirements of the riverine food web.

The current water regime has resulted in the terrestrialisation of this water regime class including increased tree density, closing of the canopy and a greater proportion of dry-phase floodplain plants. The forest provides aquatic habitat for fish, frogs and waterbirds less frequently and for shorter periods and the extent of habitat available to aquatic understorey plants has declined.

The objectives for Red Gum Forest and Woodland are to:

- restore an understorey of perennial aquatic macrophytes dependent on frequent seasonal flooding such as *Carex tereticaulis* and *Triglochin procerum*
- provide extensive seasonally flooded breeding and feeding habitat for frogs, waterfowl and vegetation-dependent fish
- contribute to the feeding requirements of wading birds
- increase forest productivity to support terrestrial fauna during the dry phase including kangaroo and bush birds
- contribute to the organic carbon requirements of the riverine food web.

These objectives will be achieved by:

- providing floods of 1 to 3 months duration 5 years in 10 with a maximum interval of 4 years.

Floodplain Box Woodlands (referred to as Box Woodlands throughout this business case)

Floodplain Box Woodlands are inundated by overbank flows that occur when river levels exceed 55,000 ML/day or exceed 50,000 ML/day for sustained periods of time.

Under natural conditions events exceeding 50,000 ML/day and lasting longer than 2 months occurred in 25% of years. Events exceeding 55,000 ML/day occurred in 35% of years with a median duration of duration of 37 days. Seventy five percent of these events were less than 2 years apart (636 days).

These areas are represented by Riverine Chenopod Woodland and, where flood water can pond, Lignum Swampy Woodland.

Flooding would promote the opportunistic growth of drought-tolerant aquatic plants such as *Eleocharis acuta* and *Juncus* spp. and would briefly provide habitat for aquatic fauna including frogs, fish and waterbirds. Muddy soil exposed by receding floodwater would promote a range of grasses including *Pasaplidium jubiflorum* which provide forage and seeds for woodland fauna including herbivores (such as kangaroo) and granivores (such as diamond firetail. The persistent forest productivity that follows floods supports higher-level predators such as carpet python.

Long sequences of years without flooding rarely occurred and would have allowed limited development of a terrestrial plant understorey.

Under current conditions the frequency of events exceeding 50,000 ML/day for more than 2 months has decreased to less than 10% of years. Events exceeding 55,000 ML/day also now occur in only 10% of years and have a median duration 35 days. The interval between 75% of events is now 6.5 years.

The current water regime has resulted in a significant change in vegetation composition and productivity. Flood-dependent plants have been largely lost from the understorey. The long intervals between floods, and shorter flood durations, have allowed the development of a terrestrial understorey. Tree growth and recruitment is likely to be lower and overall forest productivity, including the production of browse, nectar and flowers, will be lower. As a result the woodland has lower habitat value for terrestrial fauna between flood events.

The objectives for box woodlands are to:

- restore drought-tolerant aquatic plants to the understorey
- increase woodland productivity and habitat value for terrestrial fauna

These objectives will be achieved by:

- inundating box woodland for 2 months in 2.5 years in 10 with a maximum interval between events of 5 years.

Terrestrial Box Woodlands (included in the Box Woodlands WRC throughout this business case)

Terrestrial box woodlands are located on the floodplain but at high elevations. This community is derived from Plains Woodland and Riverine Chenopod Woodland EVC mapping at locations that were not inundated by the high flow peaks of:

- 22 Oct 1992 (54,679 ML/day)
- 23 Sep 1993 (54,932 ML/day)
- 17 Oct 1996 (53,278 ML/day)

This is essentially a terrestrial plant community comprising species that do not depend on flooding. If it occurs at all, flooding only results from very high (greater than 55,000 ML/day) flows that are sustained for long periods and encroaches on the perimeter of this community. Flooding represents an intermittent disturbance and is not an ecological requirement.

Appendix 3: Risk assessment methodology

Introduction

A comprehensive environmental, social and economic risk assessment in line with AS/NZS ISO 31000:2009 has been completed by the North Central CMA for the *Gunbower National Park Environmental Works Project*. The process for completing the risk assessment involved the following:

- A risk register (Appendix 4) was developed by a team of specialists with knowledge of the relevant sites and experience of delivering similar projects. This risk register identified core values at the sites, categories of threat, individual threats and a risk rating for each threat with a score against:
  - The likelihood of those events occurring
  - The severity of the outcome if the event occurred
  - A consequential risk rating
  - The available mitigation strategies and controls to offset these risks
  - The residual risk once those controls were imposed.
- The risk register was subject to critique, challenge and validation by a panel of stakeholders with a wide range of expertise (NCCMA, GMW, DEPI, Parks Victoria, MDBA, Campaspe Shire and the Gannawarra Shire) who:
  - Identified the key risks that merited priority attention. These were defined as any risks with a score of 8 or above, with a focus on the categories 'High' or 'Very High'
  - Confirmed appropriate mitigation controls
  - Agreed to the residual risk after mitigation options were identified.

Risk assessment methodology and approach

The risk assessment assesses the potential risks against the variables of 'Likelihood' and 'Consequence'. That then allocates each risk an overall rating from A - D in line with the methodology in ISO 31000:2009, Risk management. Table 1 presents the risk management matrix used and Table 2 and 3 present the likelihood and consequence descriptions respectively.

Table 1: ISO Risk management matrix

	Consequence				
Likelihood	Negligible	Minor	Moderate	Major	Extreme
Almost certain	D	C	B	A	A
Likely	D	C	B	A	A
Possible	D	C	C	B	A
Unlikely	D	D	C	B	B
Rare	D	D	D	C	B

The five different ratings for the likelihood of an event occurring are presented in Table 2.

Table 2: Risk Likelihood Description

Rating		Description	% Probability
Rare	1	Event may occur only in exceptional circumstances	0-5
Unlikely	2	The event could occur at some time	5-20
Possible	3	The event might occur	20-50
Likely	4	The event will probably occur in most circumstances	50-80
Almost certain	5	The event is expected to occur in most circumstances	80-100

