Greiner's Lagoon Environmental Watering Plan

Final Report

18 November 2020

Goulburn-Murray Water Connections Program

20014715

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Project Manager:	Damien Sullivan
Author:	Melanie Tranter, Bronwyn Gwyther, Lisa Duncan and Milos Pelikan
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Jacobs Group (Australia) Pty Limited
ABN 37 001 024 095
50 Mitchell St
PO Box 952
Bendigo VIC 3552 Australia
T +61 3 5444 1861
F +61 3 5444 1862
www.jacobs.com

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Contents

Executive Summary

The Greiner's Lagoon Environmental Watering Plan (EWP) documents the approach to mitigating the potential impacts of the Goulburn-Murray Water (GMW) Connections Project, previously named the Northern Victorian Irrigation Renewal Project. EWPs are prepared for wetlands or waterways that could be adversely impacted due to the changed irrigation water contribution by implementation of the Connections Project.

An EWP is required for Greiner's Lagoon (or Wetland 1), the largest of the four wetlands in the Yambuna Wetlands complex, in response to the completed upgrade of the regulator on the CG 5/27/6 channel which outfalls to the drain connecting the wetland complex to the irrigation system. The upgrade of the regulator has generated water savings (through reduced outfalls) that will contribute to the Connections Project overall water savings. Greiner's Lagoon now receives less water than it did historically as a result of reduced outfalls. In accordance with the Water Change Management Framework (GMW, 2018), the potential impacts of reduced outfalls to the lagoon is managed by preparing and implementing an EWP.

The following components are the primary means by which the commitment of no net environmental loss for Greiner's Lagoon will be achieved for the GMW Connections Project. The main conclusions for each of these components are summarised below.

Scope of this EWP

The Yambuna Wetlands are made up of four individual wetlands forming a larger wetland complex of approximately 22 hectares immediately adjacent to the lower Goulburn River. Greiner's Lagoon (the largest of the four wetlands) is largely on private property and is classified as a shallow freshwater marsh. The remaining three wetlands are located within the Lower Goulburn National Park and are classified as deep freshwater marshes. The wetland complex forms part of the Lower Goulburn Floodplain, which is listed on the Directory of Important Wetlands in Australia.

Water savings assessments completed as part of the development of this EWP found that only Greiner's Lagoon was influenced by water from the irrigation district in the 2004/05 baseline year. The focus of this EWP is on the mitigation water requirements to offset the adverse impact of the channel upgrade on Greiner's Lagoon only.

Defining the environmental values of Greiner's Lagoon

The area in and around Greiner's Lagoon has been impacted by stock grazing and timber harvesting however have retained some significant native vegetation. The lagoon provides a diversity of habitats for aquatic and amphibious plants as well as habitat and food sources for birds, frogs, reptiles and mammals.

A management goal for the lagoon has been developed in consultation with key project stakeholders, the Goulburn Broken Catchment Management Authority's Wetland Technical Reference Group and the GMW Connections Program's Expert Review Panel.

Water management goal for Greiner's Lagoon:

Provide a watering regime for Greiner's Lagoon that creates conditions suited to the growth of a diverse vegetation community typical of a freshwater marsh, providing habitat for a variety of waterbirds and frogs

Defining the water regime required to protect the environmental values

An ecological objective to support the achievement of this management goal is aimed at the restoration of vegetation (and habitat) within the complex. The hydrological requirements to achieve this objective was identified, and a desired water regime required to achieve the water management goal is described.

Greiner's Lagoon water regime:

Fill the lagoon six in ten years to 96.6 m AHD and an additional two in ten years to 96.0 m AHD before allowing water levels to recede by natural drawdown to provide six to eight months of ponded water. Spring top ups (up to 96.0 mAHD) may be provided in some years. The maximum ponding time recommended in wet seasons is 12 months and the maximum dry period recommended is 2 years.

The volume of water required to provide the desired water regime for Greiner's Lagoon has been assessed using a water balance model. The mean long-term annual controlled inflow requirement to provide the desired water regime is 56 ML.

Water regime requirements for the entire wetland complex, including Wetlands 2, 3 and 4, will be addressed in the Yambuna Wetlands Environmental Water Management Plan (EWMP), which also guides the use of environmental water at the site over the longer term.

Assessment of mitigation water requirement

Mitigation water is defined as the volume of water required to ensure no net impacts on high environmental values resulting from the GMW Connections Project.

The assessment process for the requirement of mitigation water (GMW, 2018) demonstrates that the supply of irrigation water provided significant benefit to Greiner's Lagoon and mitigation water is warranted. This means additional water would need to be secured to maintain the lagoon's environmental values (specifically vegetation values) to offset the reduction in irrigation outfalls to the wetlands.

The incidental water at the origin was 71.6 ML in the baseline year and the annualised baseline mitigation water volume was calculated as 57.3 ML. The Mitigation Water Commitment for Greiner's Lagoon is 80%.

Potential risks and constraints associated with the recommended water regime

A number of potential risks and limiting factors are identified that may result from the provision of mitigation water as a portion of the recommended water regime. Major risks that pose a constraint to the achievement of the ecological outcomes set out in this plan include:

- A landowner has a drainage diversion licence over Greiner's Lagoon which allows the extraction of 228 ML per year. This licence presents a risk to achieving the identified objectives and goal for the Yambuna Wetlands. This risk will be mitigated through the Victorian environmental water planning processes which will require an agreement to prevent the extraction of water prior to the delivery of mitigation water to the lagoon.
- Most of Greiner's Lagoon is located on private property. Livestock access to the lagoon poses a threat to the health of the wetland through grazing or trampling of vegetation, as well as loss of water quality. This risk can be potentially mitigated through a negotiated management agreement with the private landholder.
- Water is retained within Greiner's Lagoon by an embankment and gated pipe located within the National Park at the northern end of the lagoon. Manual opening of this pipe poses a risk to achieving the desired water regime. This risk can be mitigated through the development of a formal agreement between Parks Victoria and the private landholder regarding the use and operation of infrastructure within the parks reserve.

Infrastructure requirements

Greiner's Lagoon has the required delivery infrastructure to provide water from the irrigation system at a rate of 5-7 ML/d via the 5/27/6 channel. The capacity of the existing infrastructure, if operating at full capacity, would

allow the wetland to be filled via service point RN 821 with ten days (assuming sufficient capacity is available in the 5/27/6 channel).

The current delivery infrastructure is considered adequate to deliver the desired water regime and no infrastructure upgrades are required as part of the GMW Connections Project. However, it is recommended Goulburn-Murray Water pursue measurement of extractions at the privately-owned drainage diversion pump.

Adaptive management framework

An adaptive management approach (assess, design, implement, monitor, review and adjust) is incorporated into the EWP to ensure that it is responsive to changing conditions.

The Greiner's Lagoon EWP has been developed using the best available information. However, the groundwater/surface water relationship is poorly understood, and it is possible the duration of ponding may be less than predicted by the water balance model. Installation of depth gauges within the lagoon would allow monitoring of wetland drawdown following environmental watering and support the refinement of the water regime over time. Ecological monitoring may provide additional information that contributes to an improved understanding of the cause/effect relationships between hydrology and ecological responses, supporting an adaptive approach to how water is managed at Greiner's Lagoon.

Governance arrangements

A summary of the roles and responsibilities relating to the development and implementation of EWPs are defined. A framework for operational management outlining the relevant roles and responsibilities has also been developed to describe the annual decision-making process required to coordinate the implementation of the desired water regime for Greiner's Lagoon.

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to develop an Environmental Watering Plan for Greiner's Lagoon in accordance with the scope of services set out in the contract between Jacobs and the Goulburn Murray Water (GMW) Connections Project. That scope of services, as described in this report, was developed with the GMW Connections Project.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the GMW Connections Project and/or from other sources. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete then it is possible that our observations and conclusions as expressed in this report may change.

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This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

This report has been prepared on behalf of, and for the exclusive use of, the GMW Connections Project, and is subject to, and issued in accordance with, the provisions of the contract between Jacobs and the GMW Connections Project. Jacobs accepts no liability or responsibility whatsoever for, or in respect of, any use of, or reliance upon, this report by any third party.

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1. Background

1.1 Goulburn-Murray Water Connections Project

The Goulburn-Murray Water Connections Project (GMW Connections Project), formerly the Northern Victoria Irrigation Renewal Project (NVIRP), is a $2 billion works program to upgrade ageing irrigation infrastructure across the Goulburn Murray Irrigation District (GMID) and to save water lost through leakage, seepage, evaporation and system inefficiencies. Works include lining and automating channels, building pipelines and installing new, modern metering technology. These combined works will improve the irrigation system's delivery efficiency and recover the water previously lost from the system. The GMW Connections Project is scheduled to be completed in October 2020 (GMW 2018).

The GMID uses a number of natural carriers, rivers, lakes and wetlands for both storage and conveyance of water. While the water savings generated from the GMW Connections Project are from 'losses' within the irrigation system, in some cases the losses from the pre-GMW Connections Project operating regime provide incidental benefits to environmental assets (SKM 2008).

1.2 Decision under State and Commonwealth Acts

On 20 April 2009, the Minister for Planning determined an Environment Effects Statement (EES) was not required for the GMW Connections Project, although this decision was subject to several conditions (DPCD 2009). The conditions that apply to the protection of wetlands and waterways include:

- **Condition 3**: "*development of a framework for protection of aquatic and riparian ecological values through management of water allocations and flows within the modified GMID system to the satisfaction of the Minister of Water*"
- **Condition 5**: "*Environmental Watering Plans are required for 'at risk' waterways and wetlands before operation of the relevant NVIRP work commences*".

On 10 May 2010, the Commonwealth Minister for Environment Protection, Heritage and the Arts advised that the GMW Connections Project was approved under the EPBC Act, subject to adherence to a number of conditions. The condition that applies to the protection of wetlands is:

- **Condition 5:** "*Where a wetland that supports or is likely to support matters of national environmental significance occurs within 200 metres of a channel for which decommissioning or lining is considered, the person taking the action must ensure that:*
    - *a) Qualitative and quantitative impacts of the consequent loss of groundwater on that wetland are assessed; and*
    - b) *If significant impacts are expected or considered likely, an environmental watering plan for that wetland is prepared, or plans to decommission or line the channel abandoned*".

The GMW Connections Project have developed a Water Change Management Framework (GMW, 2018) to ensure aquatic and riparian ecological values are protected and to meet the conditions of approval under both the EES Act and the EPBC Act. The framework outlines the processes and methods for preparing Environmental Watering Plans (EWPs) to mitigate potential impacts on wetlands and waterways at risk from the implementation of the Connections Project through adaptive water management (GMW 2018).

1.3 Water Change Management Framework

The Water Change Management Framework (WCMF) describes how aquatic and riparian ecological values will be protected through management of water allocations and flows that may be impacted by the implementation of the GMW Connections Project within the modernised GMID.

The WCMF is a high level document which addresses changes resulting from the operation of the modernised works. It also addresses potential environmental impacts because of the implementation of the GMW Connections Project.

The WCMF applies to how the GMW Connections Project will:

- Develop the operational requirements for managing the ecological consequences of hydrological changes arising from the implementation of the project
- Establish the future operational requirements to achieve agreed environmental performance requirements, including the transfer of responsibility to appropriate organisations, and
- Describe how ecological consequences of hydrological changes arising from the implementation of the GMW Connections Project will be monitored, reported and adjusted though an adaptive management approach.

Potential impacts on aquatic and riparian ecological values related to the physical works associated with the GMW Connections Project are addressed as part of the Construction Environmental Management Framework (CEMF) and associated documents.

The WCMF is subsidiary to the GMW Connections Project Environmental Management System (EMS) which is an internal management system to enable compliance with environmental outcomes, compliance with legislation, control of risk; and continual improvement. The interactions between each of the GCP environmental management procedures are shown in Figure 1-1.

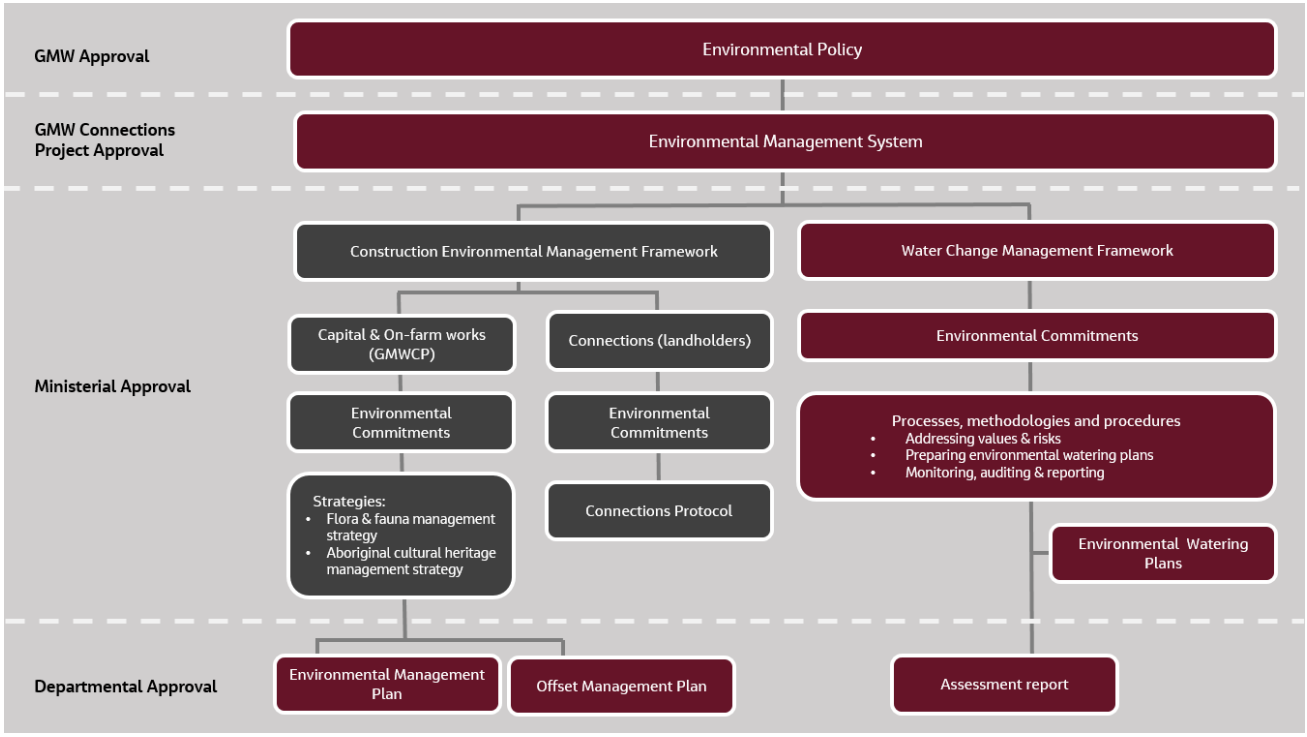

Figure 1-1 GMW Connections Project environmental management structure

The relevant principles of WCMF as they apply to the EWP for Greiner's Lagoon include:

- Mitigation water will be provided where water to be saved is shown to have a material and beneficial effect on high environmental values
- Mitigation water, where identified as needed, will be provided to replace incidental irrigation water converted to water savings
- Regional impacts will be reviewed and, where identified as needed, will be mitigated.

While the GMW Connections Project has been established to implement the modernised works, it will have no ongoing role in the operation of the modified GMID or environmental management in the region. Therefore, a critical element of any management or mitigation measures is the establishment of effective management arrangements to ensure implementation on an ongoing basis.

1.4 Shortlisting of Wetland Environmental Watering Plans

In accordance with its obligations under the WCMF, the GMW Connections Project is required to prepare environmental watering plans (EWPs) for wetlands and waterways that are 'at risk' due to the irrigation modernisation activities undertaken by the Project, such as changes in channel outfalls, delivery patterns and reductions in leakage and seepage. A preliminary list of 'at risk' waterbodies requiring further investigation was developed by SKM (2008) and further validated by HydroEnvironmental (2009) to short-list the wetland or waterbodies requiring EWPs.

The Yambuna Wetlands were not included on the preliminary list of 'at risk' wetlands. However, the GMW Connections Project identified that an EWP is required for the wetlands due to the upgrade of the CG 5/27/6 infrastructure which supplies the wetland with water.

1.5 Context of the environmental watering plans

The purpose of an EWP is to determine the impact of the GMW Connections Project against a desired water regime for the particular wetland or waterway, and to offset significant impacts through the provision of water, known as mitigation water.

The EWPs are the primary means by which the commitment of no net environmental loss will be achieved for water savings projects (GMW 2018). The WCMF requires an EWP under two broad circumstances:

- when a waterway or wetland with high environmental values could be adversely affected by changes to irrigation water contribution by the implementation of the GMW Connections Project in the GMID, or
- when uncertainty exists as to the materiality of impacts (GMW 2018).

The development of an EWP includes an assessment of the current and unregulated water regimes and statements on the preferred water regime required to achieve the ecological objectives of the site. This then provides the bases for considering the potential ecological effects of water savings to be achieved by the GMW Connections Project and identifying mitigation water requirements, if any.

Each EWP will:

- identify environmental values of the wetland
- identify the water regime required to protect the environmental values
- define the environmental water regime and the sources of water
- Identify if there is a need to provide mitigation water and, if so, determine:
  - the quantification of mitigation water
  - the infrastructure requirements
  - mitigation measures to minimise the potential risks and impacts associated with the provision of mitigation water
  - draft protocols for ongoing water supply
  - outline governance arrangements.

This EWP is not a wetland management plan or environmental water management plan (EWMP), therefore it is not intended to provide management guidance for wetlands; rather it is aimed at providing a water supply

protocol that can be agreed upon by land, water and catchment managers. An EWMP will be prepared following the completion of this EWP, as discussed in section 9.4.

The GMW Connections Project is responsible for managing and mitigating the significant environmental effects of its own activities. It is not responsible for managing and mitigating the effects of other activities or circumstances beyond its control such as:

- reduced outfalls due to Government policy initiatives
- water trade
- drought and climate change
- management and modernisation programs carried out by others (GMW 2018).

1.6 Development process

The Greiner's Lagoon EWP has been developed in collaboration with key stakeholders including GMW, the GMW Connections Project, the Department of Environment, Land, Water and Planning (DELWP), the Goulburn Broken Catchment Management Authority (GBCMA) and Parks Victoria (PV). The Murray Darling Wetlands Working Group, Yorta Yorta Nation Aboriginal Corporation, the Goulburn Broken Wetlands Technical Reference Group (Rhonda Butcher, Damien Cook and Wayne Koster) and the landholder adjacent to wetland 1 (Jamie McMaster) have also been involved in the development of the EWP.

The main activities of this project were to:

1. Develop a water balance model of the current and unregulated water regimes of the Yambuna Wetlands

2. Review the 2015 report on the environmental condition and water regime of the Yambuna Wetlands (Rakali 2015) and monitoring data collected by the Murray Darling Wetlands Working Group

3. Identify and document the current ecological condition of the Yambuna Wetlands, and define a water regime that will maintain or enhance those values

4. Provide information on the relative impacts in the change in water regime due to the reduction in irrigation outfall to the Yambuna Wetlands from the Central Goulburn 5/27/6 channel

5. Provide recommendations on mitigation measures necessary to maintain ecological values.

These tasks have been carried out in accordance with the WCMF requirements and the Guidelines for Wetland Environmental Water Management Plans where possible recognising that the level of detail required for EWPs is less than for EWMPs.

The Greiner's Lagoon EWP has also been reviewed and approved by GMW Connections Project's Expert Review Panel prior to consideration by the Victorian Minister for Water and the Commonwealth Minister with responsibility for the Environment.

An overview of key consultative meetings held during the development of this EWP is provided in Appendix A.

2. Greiner's Lagoon

2.1 Regional setting

Greiner's Lagoon forms part of a broader wetland complex known as the Yambuna Wetlands. The Yambuna Wetlands are a series of four small, connected intermittent and episodic wetlands located adjacent to the lower Goulburn River, approximately 21 kilometres east of Echuca in northern Victoria (see Figure 2-1). The wetlands are located within the Murray Fans bioregion which is characterised by a flat to gently undulating landscape with evidence of former stream channels and broad floodplain areas associated with two major river systems, the Murray and Goulburn Rivers. The land surrounding the wetlands consists of the forested floodplain of the Lower Goulburn River National Park and irrigated cropping on private property within the Central Goulburn Irrigation Area.

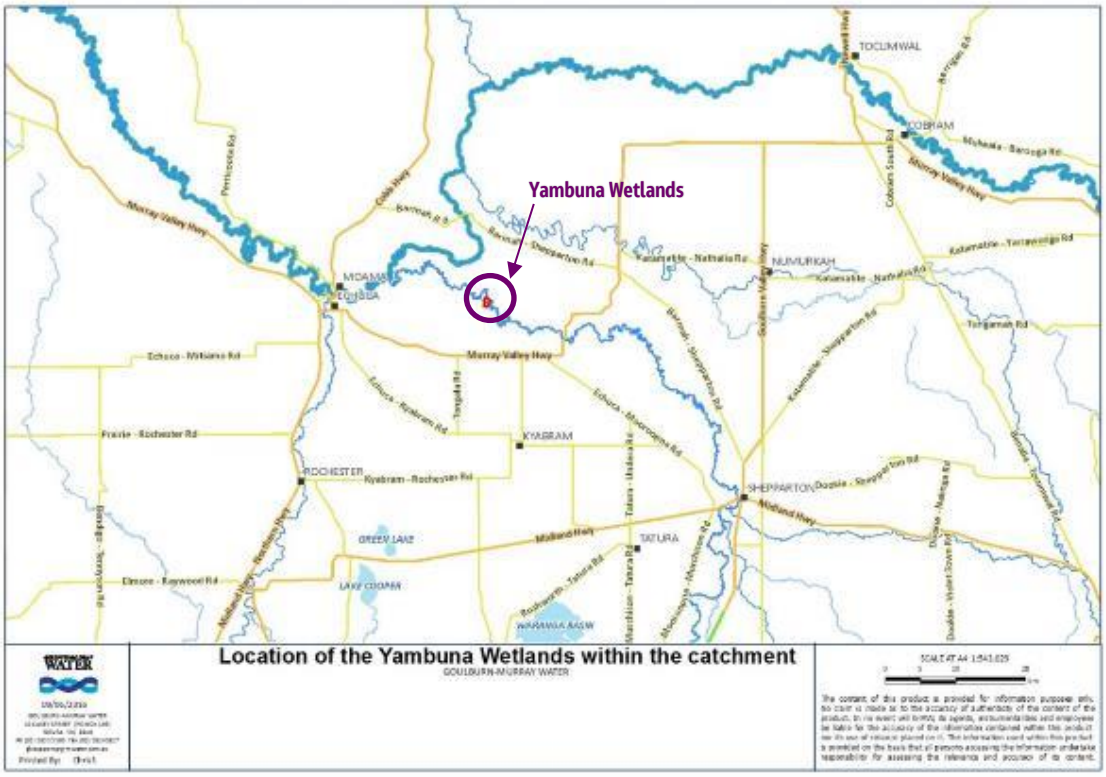

Figure 2-1 Location of the Yambuna Wetlands within the catchment

The wetlands form part of the Lower Goulburn Floodplain, which is listed on the Directory of Important Wetlands in Australia. Greiner's Lagoon (shown as Wetland 1 on Figure 2-2) is classified as a Shallow Freshwater Marsh[1] and is located mainly on privately owned property. Greiner's Lagoon is the largest of the four wetlands covering approximately 12 hectares. Wetlands 2, 3 & 4 are classified as Deep Freshwater Marsh[1] and range in size from approximately two hectares (Wetland 2) to four hectares (Wetlands 3 & 4). The wetlands are mainly contained within the Lower Goulburn National Park however parts of Wetland 1 and 3 are situated on an adjoining private property.

The wetlands naturally received water during high or overbank flows from the lower Goulburn River via natural channels linking the river with Wetlands 1, 2 and 4 which are still present today. The wetlands are now also connected to the Goulburn Murray Irrigation District via the Central Goulburn 5/27/6 channel which has a capacity of 35 ML/d and outfalls to the southern end of Wetland 1 through a fixed pipe structure with a capacity of 5 ML/d.

[1] 1994 Wetland Classification Category

Figure 2-2 Locality map showing individual wetlands within the Yambuna Wetlands complex (Jacobs, 2019)

2.2 Scope of this plan

Assessments undertaken during the development of this plan (section 5.5) determined a requirement to offset the impact of the GMW Connections Project for Greiner's Lagoon only. As such, the focus of this EWP is on Greiner's Lagoon, with reference to the broader wetland complex where relevant.

2.3 Wetland context and current condition

The Yambuna Wetlands complex would have naturally been inundated during bank full and overbank flow events in the lower Goulburn River. The shallow nature of Greiner's Lagoon means it would have dried more frequently, while the wetlands in the surrounding complex would have held water for longer periods (section 4.1).