le 3: Consequence Description

	Environment *Impact on the surrounding environment, including habitats and species, as well as the broader landscape*	Business Costs *Cost to the state*	People *Workers, local communities and other stakeholders* Safety and Well-being	People *Workers, local communities and other stakeholders* People and Culture	Political/ Reputational *How media, public and stakeholder perception of State is influenced*	Legal *Legal consequence*	Service Delivery *Effect on the business*
ting ligible arm	No material effect on the environment, contained locally within a single site/ area. Environment affected for days	Cost impact of up to 2.5% of allocated operational budgets (including capital budget); OR a cost impact of up to $2.5m	On-site first aid treatment only	Staff disgruntlement	Minimal adverse local attention (1 day only)	Non-compliance with legislation, identified internally and resulting in internal acknowledgement and process review.	Insignificant impact to the Department's capability in providing its services - no inconvenience to customers/ stakeholders
r Harm	Limited effect on the environment, restricted to a single township or locality. Environment affected for weeks.	Cost impact between 5%-10% of allocated operational budgets (including capital budget); OR a cost impact of up to $5m	Minor injuries/illness requiring medical attention	Complaints, passively upset, and uncooperative	Adverse localised public attention on a single issue over a short period. (up to 1 week)	Non-compliance with legislation or breach of duty of care, identified externally and either (1) resolved without prosecution of or civil action, or (2) resulting in prosecution or civil action involving low level of resourcing required to defend, exposure to low level remedies or damages, and low level risk of negative precedent	Minimal short term temporary impact to the Department's capability in providing its services - customers/ stakeholders slightly inconvenienced
erate	Moderate effect on the environment, impacting on a municipality or multiple localities. Environment affected for months.	Cost impact >10% of allocated operational budgets (including capital budget); OR a cost impact of up to $10m	Significant injury/illness requiring in-patient hospitalisation	Low morale, disengagement, increased absenteeism and workplace conflict	Adverse localised negative public attention on a single issue over a sustained period (up to 2 months)	Non-compliance with legislation or breach of duty of care resulting in prosecution of, or civil action, with one of high level of resourcing required to defend; exposure to high level remedies or damages or high level risk of negative precedent.	Significant impact to the Department's capability in providing its services - customers/ stakeholders inconvenienced
Harm	Major effect on the environment, impacting on a region or multiple municipalities. Environment affected for 1-3 years.	Cost impact between $10m-$50m	Extensive and/or permanent injury/ illness	Major morale issues, high absenteeism and resignations of key staff	Serious adverse public attention on more than one issue over a prolonged period (up to 2 years)	Non-compliance with legislation or breach of duty of care resulting in prosecution of or civil action, with all of high level of resourcing required to defend, exposure to high level remedies or damages, and high level risk of negative precedent); or public enquiry	Continuing difficulties in the Department's capability in servicing customers/stakeholders over a protracted period
	Major widespread effect on the environment, impacting on a region or multiple municipalities affecting [illegible]	Cost impact of over $50m	Death or permanent disability/ illness	Major morale issues, high absenteeism and resignations of key staff	Very serious public embarrassment, prolonged period (duration from 2 years), or leading to ministerial inquiry or loss of [illegible]	Non-compliance with legislation or breach of duty of care resulting in prosecution of or civil action, with all of high level of resourcing required to defend, exposure to high level remedies or damages, and high level risk of negative precedent; or public enquiry	Long term detrimental effect on the Department's capability in providing services to customers/ stakeholders

etation in the construction habitat and reduced n the local area.	Almost certain	Minor Harm	C	Detailed designs and site surveys to minimise impacts. Works supervision. Vegetation management plans. Follow relevant legislation. Establish monitoring program	Unlikely	Moderate Harm	C	Project Manager and Construction Contractor
derstorey vegetation in the degraded (e.g. trampling, on condition.	Almost certain	Minor Harm	C	Detailed designs and site surveys to minimise impacts. Works supervision. Vegetation management plans. Follow relevant legislation. Establish monitoring program	Unlikely	Minor Harm	D	Project Manager and Construction Contractor
oper hygiene protocols, then st or be distributed further, degrade the condition of the ia.	Possible	Moderate Harm	C	Site Environment Management Plan (hygiene protocols and enforcement, contractor management)	Possible	Minor Harm	C	Project Manager and Construction Contractor
opted during construction, to vegetation re-	Possible	Minor Harm	C	Site Environment Management Plan. Works supervision (site rehabilitation)	Unlikely	Minor Harm	D	Project Manager and Construction Contractor
l with construction, results in al fauna community may	Possible	Moderate Harm	C	Construction Management Plan developed	Unlikely	Minor Harm	D	Project Manager and Construction Contractor
n be relocated, individual opulation of affected species	Unlikely	Minor Harm	D	Construction Management Plan developed	Unlikely	Minor Harm	D	Project Manager and Construction Contractor
biodiversity within the lly human and property	Possible	Extreme Harm	B	Fire management plan developed. Site Environment Management Plan. Site safety plans.	Unlikely	Major Harm	B	Project Manager and Construction Contractor
cultural, assets, commercial and recreational)								
hours, the machinery may t so the amenity of local	Unlikely	Minor Harm	D	Site Environment Management Plan and Construction Management Plan, Site safety plans developed.	Unlikely	Minor Harm	D	Project Manager and Construction Contractor
esent in the construction , causing a permanent loss of	Possible	Major Harm	B	Cultural Heritage Management Plan developed.	Unlikely	Moderate Harm	C	Project Manager and Construction Contractor
the construction zone, they permanent loss of heritage	Unlikely	Moderate Harm	C	Cultural Heritage Plan developed.	Unlikely	Minor Harm	D	Project Manager and Construction Contractor
al roads, this may restrict ce and disruption for the	Possible	Minor Harm	C	Traffic Management Plan developed	Unlikely	Minor Harm	D	Project Manager and Construction Contractor, Campaspe Shire Council, Gannawarra Shire Council
80 ski race, it may impede ars and possible lost revenue	Unlikely	Minor Harm	D	Traffic Management Plan developed	Rare	Minor Harm	D	Project Manager and Construction Contractor