River regulation has altered the hydrological regime of the lower Goulburn River by reducing the number of bank full and overbank events that would have inundated the wetland. However, prior to the GMW Connections Project, the wetland complex also received drainage outfall water from the GMID causing long periods of permanent inundation (section 4). To some extent this offset the reduction in inflows from the Goulburn River, however outfalls in the summer irrigation period have changed the seasonal pattern of wetland water regime, as evidenced by the abundance of summer-growing aquatic weeds such as **Paspalum distichum* and **Alisma lanceolata* (Rakali, 2015). Since modernisation of the irrigation distribution network, the volume of water entering Greiner's Lagoon from the irrigation district has significantly reduced and it now frequently dries out.

Hydrological changes have influenced the condition, vegetation composition and structure found within the lagoon. This has impacted on native fauna such as frogs and birds that are reliant on wetland vegetation for habitat and play a vital role in the food webs that sustain them. Large dead red gums seen in Greiner's Lagoon provide evidence for extended inundation, probably caused by irrigation drainage outfalls. Other impacts include the invasion of river red gum saplings into previously open water areas of the wetland complex, invasion of weeds and reduction in diversity and cover of indigenous plants (Rakali, 2015).

Changes to the vegetation condition of the wetlands cannot be attributed to river regulation and irrigation system management alone. In the higher areas surrounding the wetlands there is evidence of impacts of past cattle grazing, notably some loss of understorey diversity and reduced cover of structural understorey and mid-storey dominants (Rakali, 2015). The low density of the palatable river swamp wallaby-grass (*Amphibromus fluitans*) may be caused by the preferential grazing of livestock for this species.

Other anthropogenic changes include a gated pipe in the embankment constructed at the downstream end of Greiner's Lagoon. This can be kept closed to prevent the spilling of water into Wetland 2, resulting in longer ponding and increased depth of inundation in the lagoon. This would improve the visual amenity of water in the landscape for adjacent landholders and provide greater access to water for extraction under the existing drainage diversion licence. No information is available on the historical operation of the gated pipe, however the dead river red gums and presence of summer growing aquatic weeds suggest this may have occurred.

Although the condition of Greiner's Lagoon has been degraded by these factors, it has retained some highly significant ecological values that require water if they are to be maintained. A diverse range of less represented floodplain plant communities persist at the site and six species of rare and threatened plant species have been recently recorded (Rakali, 2015). The brown treecreeper is a near-threatened bird species protected under Victoria's Flora and Fauna Guarantee Act that has been observed in the surrounding forested areas and a diverse range of other flora and fauna has been recorded (section 3).

Large, old trees are also present at Greiner's Lagoon which provide habitat for a large number and variety of bird species (Figure 2-3). The value of the wetland complex as habitat for native fauna is heightened by its location within remnant vegetation along the lower Goulburn River Floodplain (Rakali 2015).

Figure 2-3: Looking across Greiner's Lagoon into the Lower Goulburn National Park

2.4 Land status and management

Greiner's Lagoon is mainly located within private land with a small area at its outfall crossing over into the National Park (Figure 2-4). The three other wetlands in the complex are almost entirely contained within the Park and under the management of Parks Victoria. Accordingly, while the threats posed by grazing are now eliminated from the broader park, they remain a threat for Greiner's Lagoon.

The surrounding National Park area is largely dominated by river red gum forests and woodland with an understorey of grasses, sedges and herbs. The National Park was established in 2010 as part of the recommendations of the 2009 Victorian Environmental Assessment Council investigation into river red gum

forests, prior to this livestock grazing and timber harvesting was permitted along the floodplain and some evidence of these activities remains (Rakali, 2015).

The landowner of the private property upon which Greiner's Lagoon is partially located is supportive of improving the ecological values of the site (Jacobs 2019). Recent environmental watering of the lagoon has been undertaken in partnership between this landholder and the Murray Darling Wetlands Working Group to maintain ecological values supported by the site (MDWWG, 2018).

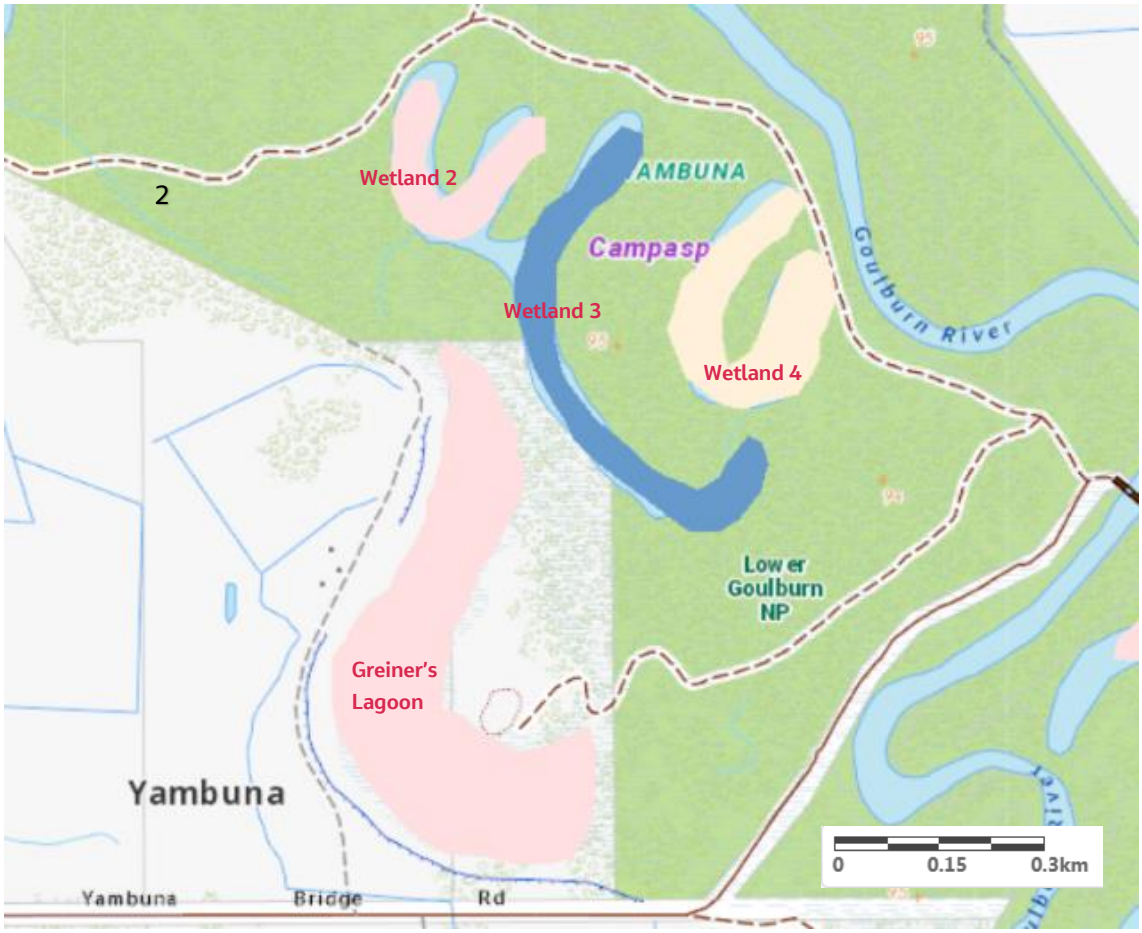

Figure 2-4 Map showing Yambuna Wetlands spanning the public-private land interface (http://mapshare.maps.vic.gov.au)

2.5 Cultural values

The broader lower Goulburn River floodplain contains a number of known sites of Aboriginal cultural heritage including scarred trees and artefact scatters adjacent to the Goulburn River, and cooking mounds at nearby Loch Garry and Kanyapella Basin (VEAC 2009). Two culturally significant trees were identified during a vegetation survey including a scarred Grey box tree (Rakali 2015), see Figure 2-5. It is likely that archaeological sites in the region have become fragmented by destruction and damage caused by past land use including stock grazing and timber harvesting.

Yambuna Wetlands is within the Yorta Yorta Registered Aboriginal Party (RAP) boundary. The Yorta Yorta Whole of Country Plan 2012-2017 includes wetland restoration within its 12 Platforms of Action. Although Yambuna Wetlands is not specifically mentioned as a key place of interest within the plan, it is likely that the Yorta Yorta Nation Aboriginal Corporation would be interested in opportunities to assist in management or rehabilitation activities at the site.

Figure 2-5 Culturally scarred Grey box recorded near Greiner's Lagoon, November 2015 (Rakali, 2015)

2.6 Recreational values

The location of Greiner's Lagoon on private land restricts the recreational values of the lagoon to those people with direct access to the wetland. While it provides a sense of well-being and gathering point for those people, these benefits are not shared by the broader public.

The Lower Goulburn National Park is a popular area for fishing, canoeing, walking, four-wheel driving, birdwatching and camping. The Yambuna Wetlands are not easily accessible by the public and the site lacks facilities such as car parking, toilets, walking paths or interpretive signage. Thickets of river red gums in wetlands 2 to 4 makes movement within the wetlands very difficult. As a result, the recreational value of the wetlands is currently low but could be increased if access to the surrounding areas of National Park was improved.

2.7 Legislative and policy frameworks

2.7.1 Federal legislation

The Environment Protection and Biodiversity Conservation (EPBC) Act 1999 is the key piece of legislation pertaining to biodiversity conservation within Australia. It aims to control potential impacts on matters of national environmental significance.

Greiner's Lagoon supports at least one species listed under the EPBC Act, *Amphibromus fluitans* or River-swamp Wallaby-grass was recorded there in 2015 (Rakali 2015). Actions that may significantly impact a species listed under the Act are subject to assessment and approval by the Commonwealth Minister with responsibility for the Environment. The GMW Connections Project works program is also subject to assessment and approval under the EPBC Act.

2.7.2 State legislation

Flora and Fauna Guarantee (FFG) Act 1988

The Flora and Fauna Guarantee (FFG) Act 1988 aims to protect a number of identified threatened species and communities within Victoria. Disturbance or collection of any species protected under the FFG Act will require a permit from DELWP. To date, no species listed under the FFG Act are known to be present at Greiner's Lagoon.

Environmental Effects Act 1978

Potential environmental impacts of a proposed development are subject to assessment and approval under the Environmental Effects Act 1978. As such, the GMW Connections Project works program and any associated environmental impacts are subject to assessment and approval under the Act (as discussed in Section 2.2).

Water Act 1989

The Water Act 1989 is the key piece of legislation that governs the way water entitlements are issued and allocated in Victoria. The Act also identifies water that is to be kept for the environment as part of the Environmental Water Reserve. The Act provides a framework for defining and managing Victoria's water resources.

Aboriginal Heritage Act 2006

All Aboriginal places, objects and human remains in Victoria are protected under the Aboriginal Heritage Act 2006 (DPCD 2007). The Yambuna Wetlands are known to have sites of Aboriginal cultural significance (Section 3.4).

Other - Threatened Species Advisory Lists

Threatened species advisory lists for Victoria are maintained by the DELWP and are based on technical information and advice obtained from a range of experts which are reviewed every one to two years. These advisory lists are not the same as the Threatened List established under the FFG Act. There are no legal requirements or consequences that flow from inclusion of a species in advisory lists. However, some of the species in these advisory lists are also listed as threatened under the FFG Act.

Greiner's Lagoon is known to support flora and fauna species that are included on advisory lists (Table 3-1 and Table 3-3).

3. Environmental values

High environmental values have previously been defined by the conservation significance of the wetland or species at an international, national or state level (SKM 2008; GMW 2018). As such, in describing the values supported by the lagoon in the sections below, an emphasis is placed on identifying listed flora and fauna species and vegetation communities, followed by the broader ecological and landscape values.

All listed values have been presented in this section with full species lists provided in Appendix B.

3.1 Fauna

The Australian Wetlands database identifies the lower Goulburn River floodplain as an important breeding area for waterbirds, particularly following overbank floods. Between floods, wetlands of the lower Goulburn floodplain provide important habitat for a number of significant fauna species, some of which have been previously recorded in and around Greiner's Lagoon.

Significant waterbird species recorded using Greiner's Lagoon following the delivery of environmental water in spring 2017 include the FFG-listed eastern great egret (*Ardea modesta*), royal spoonbill (*Platalea regia*), white-bellied sea-eagle (*Haliaeetus leucogaster*) and azure kingfisher (*Alcedo azurea*). Grey teal (*Anas gracilis*) and Pacific black ducks (*Anas superciliosa*) were both recorded with ducklings during the season and are thought to have bred at the site. Overall, a total of 25 waterbird species from three functional groups (ducks, large waders and fish eaters) were recorded using the lagoon in that year (MDWWG, 2018). A range of terrestrial wetland foragers have previously been recorded at the site including the sacred kingfisher (*Todiramphus sanctus*) and whistling kite (*Haliastur sphenurus*).

A survey of fish species in wetlands associated with the Goulburn River floodplain was conducted following the floods of October and December 2010 (SKM 2011). Nineteen sites were sampled which included Wetland 4 of the Yambuna Wetlands complex and a shallow wetland south of Yambuna Bridge. Carp gudgeon (*Hypseleotris spp*.) was the only native species detected at both sites and in very low numbers (n=3). The total catch was dominated by exotic fish (n=376 at wetland 4), with eastern gambusia (*Gambusia holbrooki*) and common carp (*Cyprinus carpio*) making most of the catch, but goldfish (*Carassius auratus*) and oriental weatherloach (*Misgurnus anguillicaudatus*) were also recorded. The study concluded that:

- environmental watering in wetlands may create optimal conditions for exotic fish (at the expense of native fish)
- delivery of water for native fish at these sites may be better focussed toward the prevention of blackwater events, rather than the maintenance of permanent habitat
- environmental objectives (that determine how environmental water is applied to the floodplain) should potentially focus on values such as vegetation and waterbirds.

Other water dependent species recorded at the Yambuna Wetlands include the common long-necked turtle (*Chelodina longicollis*), spotted marsh frog (*Limnodynastes tasmaniensis*), plains froglet (*Crinia parinsignifera*), Peron's tree frog (*Litoria peronii*), barking marsh frog (*Limnodynastes fletcheri*), eastern sign-bearing froglet (*Crinia signifera*), pobblebonk (*Limnodynastes dumerilii*) and the water rat (*Hydromys chrysogaster*). With the exception of the water rat, all of these species were recorded at Greiner's Lagoon in spring 2017 (MDWWG, 2018).

Significant water dependent fauna species recorded at the Yambuna Wetlands and expected to use Greiner's Lagoon are shown in Table 3-1. No species of international or national significance have been recorded.

Table 3-1 Significant fauna species expected to occur at Greiner's Lagoon

Common Name	Scientific Name	FFG status	DELWP status
Birds			
Nankeen night heron	*Nycticorax caledonicus hillii*	-	Near threatened
Eastern great egret	*Ardea modesta*	Listed as threatened in Victoria	Vulnerable
Freckled duck	*Stictonetta naevosa*	Listed as threatened in Victoria	Endangered
Other			
Common Long-necked Turtle	*Chelodina longicollis*	-	Data deficient

3.2 Flora

Vegetation surveys were carried out by Rakali Consulting in 2015 and used to map the different Ecological Vegetation Classes (EVCs) found at the site. Nine EVCs have been identified across the complex, of which five are within or adjacent to Greiner's Lagoon (Table 3-2). One of these EVCs, Sand Ridge Woodland, is not flood dependent and is not further considered by this plan.

The conservation status and condition[2] of water dependent EVCs associated with Greiner's Lagoon presented in Table 3-2. The dominant EVC in Greiner's Lagoon is Rushy Riverine Swamp (804). Other EVCs present in the lagoon include EVC 817 and 814. Riverine Swampy Woodland (815) is found adjacent to Greiner's Lagoon but, due to its occurrence on higher ground, has not benefited to any significant extent from past irrigation outfalls (section 5.5).

Table 3-2: Conservation status and condition of water-dependent EVCs mapped at Greiner's Lagoon (Rakali, 2015)

Ecological Vegetation Class	EVC Number	Bioregional Conservation Status in Victorian Riverina	Condition category
Riverine Swampy Woodland	815	Vulnerable	3 (moderate)
Riverine Swamp Forest	814	Depleted	2 (good)
Rushy Riverine Swamp	804	Depleted	3 (moderate)
Sedgy Riverine Forest/ Riverine Swamp Forest Complex	817	Depleted	2 (good)

The mapped distribution of EVCs across the Yambuna Wetlands complex is shown in Figure 3-1.

[2] Based on Frood condition categories as assessed by Rakali 2015

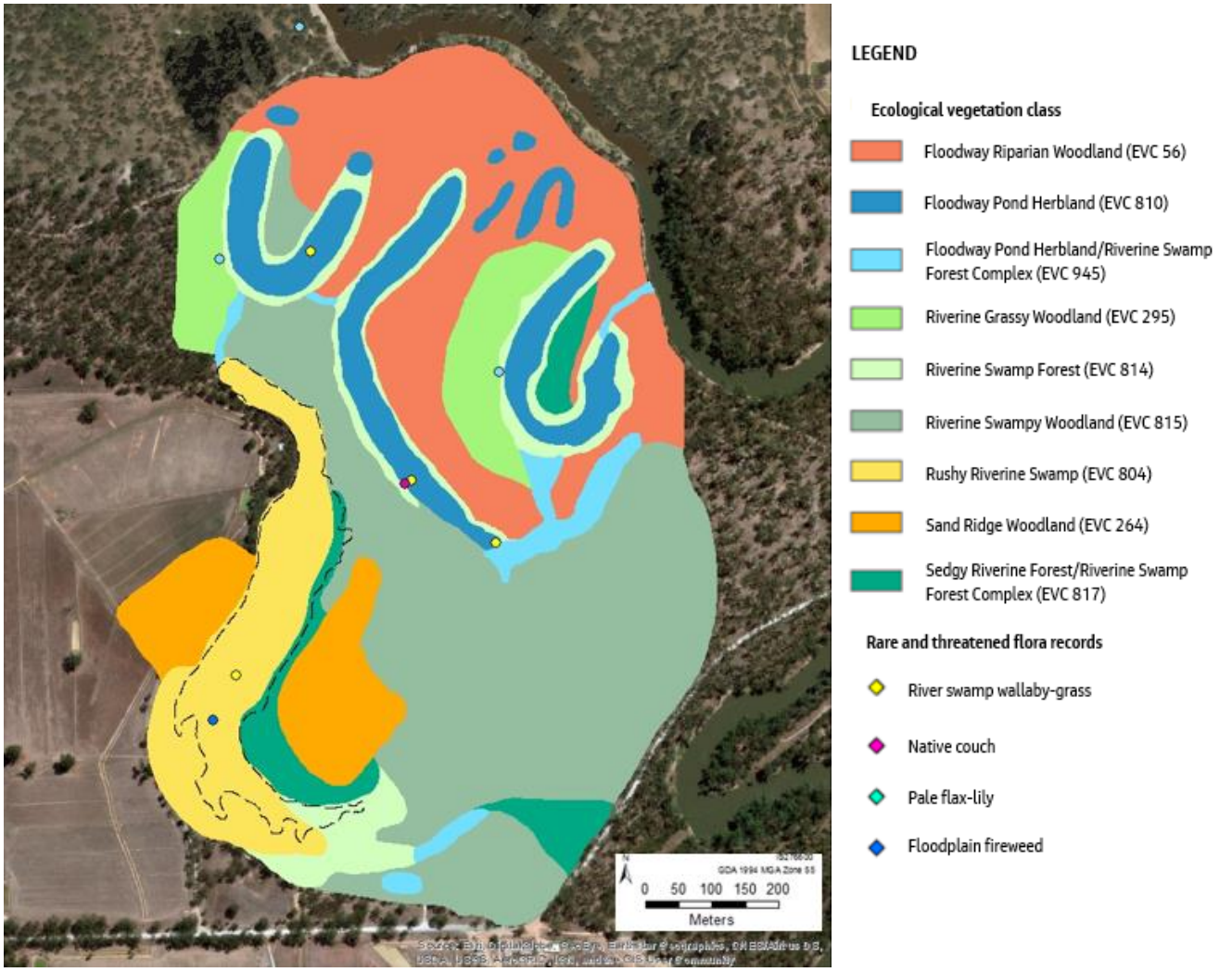

Figure 3-1 Distribution of EVCs mapped at the Yambuna Wetlands complex (Rakali, 2015)

Rushy Riverine Swamp (EVC 804) is characterised by river red gums (*Eucalyptus camaldulensis*), which are present along the edge of the wetland and scattered throughout the bed of the lagoon. Several of the river red gums have drowned due to prolonged flooding. The understorey is dominated by giant rush (*Juncus ingens*), common swamp wallaby-grass (*Amphibromus nervosus*), river swamp wallaby-grass (*Amphibromus fluitans*) and common blown-grass (*Lachnagrostis filiformis*). Aquatic, amphibious and mudflat species are also present in this EVC. The wetland also has an abundance of aquatic weeds such as water couch (*Paspalum distichum*) and slender plantain (*Alisma lanceolata*).

Sedgy Riverine Forest/ Riverine Swamp Forest Complex (EVC 817) is a forest to woodland class on riverine terraces. The vegetation is dominated by river red gum, with an understorey of poong'ort (*Carex tereticaulis*), Other common species on site include common swamp wallaby-grass (*Amphibromus nervosus*), small spike rush (*Eleocharis acuta*), Australian mint (*Mentha australis*), common blown-grass (*Lachnagrostis filiformis*), lesser joyweed (*Alternanthera denticulata*) and old man weed (*Centipeda cunninghamii*). This EVC is generally in good condition with low weed coverage and a high diversity of indigenous understorey species.

Riverine Swamp Forest (EVC 814) is a tall open eucalypt forest with understorey of obligate wetland species. River red gums (*Eucalyptus camaldulensis*) dominate the EVC with a common swamp wallaby-grass (*Amphibromus nervosus*) and small spike rush (*Eleocharis acuta*) understorey. Aquatic herbs, bare ground and leaf litter are also present in the area. This EVC is in generally good condition with low weed coverage.

Significant flora species

Of the ninety-nine vascular flora species identified across the Yambuna Wetlands complex in the vegetation survey (Rakali 2015), 63 were indigenous including five rare or threatened plant species. Approximately 30 of the indigenous plant species recorded by Rakali (2015) were also recorded in Greiner's Lagoon during the spring 2017 environmental watering (MDWWG, 2018). Two plant species of conservation significance have been observed in the lagoon during these recent surveys (Table 3-3).

Table 3-3: Threatened plant species recorded at Greiner's Lagoon (Rakali, 2015; MDWWG, 2018)

Common Name	Scientific Name	EPBC	FFG	DELWP status	IUCN	EVCs
River swamp wallaby-grass	*Amphibromus fluitans*	V	-	-	EN	804, 814 and 817
Floodplain fireweed	*Senecio campylocarpus*	-	-	R	-	804

Conservation status:

- EPBC listing: V = Vulnerable
- DELWP listing: V = Vulnerable in Victoria, R = Rare in Victoria, K = Poorly known in Victoria
- IUCN listing: CR = Critically Endangered, EN = Endangered

3.3 Wetland type significance

Greiner's Lagoon is classified as a Shallow Freshwater Marsh. Wetlands of this type are often degraded as a result of agricultural activities, including grazing or cropping, and have subsequently decreased in extent across the landscape. The area of shallow freshwater marsh across Victoria is estimated to have decreased by approximately 60% since European settlement (DNRE 1997). Similarly, the plant communities supported by Greiner's Lagoon are classified as depleted in the Murray Fans Bioregion.

Figure 3-2: Southern (upstream) section of Greiner's Lagoon during a drying phase (November 2018)

4. Hydrology

Wetland hydrology is the most important determinant in the establishment and maintenance of wetland types and processes. It affects the chemical and physical attributes of a wetland, which in turn affects the type of values the wetland supports (DSE 2005). A wetland's hydrology is determined by surface and groundwater inflows and outflows, in addition to precipitation and evapotranspiration (Mitsch and Gosselink 2000, cited in DSE 2005). Duration, frequency and seasonality (timing of inundation) are the main components of the hydrologic regime for wetlands.

4.1 Past water regime

The Yambuna Wetlands complex would have been filled from winter and spring flooding in the Goulburn River. There are a series of natural effluents, some of which have been altered, connecting the wetlands and the river (Figure 4-2).

The complex appears to be laterally connected to the Goulburn River through subsurface flow paths that result in inflows to the wetlands. Subsurface flow has been observed in the wetlands when the Goulburn River reaches approximately 11,700 ML/d at the McCoys Bridge gauge (pers. comms. Jamie McMaster) which is well below the capacity of the river through this reach.