	Possible	Moderate Harm	C	Design to minimise vandalism. Inspection and maintenance	Unlikely	Minor Harm	D	NCCMA, Asset owner
f the forest used for its may be prevented in the em for the local community.	Unlikely	Minor Harm	D	Implement stakeholder management strategy - ongoing engagement with community through multiple avenues. Adequate warning before events	Unlikely	Negligible Harm	D	NCCMA
oads (especially unsealed mage to the roads, causing	Possible	Minor Harm	C	Traffic Management Plan. Ongoing engagement with land managers (DEPI, Parks Victoria) and Local Councils	Unlikely	Minor Harm	D	Project Manager and Construction Contractor
ied prior to construction, s and inconvenience for	Unlikely	Minor Harm	D	Detailed designs and site surveys to identify essential services locations. Works supervision.	Unlikely	Negligible Harm	D	Project Manager and Construction Contractor
t followed during involved in traffic incidents	Unlikely	Major Harm	B	Traffic Management Plan developed	Unlikely	Moderate Harm	C	Project Manager and Construction Contractor
truction activities may cause resulting in liability and	Unlikely	Extreme Harm	B	Construction Management Plan developed	Unlikely	Moderate Harm	C	Project Manager and Construction Contractor
unicated with, they may be lties in gaining approvals.	Unlikely	Minor Harm	D	Implement stakeholder management strategy - ongoing engagement with community through multiple avenues.	Unlikely	Minor Harm	D	NCCMA
d supportive then the project ts or private easements as	Possible	Major Harm	B	In-principle agreements with landowners to purchase land for channels if project is funded. Alternate alignments if primary alignments not available. Land valuations conducted so acquisitions to be properly funded. Ongoing engagement with landholders and involvement in channel supply design	Unlikely	Minor Harm	D	NCCMA
include adequate ult in the costs being ortfall.	Possible	Moderate Harm	C	Detailed designs to refine costs and contingencies. Peer review of cost estimates. Adequate contingency against level of risk	Unlikely	Minor Harm	D	NCCMA
ed then the project may not delivery and may impact on	Unlikely	Moderate Harm	C	Peer review of designs.	Unlikely	Moderate Harm	C	Project Manager and Construction Contractor
need for additional work to e this could delay the works	Possible	Moderate Harm	C	Geotech investigations done to inform detailed designs to ensure foundations are secure. Sheet piling built into works program to cater for lack of geotech results. Level of contingency based on level of design and management of risks	Unlikely	Minor Harm	D	Project Manager and Construction Contractor
her conditions prevent d costs for de-mobilisation	Possible	Major Harm	B	Proper advance notice/lead times for warnings, known travel time for water movement. Liaison with VEHW/CEWH. Contractual arrangements with contractors. Contingency planning. Insurance (contractor, equipment, liability)	Possible	Minor Harm	C	Project Manager and Construction Contractor
romise the functionality and nean the desired operational	Possible	Major Harm	B	Early engagement of contractors. Peer review of designs	Unlikely	Moderate Harm	C	Project Manager and Construction Contractor
	Unlikely	Major Harm	B	Insurance (contractor, equipment, liability). Fire management plan developed. Site EMP. Site safety plans.	Unlikely	Moderate Harm	C	Project Manager and Construction Contractor
ion	Unlikely	Moderate Harm	C	Ongoing engagement with irrigators and GMW. Work will be conducted outside irrigation season	Rare	Moderate Harm	D	NCCMA, Project Manager
	Unlikely	Minor Harm	D	Construction Management and site safety plans developed	Rare	Negligible Harm	D	NCCMA, Project Manager

business, competing rtion, resignation, lead to porate knowledge.	Possible	Major Harm	B	Clear and detailed project plan including clearly articulated milestones. Clear documentation of project information and progress. Targeted recruitment process (if required) with clear description of role definition.	Possible	Moderate Harm	C	NCCMA
e parts of Lippia (e.g. seed, ish and expand, causing ted, reduced plant diversity	Possible	Moderate Harm	C	Develop an Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Unlikely	Minor Harm	D	NCCMA
e parts of Arrowhead (e.g. eed may establish and e outcompeted, reduced	Possible	Moderate Harm	C	Develop an Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Likely	Minor Harm	C	NCCMA
e parts of other regional high Senegal Tea Plant, Cabomba lands, the weeds may it diversity to decline and	Possible	Moderate Harm	C	Develop an Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Likely	Minor Harm	C	NCCMA
nental watering promotes eeper, Box Thorn, may cause understorey diversity and degraded fauna	Unlikely	Minor Harm	D	Develop an Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Possible	Minor Harm	C	NCCMA
s drained before mid spring, h and support flood- derstorey of the River Red sponse (low abundance and	Possible	Minor Harm	C	Develop an Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Unlikely	Minor Harm	D	NCCMA
tland rehabilitation (i.e. er deliveries may be other negative impacts, ond and/or contracts in una.	Unlikely	Minor Harm	D	Develop an Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Unlikely	Minor Harm	D	NCCMA
drological requirements of and Grey Box woodland may iently, causing tree death and	Unlikely	Moderate Harm	C	Develop an Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Unlikely	Minor Harm	D	NCCMA
laggot Creek stand of River ate the current overwatering nater levee), which may ee death in the long-term.	Unlikely	Moderate Harm	C	Develop an Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Unlikely	Minor Harm	D	NCCMA
s Creek before Black Charlie ceive the same outfalls as thin the permanent wetland	Possible	Minor Harm	C	Develop an Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Unlikely	Minor Harm	D	NCCMA

				program.				
quently enough, foraging in the local bird populations, l diversity and abundance.	Unlikely	Moderate Harm	C	Develop an Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Unlikely	Minor Harm	D	NCCMA
long dry period, blackwater g habitat and reduces	Possible	Minor Harm	C	Develop an Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Unlikely	Minor Harm	D	NCCMA
and other key water water flow and alters channel t and natural flood events.	Rare	Negligible Harm	D	Develop an Environmental Watering Plan (EWP) taking into account the ecological objectives. Implement the EWP and adaptively manage using a thorough monitoring and evaluation program.	Rare	Negligible Harm	D	NCCMA
ion of the Hipwell Road during low River Murray via Spur Creek (5ML/day) the river bank and sediment	Possible	Negligible Harm	D	Adaptive management. Flexibility in operating regime. Monitor and control. Implement a management strategy.	Unlikely	Negligible Harm	D	NCCMA
er discharge to the River er.	Rare	Negligible Harm	D	groundwater and salinity monitoring and adaptively manage if required	Rare	Negligible Harm	D	NCCMA
ible, which exposes s to poor health or death of red areas.	Unlikely	Moderate Harm	C	groundwater and salinity monitoring and adaptively manage if required	Unlikely	Minor Harm	D	NCCMA
becomes a series of pools not be able to migrate, sh.	Likely	Minor Harm	C	Develop and implement a fish exit strategy.	Unlikely	Minor Harm	D	NCCMA
est fish (particularly carp) nce of these species and abitats and reduces the	Almost certain	Major Harm	A	Carp screens on all offtake regulators	Likely	Moderate Harm	B	NCCMA
forest disperse carp and quatic vegetation and native .g. competition).	Possible	Moderate Harm	C	Carp screens on all offtake regulators	Possible	Minor Harm	C	NCCMA
assets, commercial and recreational)								
eaches may occur, causing	Likely	Moderate Harm	B	Peer review of designs. Levees repaired or replaced to have minimum 200mm freeboard. Supervision during repair and/or construction. Ongoing inspection and maintenance. Emergency	Unlikely	Minor Harm	D	NCCMA, Parks Victoria, DEPI