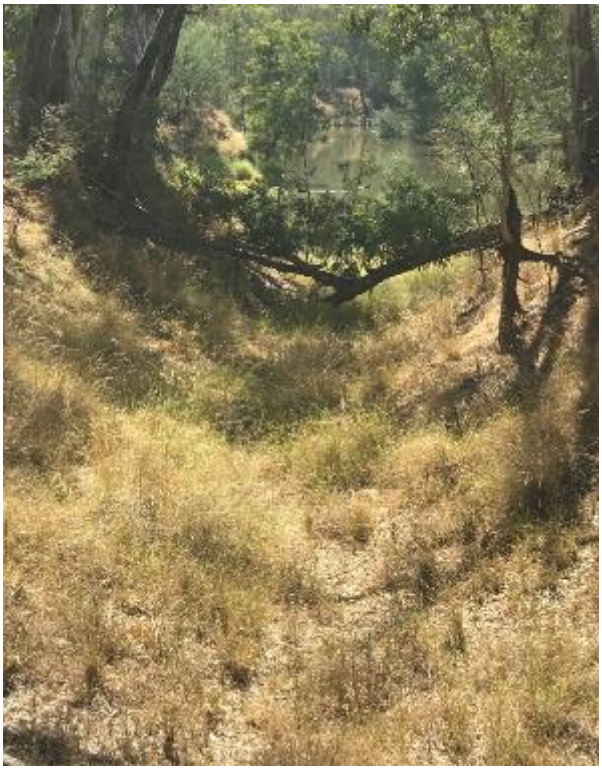

Figure 4-1 Primary effluent at the southern (upstream) end of Wetland 1

Surface flow into the complex commences when passing flow at the McCoys Bridge gauge exceeds 21,000 ML/day (pers. comms. Jamie McMaster). Greiner's Lagoon is connected to the river by effluents at the northern and southern ends of the wetlands (the 'primary effluents'), with inflows observed at river flows at McCoys Bridge of around 21,100 ML/day and 22,700 ML/day respectively.

Greiner's Lagoon and Wetland 2 would have commenced to fill first, before spilling into Wetland 3 and then 4. All four wetlands are connected at about 95.4 m AHD and continue to fill in unison until around 96.6 m AHD when water commences to break out into the fringing zone of the wetland.

As river flows decrease, the wetlands commence draining through the primary effluents until the water level in Greiner's Lagoon and Wetland 2 fall below sill level. Water is then retained within the wetlands until lost through seepage or evaporation.

Modelling shows Greiner's Lagoon (like other wetlands in the complex) would have been completely inundated on average 20 times in ten years with a maximum interval between inundations of around 2.8 years (DSE 2011). The duration of inflows is relatively short (mean of approximately 10 days) resulting in the wetlands drawing down through seepage and evaporation during the warmer months. This means the wetlands would have been inundated most years, with the shallower Greiner's Lagoon probably drying in most years. In contrast, the other wetlands (which can be up to three metres in depth) would have retained remnant pools in almost all years, except in extended dry periods.

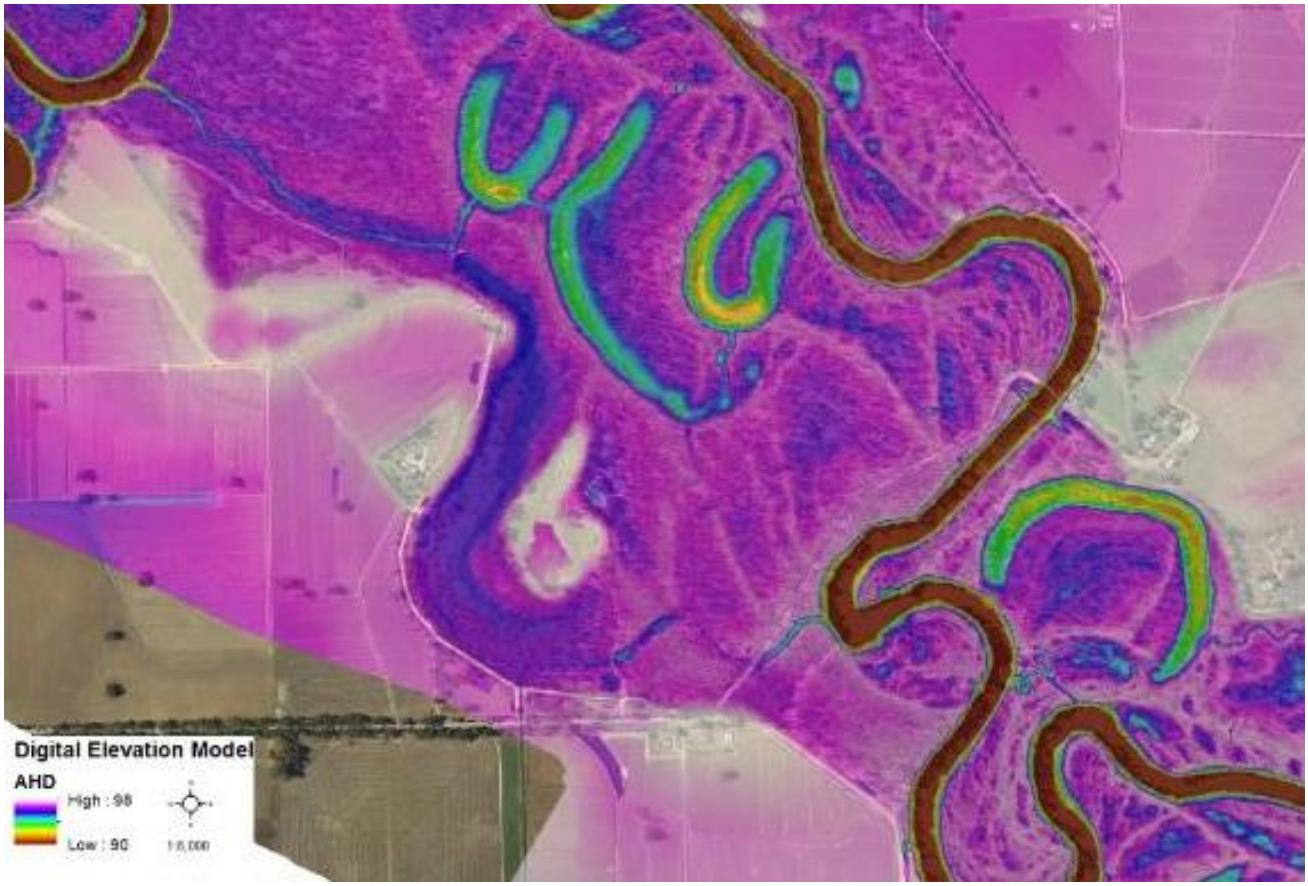

Figure 4-2 Digital elevation map showing the major flow paths connecting Greiner's Lagoon to the Goulburn River and other wetlands in the Yambuna complex (GMW, 2016).

It is possible the channels linking Greiner's Lagoon to Wetland 2, and Wetland 2 to Wetland 3 may have been modified by anthropogenic activity. If so, this might affect interpretation of 'natural conditions' particularly the water level at which these wetlands become connected.

4.2 History of water management

River regulation and the development of irrigation have had a significant effect on the hydrology of the Goulburn River and Greiner's Lagoon.

Channel and irrigation development in the Goulburn River catchment began as early as the 1880s with the formation of water trusts. The United Waranga and Echuca Waterworks Trust constructed channels across the region for the delivery of water but were largely constrained by having to pump water into the system until the construction of the Goulburn Weir in 1891.

Irrigation and associated water infrastructure gradually expanded in the Goulburn River catchment over the subsequent period with the construction and subsequent enlargements of Waranga Basin in 1908 and then 1921, and Lake Eildon in 1929, 1935 and finally to its current capacity in 1955. At some point an outfall channel from the CG 5/27/6 channel was constructed to Greiner's Lagoon. Historically, those outfalls would have flowed throughout the irrigation season (August to May), keeping the wetlands almost permanently wet. Large dead river red gums in the lagoon (Figure 3-2) provide evidence of excessive inundation caused by channel outfalls.

As irrigation expanded, so did the construction of levees, protecting floodplain land developed for agriculture from flooding. The lower Goulburn River is now almost entirely flanked by levees, which significantly constrain flood flows up to around a 10 year ARI flood event (106,065 ML/d at the Shepparton Gauge), above which the levees either overtop or fail at random (Water Technology 2005). A levee bank runs along the southern side of

the Yambuna Wetlands (Figure 4-3), effectively cutting off the broader floodplain but allowing the lagoons to be inundated from the river.

Collectively, these changes in the Goulburn River flows, means the inundation patterns at Greiner's Lagoon are significantly different now compared with natural conditions. Current inundation frequency is around 5 times in ten years, down from 20, and the maximum interval between events has extended from 2.8 years to 8.8 years (DSE, 2011).

Figure 4-3 Levee on the southern boundary of Greiner's Lagoon

Following the Millennium Drought, the GMW Connections Project and other on-farm irrigation efficiency upgrade programs have significantly improved the efficiency of the irrigation system and decreased water lost to the system from channel outfalls (Figure 4-4). This means that the volume of water received by the wetlands from the irrigation network has also been significantly reduced in recent years further altering the wetland hydrology.

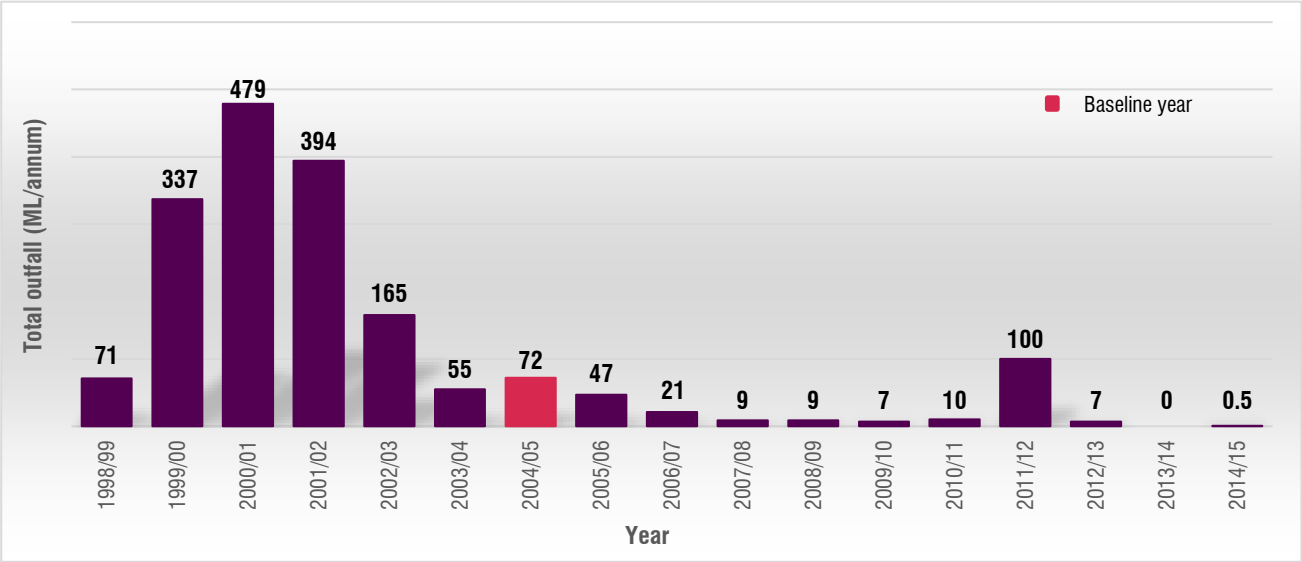

Figure 4-4 Total annual outfalls to Greiner's Lagoon from the CG 5/27/6 channel

Figure 4-5 shows historic satellite imagery for the Yambuna wetland complex from September 2009 to August 2018. The imagery shows Greiner's Lagoon has still experienced periods of both wet and dry over the last ten years, despite a reduction in the volume of drainage outfall reaching the wetlands and changes in lower Goulburn River flows.

16th September 2009	19th March 2011	7th January 2014	19th October 2015
			
Wetland 1 and 4 partially wet, wetlands 2 and 3 dry	Wetland 1 and 4 partially wet, wetlands 2 and 3 dry	Wetland 1 and 4 partially wet, wetlands 2 and 3 dry	All dry
17th November 2016	**3rd December 2016**	**24th August 2018**	
			
All wet	All wet	Wetlands 1-3 wet, 4 dry	

Figure 4-5 Historical aerial imagery of the Yambuna Wetlands showing periods of wetting and drying between September 2009 and August 2018

A recent development in the management of water at the Yambuna Wetlands has been the delivery of environmental water to Greiner's Lagoon by the Murray Darling Wetlands Working Group in September 2017.