orest, access may be reduction in tourist visits c loss to small rural	Likely	Moderate Harm	B	Local Councils have eco-tourism in their Strategic and Economic Development Plans. These projects will enhance opportunities for increased tourism	Possible	Minor Harm	C	NCCMA, Parks Victoria, DEPI
orest, there may be e in mosquito populations	Unlikely	Minor Harm	D	Public engagement / notification (people take more precautions which reduce consequences). Inform Council Public Health Officers	Rare	Negligible Harm	D	NCCMA
ide adequate flow for urrently	Unlikely	Minor Harm	D	Hydraulic modelling for designs. Water flow measurements during irrigation season to measure flows and compare to hydraulic modelling. Environmental water requirements outside of irrigation season requirements	Rare	Minor Harm	D	NCCMA, DEPI
ter level within Camerons o water, causing economic	Possible	Moderate Harm	C	Hydraulic modelling for designs. Water flow measurements during irrigation season to measure flows and compare to hydraulic modelling. Environmental water requirements outside of irrigation season requirements	Unlikely	Minor Harm	D	NCCMA
and/or erosion	Possible	Major Harm	B	Cultural Heritage Management Plan developed.	Unlikely	Major Harm	B	NCCMA, Parks Victoria, DEPI
akeholders	Possible	Major Harm	B	Cultural Heritage Management Plan developed. Ongoing engagement and involvement with Indigenous groups	Unlikely	Moderate Harm	C	NCCMA
n of the forest and the may perceive an increased iduals.	Possible	Negligible Harm	D	Implement stakeholder management strategy - ongoing engagement with community through multiple avenues	Possible	Minor Harm	C	NCCMA, Parks Victoria, DEPI
el maintenance (weeds, down so manual operation	Likely	Minor Harm	C	Maintenance and operations built into workplan	Possible	Negligible Harm	D	NCCMA, Asset owner / operator
id breach manual handling f drop boards/plates)	Unlikely	Moderate Harm	C	Infrastructure designed to not require heavy manual handling or equipment to be used to handle heavy items (e.g. tray mounted crane for lifting drop boards/plates)	Rare	Moderate Harm	D	NCCMA, Asset owner / operator
	Unlikely	Extreme Harm	B	Peer review of designs. Adequate geotech investigations. Supervision during construction. Ongoing inspection and maintenance. Emergency response procedure	Rare	Major Harm	C	NCCMA, Asset owner / operator
ump) becomes blocked by erial, the inflow rate may be tion, causing reduced	Possible	Minor Harm	C	Ongoing inspections and maintenance program. As most infrastructure is having water delivered through the irrigation system, unlikely to be problematic	Unlikely	Minor Harm	D	NCCMA, Asset owner / operator
he inflow rate may be tion, causing reduced	Possible	Moderate Harm	C	Peer review of designs. Designs engineered above capacity of waterway capacity.	Possible	Minor Harm	C	NCCMA, Asset owner / operator
n by the storage operator, causing reduced	Unlikely	Moderate Harm	C	Maintenance plan to minimise need for maintenance during operations. Dual gates on most offtakes to allow for continued	Unlikely	Minor Harm	D	NCCMA, Asset owner / operator

	Possible	Moderate Harm	C	Design to minimise vandalism. Inspection and maintenance	Unlikely	Minor Harm	D	NCCMA, Asset owner / operator
olume or flow rate due to n demand	Unlikely	Moderate Harm	C	Maintenance plan to minimise need for maintenance during operations. Dual gates on most offtakes to allow for continued flow if one is not working	Unlikely	Minor Harm	D	NCCMA and GMW
r, costs, reputation risks)								
erved post-delivery or MA may be unable to ctives, causing reputation ommunity.	Possible	Negligible Harm	D	The Living Murray Hipwell road project has implemented a monitoring program and outcomes have been observed with little time lag. Similar monitoring program to be implemented.	Unlikely	Negligible Harm	D	NCCMA
inadequate staff/funding to eses causing reduced oring and adaptive	Unlikely	Moderate Harm	C	Clear and detailed project plan including clearly articulated milestones. Clear documentation of project information and progress. Targeted recruitment process (if required) with clear description of role definition.	Unlikely	Minor Harm	D	NCCMA
hat investment costs	Possible	Moderate Harm	C	In-principle agreements with landowners to purchase land for channels if project is funded. Alternate alignments if primary alignments not available. Land valuations conducted so acquisitions to be properly funded. Ongoing engagement with landholders and involvement in channel supply design	Unlikely	Minor Harm	D	NCCMA
	Rare	Extreme Harm	B	Structures to be designed to be abandoned without impacting on floodplain hydraulics or ecology	Rare	Moderate Harm	D	NCCMA
he water account may be ities for other environmental	Rare	Major Harm	C	Seasonal watering plan developed by people with much experience of watering these types of forests	Unlikely	Minor Harm	D	NCCMA

Appendix 5: Hydraulic model development

Model establishment

The hydrodynamic models for this study were developed using MIKE FLOOD modelling software. MIKE FLOOD has been applied to a range of environmental management floodplain studies in Australia, including major studies for the Gunbower and Koondrook-Perricoota forests located immediately upstream on the River Murray.

The different models have been developed in order to address specific questions / investigations as outlined in supporting document, *Gunbower SDL Modelling* (Water Technology 2014). These are summarised in Table 1.

Table 1. Models used in the investigation of SDL works for Gunbower Forest

Model	Details	Purpose
Gunbower Forest	25 m grid resolution Coupled 1D/2D in MikeFLOOD Extends from Torrumbarry Weir Road to Gunbower Creek at Barham. Refer to Water Technology (2007) in Appendix A for calibration details.	Investigate water management options in the Gunbower Forest. Further used in this existing project to investigate the sensitivity of inflows to the forest.
Camerons Creek Inflow	10 m grid resolution Coupled 1D/2D in MikeFLOOD Extends from the Murray River inlet to Camerons Creek to Baggots Creek	Assess the feasibility of delivering flow from Camerons Creek to the upper forest
Black Charlie /Baggots flooding	4 m grid resolution 2D Mike21 model Extends from the existing stop bank on Camerons Creek to Baggots Creek	Investigate options for delivering flow to Black Charlie Lagoon from Camerons Creek and through to Baggots Creek
Old Straight Cut	5 m grid resolution 2D Mike21 model Extends from Emu Hold Track (upstream of the channel) to Munzel Corner (downstream of Deep Creek)	Investigate options to deliver water from Old Straight Cut channel to upper forest and Pig Swamp
Old Cohuna Channel	5 m grid resolution 2D Mike21 model Extends from Emu Hold Track (upstream of the channel) to Munzel Corner (downstream of Deep Creek)	Investigate options to deliver water from Old Cohuna Channel to upper forest

Modelling requirements

Modelling requirements were specified by the Murray Darling Basin Authority (MDBA) as a series of 9 points, to inform the investigation of SDL works. The necessary information is contained within the supporting document, *Gunbower SDL Modelling* (Water Technology 2014) in Appendix B.

Camerons Creek model development

A coupled 1D/2D model was developed of Camerons Creek, from upstream of the inlet to downstream of Baggots Creek. The 2D model component was represented by available LiDAR (2010) at a 10m grid resolution. The 1D model component was represented by 20 cross sections of Camerons Creek from survey data by Think Spatial, and supplemented by 9 cross sections extracted from the LiDAR. As the LiDAR was flown when water was present in Camerons Creek the bed level was not well defined by the LiDAR dataset. Hence cross sections extracted from the LiDAR were manipulated to better represent the bed level, in line with the surveyed data. That is, the bed level for cross-sections taken from the LiDAR was linearly interpolated from surveyed cross sections.

Structures were incorporated into the 1D model component based on key attributes and cross sections surveyed by Think Spatial. These included:

- Camerons Creek bridge
- Stop bank with regulating structure
- Minor road crossing with culvert
- Torrumbarry Weir Road Bridge

The 1D model component incorporates a section of the River Murray so that the impact of Torrumbarry Weir and the upstream Murray River water level could be simulated dynamically to obtain a realistic estimate of inlet conditions to Camerons Creek. Baggots Creek and Dry Tree Creek were also incorporated into the model so that any outflows from the forest back to the Murray River or Gunbower Creek were represented.

Downstream boundary conditions were represented in 2D downstream of Baggots Creek. This level was extracted from LiDAR and previous hydraulic modelling results to represent a typical water level at this point in the forest.

The hydrodynamic models for this study were developed using MIKE FLOOD modelling software. MIKE FLOOD has been applied to a range of environmental management floodplain studies in Australia, including major studies for the Gunbower and Koondrook-Perricoota forests located immediately upstream on the River Murray.

Camerons Creek model validation

No data was available for calibration, and as such, the model was validated anecdotally by comparing photographs, aerial imagery and water levels captured in the LiDAR to extents produced by the simulation. This form of validation is very basic, and greater confidence will be gained by undertaking a validation watering event in 2015, where conditions are observed and compared to the model results. This would allow more confidence in the modelling results.

It was assumed that the photos/LiDAR are representative of normal conditions, i.e. with normal operating levels at Torrumbarry Weir Pool and a typical daily flow event along the Murray River.

The Torrumbarry Weir Pool is operated at a level of 86.05 m AHD. A typical winter-spring flow in the Murray River at this location was modelled at 10,000 ML/day (note that the range of Murray River flows is large, with significant floods up around 60,000 ML/day).

The resulting levels in the 1D network of Camerons Creek, along with water levels represented by the LiDAR, indicated that the model was behaving as expected, with the water levels upstream and downstream of the stop bank within the range represented by the LIDAR. Given the uncertainty of the actual flow conditions at the time of the LiDAR and photograph capture, and the uncertainty with respect to the operation level of the timber gates in the stop bank regulator, the modelled results were sufficiently representative of normal existing condition water levels. A roughness value of 0.05 was used for this validation, representative of a winding channel with some pools and shoals, weeds and stones.

Black Charlie Lagoon model development

A 2D, 4m grid hydraulic model was developed of Black Charlie and the surrounding area, from the inflow point at the Camerons Creek stop bank, downstream to Baggots Creek. The upstream boundary was a source inflow point, just downstream of the stop bank (it is assumed this structure will be modified as required). The outflow boundary was a constant water level boundary at Baggots Creek, equivalent to the normal standing water level of 84.0 m AHD.

Preliminary modelling indicated the need for exclusion mounds to prevent inundation of riverine chenopod woodlands on the north-east side of Black Charlie lagoon, and adjacent Foster road. These were incorporated into the model.

Various inflows from Camerons Creek were modelled to assess the filling of Black Charlie Lagoon. A flow of 20ML/day was found to undesirably inundate adjacent areas. The optimal inflow rate was determined to be 10ML/day. This is sufficient to fill the lagoon within 10 days.

Old Cohuna Channel model development

A 5m grid resolution 2D model was developed for investigating inflow from Old Cohuna Channel, with the inflow boundary being a source point within the Cohuna Channel, just east of the regulating structure (aligned roughly with the forest boundary). Inflow rates of 50 to 200 ML/day were modelled.

Model calibration

The development of a hydraulic model of a large floodplain requires a rigorous calibration process to ensure the hydraulic model accurately reproduces the observed flooding behaviour. The calibration process consists of systematically comparing observed flooding behaviour within the study area against the hydraulic models reproduction of that behaviour. This process generally incorporates comparisons between gauged stream flow data, observed flood levels and areas of inundation as derived from analysis of satellite imagery. Where the model does not adequately represent the observed behaviour, reasons for the discrepancies are identified and inputs to the model adjusted. This process is repeated until a satisfactory result is achieved.

In order for a calibration event to be most useful it should have the following data attributes:

- Well defined inflows and outflows (boundary conditions).
- Flow and level measurements over time (temporal distribution) at discrete points of interest within and along the forest such as effluent points and control structures.
- Flood extent and/or depth measurements (spatial distribution) at multiple times.
- Measures over a time period that exhibits the desired hydraulic responses in terms of flooding and drying of the system.

The historical floods used to calibrate the model were chosen based on the following criteria:

A reasonable calibration data set of coincident flood information was available to make meaningful comparisons with the model.

The flood was of a significantly different magnitude to the other calibration floods to ensure the model was capable of accurately reproducing the flooding behaviour of the forest over a range of flood magnitudes.

The choice of calibration events reflects the nature and magnitude of flooding likely to be of interest as part of the water management option investigations. This ensures the model schematisation is appropriately targeted to accurately and efficiently model hydraulic behaviour at scales relevant to the various water management options proposed. The water management options for Gunbower Forest are expected to investigate minor to moderate flooding via discrete flows from a series of Gunbower Creek and River Murray effluents.

Following a review of the available data on historical floods in the Gunbower forest and through discussions with the steering committee, the following historical floods were selected for calibration of the model.

- September – December 2003
- October – December 2000
- September – December 2004
- September – November 1993