4.3 Drainage diversions

A drainage diversion licence exists on Greiner's Lagoon which allows up to 228 ML of water to be taken per year when available (i.e. there is no guarantee of water being available in any given year). Under this licence water can be opportunistically extracted from the lagoon following natural inflows from the Goulburn River or if outfalls occur due to excess water in the CG 5/27/6 channel. It is assumed that when inflows exceeded the capacity of Greiner's Lagoon the gated pipe at the downstream end of the lagoon was opened to allow water to spill into wetland 2.

There is currently no allowance for measuring water pumped off the wetland via this drainage diversion point. It is not known how frequently this licence has been used and how much water is diverted from the wetlands or how this has changed over time. However, the adjacent landowner (and licence holder) has willingly entered into

an agreement with the Murray Darling Wetlands Working Group to not extract any environmental water delivered to the lagoon.

4.4 Surface-groundwater interactions

Greiner's Lagoon is situated on the lower Goulburn River floodplain on the upper floodplain alluvial sediments consisting of silt, sand and gravel (VVG 2019). It has been observed the lagoon is highly connected to the Goulburn River via subsurface flow and water enters the wetlands through the permeable substrates as the river rises prior to overtopping. The subsurface inflow occurs when the Goulburn River reaches approximately 11,800 ML/d at the McCoys Bridge gauge (pers. comm. Jamie McMaster).

Groundwater monitoring has been undertaken within the Central Goulburn irrigation area by the Department of Economic Development Jobs Transport and Resources (DEDJTR) since 1990, however no groundwater monitoring bores are located at the wetlands or between the wetlands and the Goulburn River. DEDJTR collect groundwater data from regional bores in the State Observation Bore Network as well as from other bores in the vicinity.

Figure 4-6 illustrates groundwater levels from a bore approximately 5.8 km west of Greiner's Lagoon and shows regional groundwater levels increased from the mid-1980s to the late 1990s in response to the application of irrigation water to land. A decrease followed from the late 1990s until 2010 in response to a long period of below average rainfall (the Millennium Drought) and improved irrigation practices. Extensive flooding in 2010/11 led to a temporary rise in groundwater levels, with a further rise being measured in response to the above average rainfalls and minor flooding during winter and spring of 2016.

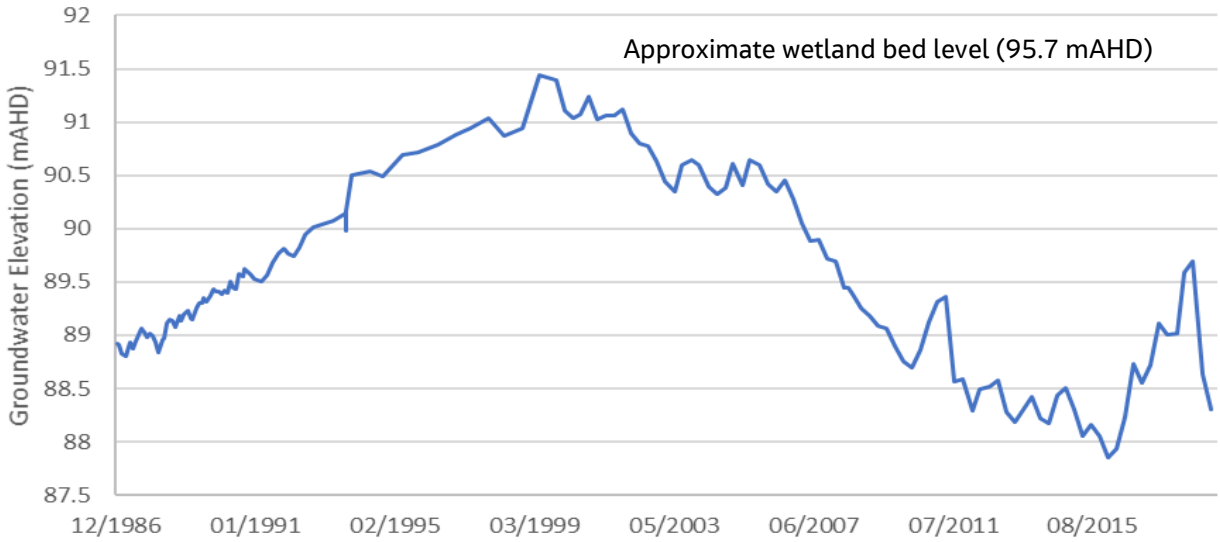

Figure 4-6 Groundwater levels from nearest State Observation Bore (105702) 5.8 km west of Greiner's Lagoon (DELWP, 2019)

The bed level of Greiner's Lagoon is approximately 95.7 mAHD at its lowest point. It can be seen from Figure 4-6 that groundwater levels were at least 4 metres below the bed of the lagoon even when groundwater levels were at their highest (late 1990s) suggesting a very low risk of regional groundwater intrusions to the bed of the lagoon. Regular monitoring of salinity is not undertaken at this bore. The last reading was taken in 2008 and measured a salinity of 20,100 µS/cm.

The closest bore to the site (WRK011739) was installed in December 2006 for private stock and domestic use and has not been monitored since its installation (Figure 4-7). There are four additional bores located to the south of Yambuna Bridge Road installed for the purpose of groundwater investigation (4284, 43394, 45053 and 45054) located 300-500 m away from the margins of Greiner's Lagoon (Figure 4-7). However, none of these

have been routinely monitored since 2011 (Figure 4-8). Table 4-1 provides a summary of the available information for these bores.

Information from local bores (not shown) supports anecdotal observations (pers. comm. Jamie McMaster) that inflows of groundwater to the Yambuna wetlands has historically occurred but not in Greiner's Lagoon which is situated higher in the landscape. The lack of evidence of salinity at the site, suggests these inflows are from local aquifers with lower salinity levels, suitable for stock and domestic use.

Based on available information, it is reasonable to conclude the effect of sub-surface flows to the Yambuna Wetlands complex is the most likely source of groundwater contribution to the system. As it is not possible to quantify the contribution of groundwater inflow to the wetlands based on the data available, it has been assumed to be zero.

Figure 4-7 Aerial photo showing the locations of groundwater bores closest to Greiner's Lagoon

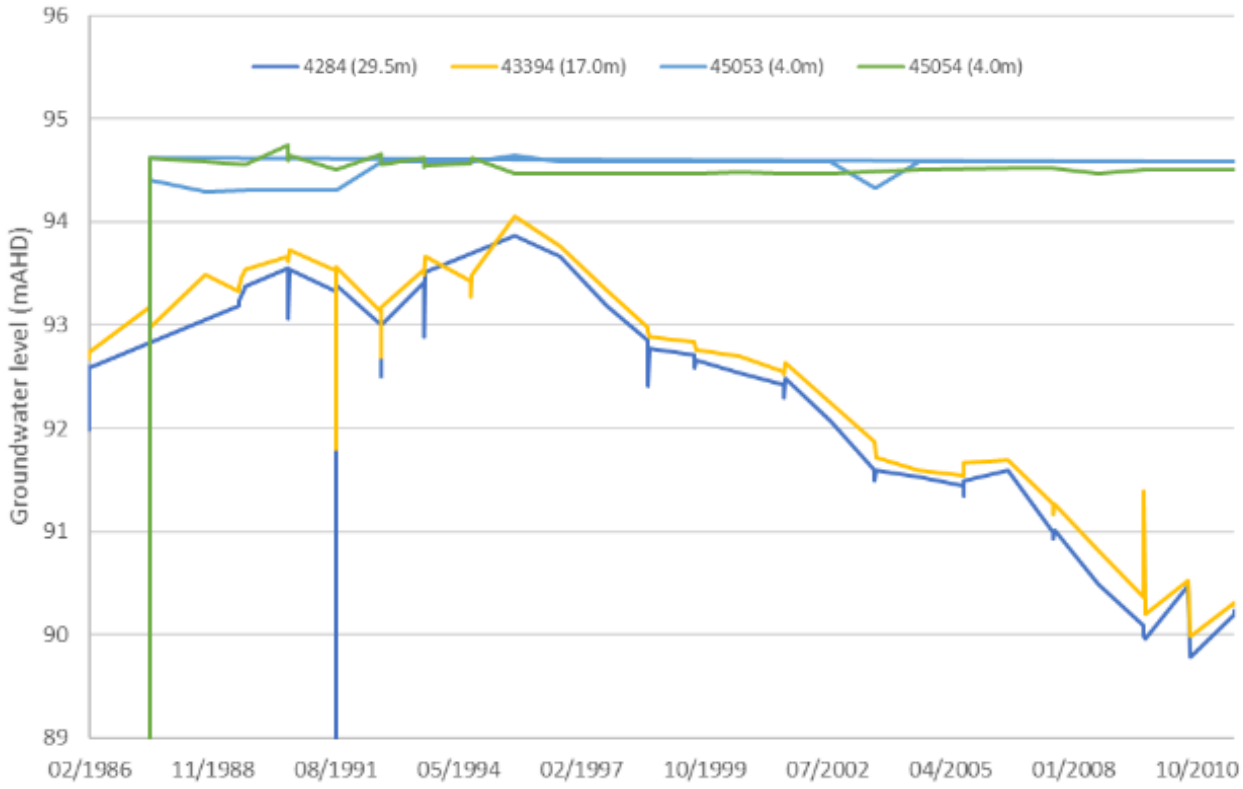

Figure 4-8 Groundwater levels at four monitoring bores to the south of Greiner's Lagoon (DELWP, 2019b)

Table 4-1 Information summary for closest bores to Greiner's Lagoon

Bore ID	Bore use	Depth (m)	Last monitored
WRK011739	Stock and domestic	10.5	N/A
45054	Groundwater investigation	2.5	15/08/2011
43394	Groundwater investigation	17.0	15/08/2011
45055	Groundwater investigation	2.5	10/08/1993
4285	Groundwater investigation	20.0	29/09/2000

4.5 Surface water balance

The existing water regime for the Yambuna Wetlands was determined through the development of a bathymetric filling model and water balance using Microsoft Excel. The bathymetric model and the water balance were used to answer the following questions:

- The volume required to fill Greiner's Lagoon to 96.6 mAHD
- How the wetlands interact, and
- The frequency of inflows and the rate of drawdown based on evaporation and seepage.

The bathymetric and water balance models and their inputs are described below, with the results of the assessment presented in Appendix D and Appendix E.

Bathymetric assessment

The bathymetric assessment for the wetlands was developed using a 1m Digital Elevation Model (DEM) produced from LiDAR. A spatial rating curve linking surface area to volume and level was produced that enabled

a relationship to be derived of the filling sequence of the four wetlands, including levels at which water would spill between the wetlands. This assessment considers only water delivered through the irrigation system. It does not consider overbank flows from the Goulburn River.

According to the bathymetric assessment water first enters the wetland complex via the drain connecting Greiner's Lagoon with the CG 5/27/6 channel. Water then flows from Greiner's Lagoon to Wetland 2 via a pipe constructed through an earthen embankment to the north of the lagoon. Water spills from Wetland 2 to Wetland 3 and finally Wetland 3 spills into Wetland 4.

The full supply level of the wetlands was estimated based on an assumed spilling level between each wetland that was obtained from the LiDAR. This assumed spilling level impacts the volume of the wetlands and the volume may therefore change if a different level is adopted, for example if a survey was undertaken at the Yambuna Wetlands. The extent of the wetland inundation based on the bathymetric model can be seen in Figure 4-9. The bathymetric analysis estimated the total volume of the four wetlands to be 202 ML. Table 4-2 shows the individual volumes of the four wetlands.