Appendix 6: Concept designs

Note: Concept design report is included within supporting documents

URS

Concept Design Report

North Central CMA Sustainable Diversion Limit Projects

AUSTRALIA

Confirming Concepts for Gunbower National Park

18 December 2014
43260685/01/02

Prepared for:
North Central Catchment Management Authority

Prepared by **URS Australia Pty Ltd**

tthrough dard monthly ee (5 weekly meetings) tings t appointed staff uding roles and	• Land managers – management of licences, access management • Clarification of links to the Torrumbarry Irrigation System including operational constraints, irrigation channel capacity and operational and maintenance costs	• Project Control Board endorsement of business case • Steering Committee endorsement of business case • Comprehensive involvement by project partners in project development • Project ownership shared between the project partners and North Central CMA • Large level of trust between project partners and North Central CMA to formulate options and solutions	• Desire for involvement of project partners in project from inception • Roles and responsibilities clearly defined • Investigation results reviewed independently and deemed 'fit for purpose' • North Central CMA sought direct advice from Partners when relevant leading to innovative solutions and recommendations
to face) briefing ct site visits nt landholder project ers and meetings (face- nducted by North	• Directly affected landholders – construction works on or adjacent to their properties, access tracks through their properties, or acquisition of their land for irrigation channels to water the forests • Irrigators – change to irrigation setting affecting security of supply (2 Camerons Creek diverters) • Traditional Owners – potential impact on cultural sites, potential changes to cultural values	• Recognition of the importance of the health of the forest for environmental and economic values • Support to increase the health and vitality of the forest • Increase the frequency of flooding as this is considered the best way to restore and enhance forest health • Further engagement and awareness raising is required to dispel commonly held myths, including the impact of environmental water on irrigators' entitlements • Recognition that increased watering will involve some restriction on access to the forests • Common concerns – unplanned flooding, blackwater, limited access to forests, fire risk, environmental policy	• Work directly with stakeholders through project development • Stakeholder issues and concerns understood and considered as part of the project development • Informing stakeholders in a timely manner of any planned works or major decisions related to the project • Meet stakeholder expectations and respond to their concern • Robust and rigorous investigative approach to ensure best environmental outcomes are achieved • Results of investigations available for review • Independent technical review of investigation results with a being deemed 'fit for purpose'
neting sessions ducted ter letters to all license	• Licence holders – disturbance to aquaculture practices • Industry / Special Interest Groups – economic opportunities reduced through limited access to forest during watering events •		• Views of stakeholders sought that have contributed to influencing decisions • Informing stakeholders in a timely manner of any planned works or major decisions related to the project • Meet stakeholder expectations and respond to their concer • Robust and rigorous investigative approach to ensure best environmental outcomes are achieved • Results of investigations available for review • Independent technical review of investigation results with a being deemed 'fit for purpose'
ssed through the North site	• Limited access to forest during watering events	• Positive feedback through comments and email replies	• Stakeholders are informed about the project and/or decisions that have already been made • Objective information provided which is of a high quality, consistent, timely, appropriately targeted and clearly and easily understood by the audience
ages accessed on the CMA website (fact sheets, information) ressed through the MA website and social edia, Twitter, nals	• Limited access to forest during watering events	N/A	N/A

Supporting documents

Biosis 2014, *Flora and fauna assessment of the Gunbower National Park and Guttrum and Benwell State Forests*

Cummins, J and McGrath, S 2014, *Gunbower National Park Business Case level Engineering Review*

Department of Environment and Primary Industries 2014, *Basin Plan Environmental Works Program: Regulatory Approvals Strategy*

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Hillman, T 2014, *SDL Adjustment Proposals – Ecological Review*

Hillman, T 2014, *Review of ecological aspects of Proposals for SDL adjustments – NCCMA - October 2014*

Gippel, CJ 2014, *Peer Review of Hydraulic Models for Gunbower Forest- July 2014*

GJM Civil 2014, *SDL Project – Comerons Creek Diverters, Options for existing Diversion Customers*

Jacobs 2014, *Semi-Quantitative assessment of potential salinity impacts of environmental works and measures, Guttrum & Benwell Forests*, unpublished document prepared for North Central CMA, 28 November 2014

Jacobs 2014, *Gunbower National Park- Salt Wash Off*

North Central Catchment Management Authority 2014, *Risk Register*

North Central Catchment Management Authority 2014, *Risk Management Strategy*

North Central Catchment Management Authority 2014, *North Central CMA SDL Offset Projects Stakeholder Management Strategy*

North Central Catchment Management Authority 2014, *Gunbower National Park Environmental Works Project Operating Plan*

North Central Catchment Management Authority 2014, *Gunbower National Park Environmental Works Project Monitoring & Evaluation Plan*

North Central Catchment Management Authority 2014, *Gunbower National Park Ecological Objectives & Hydrological Requirements*

North Central Catchment Management Authority 2014, *Gunbower National Park Environmental Works Project Key Decisions Paper*

North Central Catchment Management Authority 2014, *Gunbower National Park Environmental Works Project Ecological Risks and Mitigation*

Shane McGrath SGM (Aust) Consulting Pty Ltd, (personal communication by letter. 30th October 2014)

Telfer, A and Charles, A 2014, *Gunbower National Park- Revised #2- Expert Review Salinity Impact SDL Offsets*

URS 2014, *Concept Design Report, North Central CMA Sustainable Diversion limits Projects, Confirming Concepts for Gunbower National Park*, Unpublished document prepared for North Central CMA

Water Technology 2014, *Gunbower SDL Modelling*

Water Technology 2014, *Gunbower Levee failure Breach Modelling*

Water Technology 2014, *North Central CMA Levee Breach Risk Assessment and Strategy*

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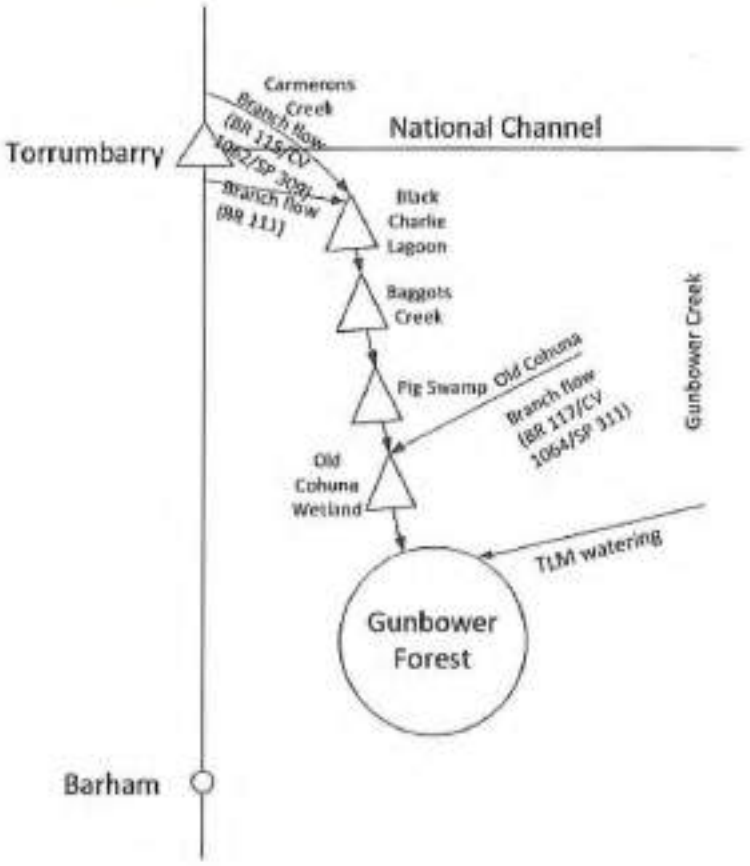
Carmerons Creek
Branch flow (BR 115/CV 1062/SP 309)
Branch flow (BR 111)
National Channel
Torrumbarry
Black Charlie Lagoon
Baggots Creek
Pig Swamp
Old Cohuna Branch flow (BR 117/CV 1064/SP 311)
Gunbower Creek
Old Cohuna Wetland
TLM watering
Gunbower Forest
Barham

Appendix B Level-volume-area relationship

To represent the storage sites in Gunbower National Park the following level-volume-area relationships from the hydraulic model have been used.