Table 4-2 Wetland volumes

Site	Greiner's Lagoon	Wetland		
		2	3	4
Volume (ML)	56	36	43	67

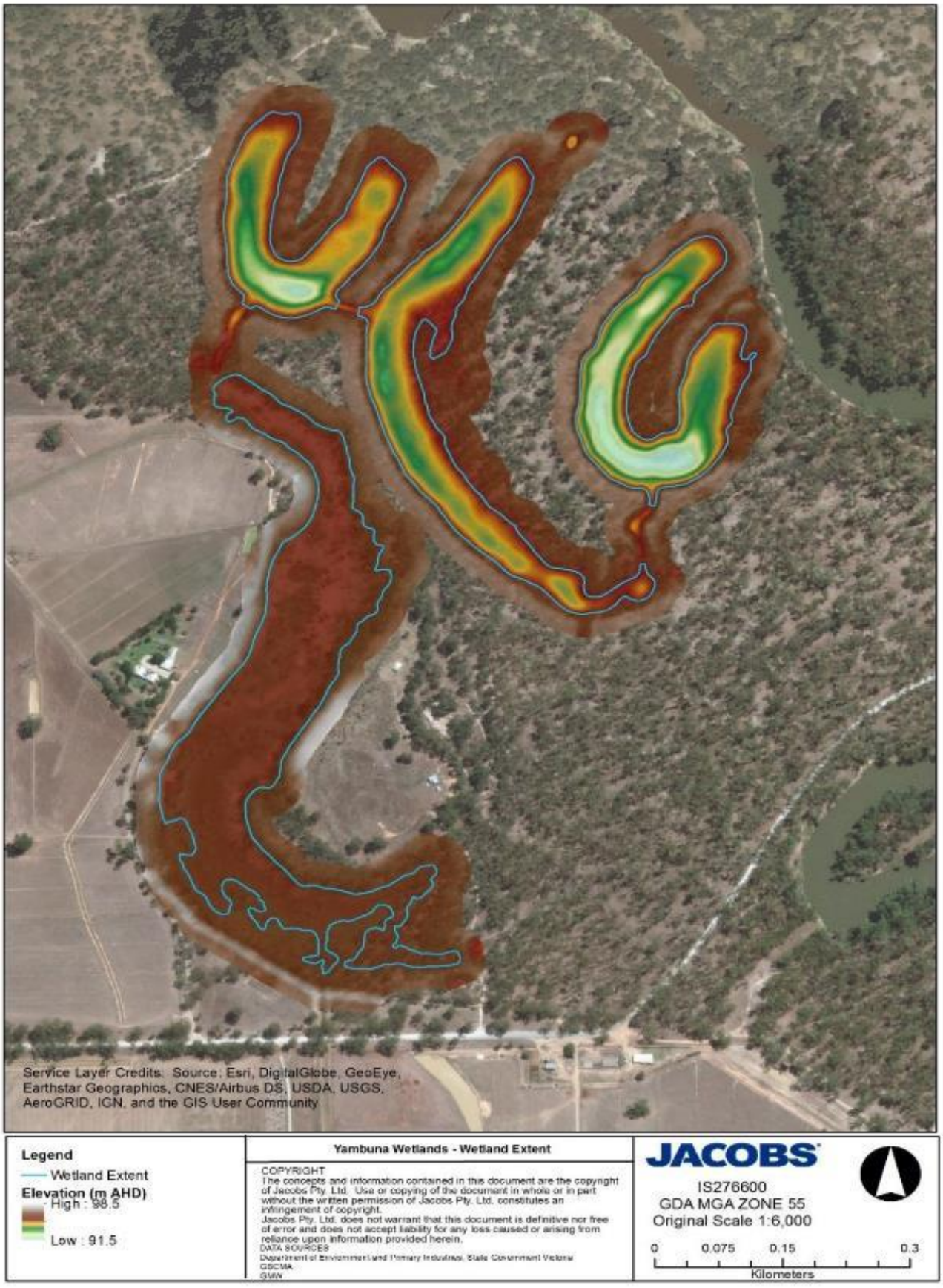

Figure 4-9 Yambuna Wetlands extent as represented in the water balance model

Water balance

The rating curve from the bathymetric model was used as an input to the water balance to determine how the wetlands filled and spilled historically. Other inputs to the water balance included channel inflows, net evaporation and seepage. The water balance was based on a daily timestep and was developed using the following equation:

Water Volume = Water Volume Previous Day – Net Evaporation – Seepage + Water Added

Climate inputs

Daily climate data including rainfall and evaporation was obtained from SILO Data from the Kyabram Gauge (80091) (Queensland Government 2019). The period of record used was 49 years to match nearby streamflow records.

Channel inflows

Inflow data from the CG 5/27/6 channel was supplied by GMW in various timesteps (daily, monthly and yearly) for 18 years. The data from 2004-05 was used to simulate the baseline filling pattern of the wetlands and was applied as a direct inflow into Greiner's Lagoon to represent the inflow from CG 5/27/6. This is because 2004-05 is the baseline year for calculating water savings under the GMW Connections Project and is also used to calculate mitigation water requirements under the EWP process. In the calculation, potential losses from the 500m drain connecting the CG 5/27/6 to the lagoon are treated as zero and was subsequently estimated as a post-processing calculation as discussed in section 5.5.

Model simulation

The water balance model calculated the volume of water in each wetland and the volumes spilling between wetlands based on the rating curve developed from the bathymetric model using a daily timestep. The exception to this was the link between Greiner's Lagoon and Wetland 2 as they are not connected through topography, but through a small pipe. A Manning's pipe formula was used to determine the flow rate between the two wetlands assuming a circular pipe of 300 mm diameter. It should be noted that the exact size and inverts of the pipe were unavailable and therefore the flow rate between Greiner's Lagoon and Wetland 2 is estimated. Collecting more precise information about the pipe would improve the accuracy of the water balance model simulation.

A summary of key assumptions underpinning the water balance modelling include:

- Groundwater inflows were assumed to be zero
- Antecedent conditions were assumed to be cracking dry soils with an average seepage rate on 0.005 ML/d from Greiner's Lagoon
- The upstream invert of the pipe exporting water out of Greiner's Lagoon was assumed to be 95.9 mAHD with a diameter of 300mm and a slope of 2%
- Abstraction under licence was assumed to be zero
- Outfalls occurred across the 9 months of the irrigation season, representing approximately 12 days of flow based on an outfall capacity of 7 ML/d.

No other scenarios were tested however, there is a reasonable level of confidence in the results of the water balance model as it corresponds well with the fill volume of 57.4 ML delivered to the lagoon by the MDWWG in spring 2017 (MDWWG, 2018). Additionally, the inundation extent corresponds to what may be expected based on recorded flows in the Goulburn River and channel outfall data supplied by Goulburn-Murray Water.

5. Management objectives

No management objectives have previously been set for either Greiner's Lagoon or the broader wetland complex. However, recommendations have been made by Rakali (2015) on how to provide a water regime that protects and enhances environmental values supported by the wetlands. The ones relevant to Greiner's Lagoon are used to inform the management objectives set out by this plan.

5.1 Water management goal

The water management goal for Greiner's Lagoon was developed collaboratively between stakeholder agencies, the Wetlands Technical Reference Group and the Expert Review Panel. Previous water regime recommendations and local knowledge were appraised and considered in the context of water availability, feasibility of delivery and other constraints. The goal takes into consideration the intent of the GMW Connections Project, being to generate water savings without impacting on the values the wetlands support.

Water management goal for Greiner's Lagoon:

Provide a watering regime for Greiner's Lagoon that creates conditions suited to the growth of a diverse vegetation community typical of a freshwater marsh, providing habitat for a variety of waterbirds and frogs

5.2 Ecological objectives

Ecological objectives to achieve the water management goal for Greiner's Lagoon were developed in conjunction with agency stakeholders and technical experts at the wetland workshop held on 23 January 2019 and subsequent discussions with the Expert Review Panel.

The focus of the ecological objectives contained within this EWP is to achieve the water management goal by protecting the current environmental values of Greiner's Lagoon that may be negatively impacted by a reduction in outfall water. The vegetation classes inundated at the approximate full supply level of the lagoon (96.6 mAHD) is shown in Figure 5-1.

Meeting the hydrological requirements for vegetation at the lagoon is anticipated to meet the habitat requirements for waterbirds and frogs. As such, no specific objectives have been set for these species.

The ecological objective aims to 'restore' Greiner's Lagoon, reflecting the intended trajectory is to improve the condition of vegetation over time.

Hydrological requirements describe the water regime required for achieving ecological outcomes (ecological objectives) (DEPI 2013). All values identified have components of their life-cycle or processes that are dependent on particular water regimes for success e.g. plant species that require certain timing, duration and frequency of flooding to flower and set seed to maintain their population. Requirements for the three components have been used to identify a recommended watering regime for the wetlands (section 5.3).

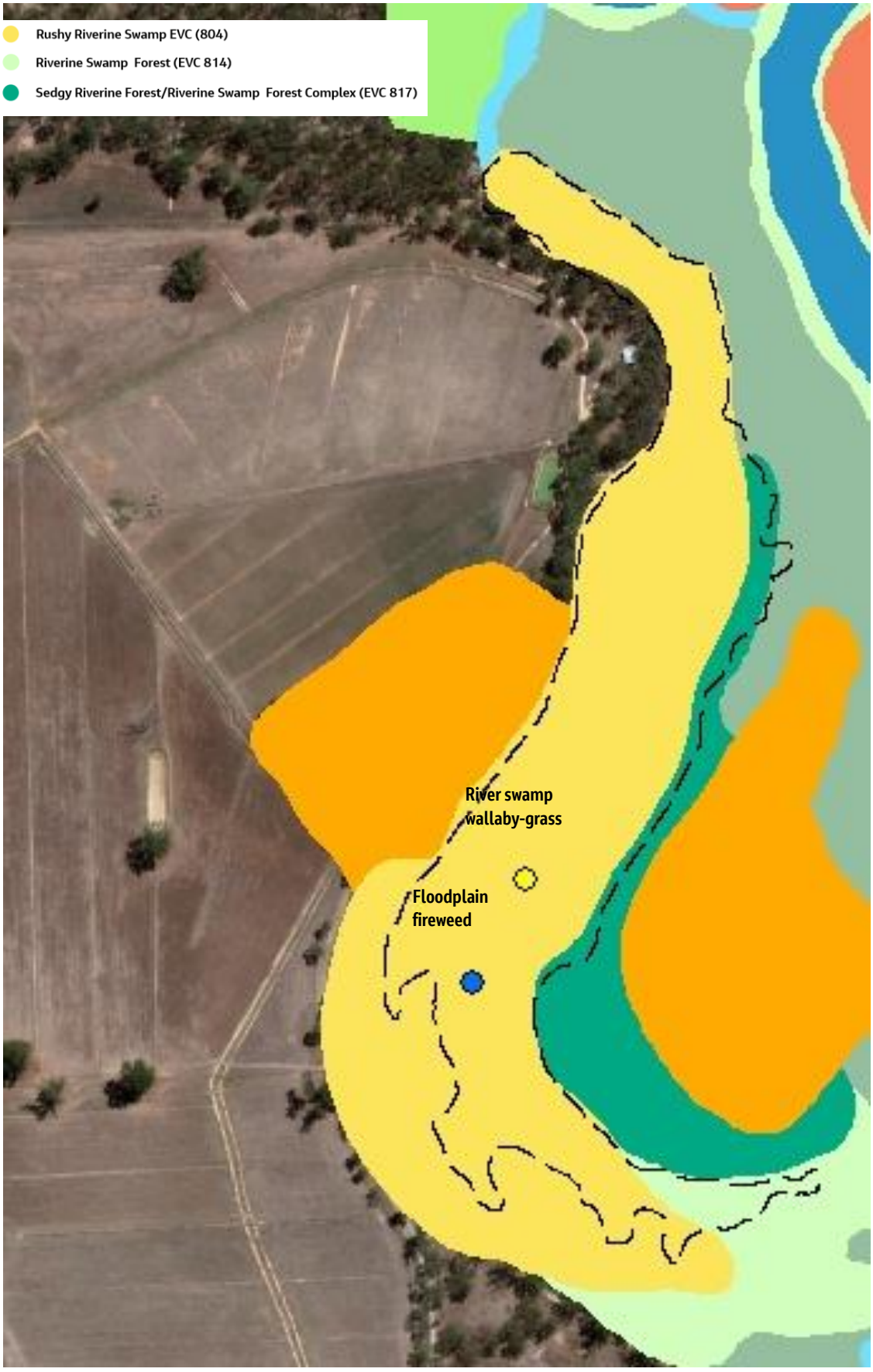

Figure 5-1: Inundation of ecological vegetation classes and threatened species when Greiner's Lagoon is at full supply level as represented by the dashed black line

Table 5-1 Greiner's Lagoon proposed ecological objective

Ecological objective	Justification	Benchmark condition[3]
Restore the condition of the vegetation in the inundated zone of Greiner's Lagoon characteristic of a shallow freshwater marsh	EVC 804 is a depleted vegetation community and contains listed species (river swamp wallaby-grass and floodplain fireweed). Improving the condition of this EVC (from moderate) is a key focus of the management goal, as represented by the diversity and nativeness of plant species in the lagoon. Mature trees in the bed of the wetland (EVC 804) and the fringing zone (EVC 817 and 814) provide valuable habitat for listed species recorded in the area including eastern great egret and white-bellied sea-eagle.	EVC 804 - Moderate EVC 817 – Good EVC 814 – Good

5.3 Desired water regime

The hydrological requirements used to determine the desired water regime for Greiner's Lagoon is presented below.