Table 1 Level-volume-area relationship for different storages in Gunbower national park

Black Charlie Lagoon			Baggots Creek area			Old Cohuna Wetland		
Level (mAHD)	Volume (ML)	Area (ha)	Level (mAHD)	Volume (ML)	Area (ha)	Level (mAHD)	Volume (ML)	Area (ha)
85.060	0.0	0.0	84.610	0.0	0.0	83.560	0.0	0.0
85.068	20.0	19.5	84.648	21.8	34.5	83.571	34.0	128.9
85.076	40.0	39.1	84.662	38.8	68.9	83.593	62.2	141.2
85.084	60.0	55.0	84.664	56.5	93.1	83.611	89.6	151.6
85.120	80.0	74.5	84.672	75.4	105.5	83.627	116.3	163.2
85.144	92.7	86.5	84.684	95.0	119.4	83.640	141.9	172.1
85.150	98.2	89.9	84.696	114.7	131.3	83.652	166.2	181.3
85.151	101.2	92.4	84.705	134.3	139.0	83.664	188.7	189.8
85.152	103.5	93.8	84.713	154.1	147.4	83.676	208.6	196.0
85.153	104.6	94.1	84.721	173.7	153.1	83.685	225.6	202.2
85.154	106.6	94.6	84.730	186.1	157.1	83.692	240.3	207.9
			84.738	200.4	160.8	83.699	252.9	209.1
			84.746	211.4	164.6	83.704	263.4	214.4
			84.753	222.7	168.2	83.709	272.3	215.4
						83.725	326.3	225.9
						83.746	373.9	238.1
						83.762	413.5	249.0
						83.773	446.8	256.4
						83.785	474.8	262.4
						83.794	496.8	268.1
						83.801	513.6	269.3
						83.805	526.1	274.3
						83.809	535.3	274.8
						83.812	542.0	278.9
						83.814	546.9	279.4
						83.815	550.5	279.6
						83.816	553.2	279.7
						83.817	555.1	279.8

Appendix C Interaction between river flows and inflow into the works proposal area

The inflow into Cameron's Creek and Old Cohuna Channel from the Murray River is dependent on the flow downstream of Torrumbarry, the level in the River Murray and levels inside the Gunbower National Park. Under the benchmark, overbank flow is modelled as one branch flow relationship. The relationship is presented in Table 2.

Table 2 Relationship between river Murray flow and the unregulated inflow to Gunbower national park

Flow at DS Torrumbarry (ML/d)	Existing flow to the Forest (ML/d)	Revised flow to the Forest (ML/d)	Flow to Cameron's Creek (ML/d)	Flow to Old Cohuna (ML/d)
0.0	0.0	0.0	0.0	0.0
13700.0	0.0	0.0	0.0	0.0
14000.0	2.4	2.4	0.0	0.0
17500.0	32.6	32.6	0.0	0.0
21000.0	60.0	60.0	0.0	0.0
25000.0	250.0	250.0	0.0	0.0
34000.0	1000.0	1000.0	0.0	0.0
37000.0	1700.0	1700.0	0.0	0.0
40000.0	2350.0	2350.0	0.0	0.0
45000.0	3500.0	3450.0	0.0	50.0
50000.0	5200.0	5105.7	20.0	74.3
55000.0	7000.0	6873.1	26.9	100.0
60000.0	8700.0	8542.2	33.5	124.3
70000.0	10000.0	9818.6	38.5	142.9

Appendix D Return flow from the site to the river

Once inflows to the site are calculated, the model applies hydrologic routing to calculate level, volume and inundation for key floodplain storage areas within the site. When an upstream storage level is beyond the natural drainage sill level, water drains to the downstream storage. For this site, Black Charlie Lagoon fills first followed by Baggots Creek, Pig Swamp and Old Cohuna wetland (in sequence before additional water drains into the Gunbower TLM site). Natural drainage levels used in MSM-Bigmod are as follows:

- Black Charlie Lagoon: 85.120m (AHD),
- Baggots Creek: 84.721m (AHD),
- Pig Swamp: 84.587m (AHD), and
- Old Cohuna Wetland: 83.566m (AHD).

For storage routing, the following relationships have been used in MSM-Bigmod to enable outflows comparable to hydraulic model results.

Table 3: Return flow from the site to the river

Black Charlie Lagoon		**Baggots Creek area**		**Old Cohuna Wetland**	
Level (mAHD)	Outflow (ML/d)	Level (mAHD)	Outflow (ML/d)	Level (mAHD)	Outflow (ML/d)
85.06	0	84.61	0	83.560	0
85.12	0.1	84.721	0.1	83.571	16

85.144	7.3	84.73	5	83.593	21.8
85.15	14.5	84.738	5.8	83.611	22.6
85.151	17.1	84.746	8.6	83.627	23.3
85.152	17.7	84.753	8.7	83.640	24.4
85.153	18.9			83.652	25.7
85.154	19.9			83.664	27.5
				83.676	30.1
				83.685	33
				83.692	35.3
				83.699	37.4
				83.704	39.4
				83.709	41.1
				83.725	46
				83.746	52.5
				83.762	60.3
				83.773	66.7
				83.785	72.1
				83.794	78
				83.805	87.5
				83.812	93.3
				83.815	96.4
				83.817	98.1

Appendix E Surface water loss relationships

The hydraulic modelling report provided by the Victorian Government mentions 2mm/d seepage loss and a uniform evaporation loss rate. A standard loss rate for evaporation is applied based on monthly data from climate station at Swan Hill. A constant seepage loss rate of 2 mm/day has been applied for the site in MSM-Bigmod.

Appendix F Representation of the each operating strategy in the MDBA modelling framework

Chapter 9 of the business case (which is included as an Appendix to the Notification) outlines a series of proposed operating regimes. This information has been summarised in Table 4.

Table 4 Operating strategies as proposed for Gunbower national park

Operating Regime	Operation of structures	Frequency and timing of delivery	Inundated Area	Peak inflow rate and delivery time

Permanent Wetland Watering	Water will be delivered to Black Charlie Lagoon via Camerons Creek using the new regulator and irrigation weir. Filling at peak flows delivered to fill Camerons Creek downstream of the regulator and inundate Black Charlie Lagoon to Full Supply Level. Closing the regulator and ponding water for at least 12 months. Delivering top-up flows if required.	10 years in 10 during winter/spring	Achieve a water level of 85.05m AHD within Black Charlie Lagoon corresponding to 16 Ha of inundation	Peak flows of 20ML/d for 15 days.
Central Forest Floodplain Watering (from Dry)	Water will be delivered to the Central forest floodplain using the Old Cohuna Main Channel. This requires upgrades to the flume and crossing points to reach 50ML/d. Total duration of ponding is approximately 3 months.	3 years in 10 during winter	175 ha – upstream of Deep Creek 80 ha – downstream of Deep Creek	Filling occurs for 14 days at 50ML/d to fill from dry followed by 31 days of maintenance flows.
Baggots Creek area Floodplain Watering	Water will be delivered to the Baggots Creek area immediately downstream of Black Charlie Lagoon from Camerons Creek. Filling occurs for 14 days at 20ML/d to fill from dry followed by 6 days of maintenance flows. Total duration of ponding is approximately 2 months.	3 years in 10 during winter	76 ha – Black Charlie Lagoon and Camerons Creek 170 ha – Black Charlie Lagoon and Camerons Creek	Filling occurs for 14 days at 20ML/d to fill from dry followed by 6 days of maintenance flows.
Hybrid Scenario	Natural inflows will be supplemented by operation of the works.	Late winter-spring following natural overbank flow		Central forest floodplain - continuous inflow of 50 ML/d Baggots Creek area minimum inflow of approximately 2.7 ML/d

In addition to the outlining the operating strategies, Table 5 highlights the links between the operating strategies and the inundation extent for each strategy.

Table 5 Operating strategies used for Gunbower national park in MSM-Bigmod

Operating Strategy	Frequency	Duration	Target	Water used	Inundation extent
Strategy 1 (GBW) - Permanent Wetland Watering	every year	Until evaporated from the target level	Black Charlie Lagoon @ 85.154m AHD	Maintenance of a continuous trickle flow to maintain the inundation extent of Cameron's Creek and keep the lagoon above half full, with a top up flow in Winter/Spring to bring the lagoon to FSL	Black Charlie Lagoon – 16 ha at FSL U/s of Black Charlie Lagoon at 85.2 m AHD – 91 ha.
Strategy 2 (GBP) - Baggots Creek area Floodplain Watering	1 in 3 yr.		Baggots @ 84.753m AHD	Divert water at 20 ML/d for a further 14 days in addition to OP1	Baggots Area downstream of Black Charlie Lagoon 170 Ha (20 ML/d)
Strategy 3 (GBC) - Central Forest Floodplain Watering	1 in 3 yr.		Old Cohuna @ 83.725m AHD	Filling occurs for 14 days at 50ML/d to fill from dry followed by 31 days of maintenance flows.	Upstream of Deep Creek, 175 ha at 50 ML/d. Downstream of Deep Creek, 80 ha at 50 ML/d

Appendix G Spatial data describing the inundation extent associated with the operation of the measure

Spatial inundation extents for each proposed operating strategies (as described above) are described in the Water Technology Gunbower SDL Modelling Report (see Figures 6.2, 7.2 and 7.3). Spatial data describing the inundation extents for the various operating regimes have been included into the MDBA Assessment Framework. It is important to note that a single spatial dataset was provided for inundation derived by the Cameron's Creek supply inlet operating strategy, however Baggot's Creek and Black Charlie Lagoon can be operated independently. To enable these operating strategies to be accurately integrated into the MDBA's Assessment Framework, inundation extents for each strategy would need to be supplied.

The area of inundation associated with the operation of the works has been modelled with the hydrodynamic model. The total area of inundation for each of the operating strategies is given in the table below.

Table 6 Total area of inundation for operating strategies

Operation strategy	Inundation area (ha)
Gunbower National Park Wetland (GBW)	232
Gunbower National Park Floodplain (GBP)	224
Gunbower National Park Old Cohuna option (GBC)	236

For the purpose of calculating scaling factors for the Ecological Outcomes scoring method, the maps of the inundation areas associated with the works were combined with maps of SFI flow bands and maps representing the ecological elements used in the scoring method. The areas for the resulting hydrological assessment units (HAU) are provided in tables below. The area inundated by the Gie Gehuna option (GBC) includes the area inundated by the Park Wetland (GBW) strategy. The table below for GBC below provides the areas inundated by GBC that are *in addition* to the areas inundated by GBW.

Table 7 Area of inundation for GBW

Inundation area (ha) for GBW	SFI Flow Bands				
Ecological Element	**16,000**	**20,000**	**30,000**	**40,000**	**>40,000**
General health and abundance – all Waterbirds	0.0	0.0	0.0	11.0	232.0
Bitterns, crakes and rails	0.0	0.0	0.0	2.0	23.5
Breeding – Colonial-nesting waterbirds	0.0	0.0	0.0	11.0	232.0
Breeding – other waterbirds	0.0	0.0	0.0	2.0	23.5
Redgum Forest	0.0	0.0	0.0	3.8	91.9
Redgum Woodlands	0.0	0.0	0.0	3.8	21.0
Forests and Woodlands: Black Box	0.0	0.0	0.0	1.0	100.8
Lignum (Shrublands)	0.0	0.0	0.0	0.0	0.0
Tall Grasslands, Sedgelands and Rushlands	0.0	0.0	0.0	2.0	23.5
Benthic Herblands	0.0	0.0	0.0	0.0	0.0
Short lived fish	0.0	0.0	0.0	2.0	23.5
Long lived fish	0.0	0.0	0.0	11.0	232.0

Table 8 Area of inundation for GBP

Inundation area (ha) for GBP	SFI Flow Bands				
Ecological Element	**16,000**	**20,000**	**30,000**	**40,000**	**>40,000**
General health and abundance – all Waterbirds	0.0	0.0	0.0	33.0	224.0
Bitterns, crakes and rails	0.0	0.0	0.0	15.8	115.8
Breeding – Colonial nesting waterbirds	0.0	0.0	0.0	33.0	224.0
Breeding – other waterbirds	0.0	0.0	0.0	15.8	115.8
Redgum Forest	0.0	0.0	0.0	3.9	74.2
Redgum Woodlands	0.0	0.0	0.0	11.6	53.9
Forests and Woodlands: Black Box	0.0	0.0	0.0	16.9	94.2
Lignum (Shrublands)	0.0	0.0	0.0	0.0	0.0
Tall Grasslands, Sedgelands and Rushlands	0.0	0.0	0.0	15.8	115.8
Benthic Herblands	0.0	0.0	0.0	0.0	0.0
Short lived fish	0.0	0.0	0.0	15.8	115.8
Long lived fish	0.0	0.0	0.0	33.0	224.0

Table 9 Additional area of inundation for GBC

Inundation area (ha) for **GBC**	SFI Flow Bands				
Ecological Element	**16,000**	**20,000**	**30,000**	**40,000**	**>40,000**
General health and abundance – all Waterbirds	0.0	0.0	0.0	0.0	4.0
Bitterns, crakes and rails	0.0	0.0	0.0	0.0	4.0
Breeding – Colonial-nesting waterbirds	0.0	0.0	0.0	0.0	4.0

Breeding other waterbirds	0.0	0.0	0.0	0.0	4.0
Redgum forest	0.0	0.0	0.0	0.0	1.5
Redgum Woodlands	0.0	0.0	0.0	0.0	0.2
Forests and Woodlands: Black Box	0.0	0.0	0.0	0.0	0.4
Lignum (Shrublands)	0.0	0.0	0.0	0.0	0.0
Tall Grasslands, Sedgelands and Rushlands	0.0	0.0	0.0	0.0	4.0
Benthic Herblands	0.0	0.0	0.0	0.0	0.0
Short lived fish	0.0	0.0	0.0	0.0	4.0
Long lived fish	0.0	0.0	0.0	0.0	4.0