Inundation Timing: Winter/Spring

Frequency of wetting: Variable, six years in ten for the higher edges of the lagoon (96.0 – 96.6 m AHD) and eight years in ten for the deeper sections of the lagoon (95.7 – 96.0 m AHD)

Duration: Variable, 1-3 months for the higher edges of the lagoon (96.0 – 96.6 m AHD), 6 months for the deeper sections of the lagoon (95.7 – 96.0 m AHD). Dry spells between recurrent year watering events should extend for between 3 and 6 months.

Extent and depth: Fill to 96.6 m AHD for Greiner's Lagoon. This will provide a maximum depth of 0.9 m.

Variability: The higher edges of Greiner's Lagoon (96-96.6 m AHD) have different water regime requirements to the deeper sections (95.7 – 96.0 m AHD). Allowing the lagoon to drawdown will provide variability in these zones which will assist in maintaining a mosaic of open water, Rushy Riverine Swamp and will maintain the health of river red gum trees able to access water at the edge of the lagoon.

Wetland water regime: Fill the lagoon six in ten years to 96.6 m AHD and an additional two in ten years to 96.0 m AHD before allowing water levels to recede by natural drawdown to provide six to eight months of ponded water. Spring top ups (up to 96.0 mAHD) may be provided in some years. The maximum ponding time recommended in wet seasons is 12 months and the maximum dry period recommended is 2 years.

5.4 Required volumes

The volume of water required to provide the desired water regime for Greiner's Lagoon is presented in Table 5-2. This volume reflects the results from the water balance modelling (model described in Section 5.3). The actual volumes predicted by the water balance model will need to be further validated in the implementation stage of this plan.

[3] As assessed by Rakali (2015)

Table 5-2 Volumes of water required to meet desired water regime for Greiner's Lagoon

Wetland: Greiner's Lagoon		
Timing:	Winter/spring	
Frequency:	6 years in 10 to 96.6 mAHD	2 years in 10 to 96.0 mAHD
Target duration:	6 to 8 months	
Maximum depth:	0.9 m	
Volume required to fill to full supply level:	56 ML	

5.5 Mitigation water

The volume of water that is required to offset the impact of the GMW Connections Project on wetlands that have become reliant on outfall water to support high environmental values is termed 'mitigation' water. The potential impact of the GMW Connections Project considered in the Yambuna Wetlands EWP is related to the upgrade of the regulator on the CG 5/27/6 channel which outfalls to the drain connecting Greiner's Lagoon to the irrigation system. Other potential impacts to the wetland will be managed in accordance with the Water Change Management Framework and Site Environmental Management Plans.

Guiding principles for mitigation water based on government policy have been defined by the Water Change Management Framework and are:

1. Water savings are the total (gross) volumes saved less the volume of water required to ensure no net impacts due to the project on high environmental values.
2. Using the same baseline year (2004–05) as that used to quantify savings, taking into account the long-term average annual patterns of availability.
3. The mitigation water will be deployed according to the EWP.
4. Sources of mitigation water will be selected to ensure water can be delivered in accordance with the delivery requirements as specified in the EWPs. Water quality will need to be considered for all sources of water to ensure it is appropriate.

In the majority of cases, actual outfall volumes will be less than what is required to support all water-dependent environmental values of a particular wetland. Therefore, the outfall water only forms part of the overall volume required to provide the water regime of the wetland. The water regime supports processes and systems which in turn may provide suitable conditions for defined ecological values (e.g. breeding of waterbirds).

A process for calculating mitigation water based on the best available information has been developed as follows:

Step 1: Describe the desired water or flow regime

Step 2: Determine the baseline year incidental water contribution

Step 3: Assess dependency on baseline incidental water contributions

Step 4: Calculate the annualised baseline mitigation water volume

Step 5: Calculate the mitigation water commitment

5.5.1 Greiner's Lagoon mitigation water

Step 1: Describe the desired water or flow regime

Fill the lagoon six in ten years to 96.6 m AHD and an additional two in ten years to 96.0 m AHD before allowing water levels to recede by natural drawdown to provide six to eight months of ponded water. Spring top ups (up to 96.0 mAHD) may be provided in some years. The maximum ponding time recommended in wet seasons is 12 months and the maximum dry period recommended is 2 years.

The maximum inflow requirement to meet the desired water regime in Greiner's Lagoon in any 12 month period is estimated to be 56 ML.

Step 2: Determine the baseline year incidental water contribution

This step determines the baseline year incidental water for each hydrological connection assessed, being the difference in the volume at the outfall and the volume estimated to enter the wetland once evaporation, seepage and leakage losses have been considered.

Incidental water contribution from the channel outfall to the south of the Yambuna Wetlands has been quantified using data provided by GMW. Monitoring records of outfalls to the Yambuna Wetlands have been equated to flows at CG O/F SUTTON 5/27/6 (RN821).

Estimates of channel losses due to evaporation, seepage and leakage are 50 ML/km per annum (NCCMA, 2010; DELWP, 2018). At 500 metres in length, the estimated losses through the CG 5/27/6 outfall would be 25 ML/annum if it flowed for all 270 days of the irrigation season (an average loss of 0.09 ML/day). Daily flow data is only available for the 2001/02 season. Analysis of data collected in 2001/02 showed a total outfall volume of 394 ML on 40 occasions, resulting in an estimated 60 days where the channel flowed. Based on this analysis, an estimated 3.7 ML of losses occurred during the 2001/02 season. Outfall volume in the 2004/05 season was significantly less than in 2001/02 (approximately 72 ML compared to 394 ML). It is estimated outfall channel flowed for approximately 12 days during the 2004/05 season which would equate to approximately 1.1 ML of losses.

The baseline year incidental water contribution in the 2004/05 season was 70.5 ML (Table 5-3).

Table 5-3: Determination of the baseline year incidental water contribution

Hydrological connection or incidental water source	Baseline year incidental water at origin (Gross)	Estimated losses between origin (irrigation system) and wetland (2004-05)	Baseline year incidental water contribution at the waterway or wetland (Net)
Outfall from CG 5/27/6 channel to Greiner's Lagoon	71.6 ML	1.1 ML	70.5 ML

Step 3: Assess dependency on baseline incidental water contributions

The Water Change Management Framework specifies criteria to be applied in assessing whether or not mitigation water is required for a wetland or waterway with high environmental values. These criteria have been assessed for Greiner's Lagoon with the results presented in Table 5-4.

Table 5-4: WCMF criteria assessment for Greiner's Lagoon

Criteria by which mitigation water may be assessed as not required	Link between incidental water (losses) and environmental values
1. Mitigation water may be assessed as not required where:	
1.1 There is no hydraulic connection (direct or indirect) between the irrigation system and the wetland or waterway	Criterion not applicable. Outfall water was received directly by the lagoon via the 5/27/6 channel outfall from the south of the wetland complex.
1.2 The water does not reach the wetland or waterway with environmental values (e.g. the outfall is distant from the site and water is lost through seepage and evaporation before reaching the area with environmental values)	Criterion not applicable. There are no diversions or impediments that prevent the water from reaching Greiner's Lagoon. The outfall feeds directly into the site with minimal losses.
2. Mitigation water may be assessed as not required where the wetland or waterway receives water from the irrigation system:	
2.1 That is surplus to the water required to support the environmental values (e.g. changing from a permanently wet to an intermittently wet or ephemeral regime is beneficial or has no impact)	Criterion not applicable. The water received is not surplus to what is needed to support the lagoon's environmental values.
2.2 That occurs at a time that is detrimental to the environmental values	Criterion not applicable. Water provided to the lagoon occur at a time that supported its environmental values.
2.3 That is of poor quality (or results in water of poor quality entering a site e.g. seepage resulting in saline groundwater intrusions to wetlands) and the removal of which would lead to an improvement in the environmental values	Criterion not applicable. No data is available on the quality of water received via the 5/27/6 channel outfall but is assumed to be of good quality. There has been no history of complaints from the landholders.
3. Mitigation water may be assessed as not required where the environmental values:	
3.1 Do not directly benefit from the contribution from the irrigation system (e.g. river red gums around a lake may not directly benefit from an outfall and may be more dependent on rainfall or flooding)	Criterion not applicable. The vegetation communities inundated by the outfall water require periodic inundation at a frequency that cannot be provided by overbank flows from the regulated Lower Goulburn River.
4. Mitigation water may be assessed as not required where the removal of the contribution from the irrigation system does not:	
4.1 Increase the risk of reducing the environmental values (e.g. outfalls form a very small proportion of the water required to support the environmental values and their removal will not increase the level of risk)	Criterion not applicable. Outfall water has represented a significant proportion of inflows to Greiner's Lagoon and its removal may cause a decline in the quality of EVC 804.
4.2 Diminish the benefits of deploying any environmental water allocations (over and above the contribution from the irrigation system).	Criterion not applicable. Provision of mitigation water will not diminish the benefits of deploying additional environmental water to Greiner's Lagoon. The two water sources will work together to provide the desired water regime for the lagoon and support environmental values.

The assessment of the requirement for mitigation water for Greiner's Lagoon demonstrates that the incidental irrigation supply from the 5/27/6 channel outfall provided environmental benefits and that the provision of mitigation water is warranted. The contribution from the 5/27/6 channel has been removed and additional water is now needed to provide the desired watering regime outlined in Section 5.3.

Step 4: Calculate the annualised baseline mitigation water (BMW) volume

The BMW volume is expressed as the baseline incidental water contributions divided by the number of years in the cycle of the desired water regime. As there are no losses associated with transmission, the annualised

baseline mitigation water volume has been equated to flows at CG O/F SUTTON 5/27/6 (RN821) provided by GMW.

$$\text{Gross BMW} = \frac{\text{Baseline year incidental water contribution at origin}_{(\text{gross})}\text{(Step 2)}}{\text{The inherent cycle (years) of the desired water regime (Step 1)}}$$
$$= 71.6 \text{ ML} * \left(\frac{8}{10}\text{years}\right)$$
$$= 57.3 \text{ ML}$$

Step 5: Calculate the mitigation water commitment (MWC)

The MWC expresses the BMW (Step 4) as a percentage of the baseline incidental water contribution. It is used to calculate the share of annual water savings. These are calculated each year in accordance with the Water Savings Protocol and the associated Technical Manual (DSE 2009) and will become available in any following year.

$$\text{MWC (\%)} = \frac{\text{BMW}_{(\text{Yambuna Wetlands 2004-05})}\text{(Step 4)}}{\text{Baseline incidental water contributions at origin}_{(\text{Gross})}\text{(Step 2)}}$$
$$= \left(\frac{57.3}{71.6}\right) * 100$$
$$= 80\%$$

The overall MWC for Greiner's Lagoon is 80%.

5.6 Other water sources

The annualised baseline mitigation water volume (57.3 ML) approximates the volume of water needed to fill Greiner's Lagoon to full supply level from dry (56 ML). In years when additional water is to be delivered for 'top ups' this water may be sourced through the Victorian Environmental Water Holder or the Murray-Darling Wetlands Watering Group (section 9).

6. Potential risks and site constraints

An important component of the EWPs is the identification of potential risks or limiting factors associated with the delivery of the desired water regime or the achievement of the ecological outcomes sought by the provision of this water. Awareness of these key risks and how they may be managed will influence future monitoring undertaken at Greiner's Lagoon will inform the adaptive management of the water regime, including the provision of mitigation water (Section 8.2).

A more rigorous assessment of risks will be completed as part of the Environmental Watering Management Plan development which operationalises this EWP.

6.1 Constraints

The realisation of the water regime and ecological outcomes sought for Greiner's Lagoon is constrained by activities associated with the private management and use of the lagoon, primarily the drainage diversion licence and grazing by cattle. These constraints must be resolved prior to delivering mitigation water to the lagoon and will be overseen by the Victorian Environmental Water Holder in line with planning requirements for the delivery of environmental water.

The volume of water that may be extracted under the drainage diversion licence means failure to align its deployment in sympathy with the hydrological objectives constitutes a significant threat to achieving the ecological objectives. The conditions of the diversion licence allow for water to be 'taken when available' and, without other agreement in place, would allow the extraction of mitigation water delivered to the wetland. In the short term, annual agreements may be entered into with the affected landholder as required by the Victorian Environmental Water Holder prior to the seasonal allocation of water to the lagoon. The current landowner has willingly entered into such agreements with the Murray Darling Wetlands Working Group however, as the licence is attached to the land more enduring arrangements that are linked to the licence and not reliant on a cooperative landholder are required.

Similarly, failure to manage grazing of Greiner's Lagoon constitutes a significant threat to achieving the ecological objectives. Livestock grazing in wetlands can degrade the condition of wetlands by compacting or pugging soils, dispersing the seeds of weeds, trampling vegetation and contaminating the water with animal waste (Peters et al., 2015). This can lead to an increase in weeds, a reduction in native flora abundance and diversity, an alteration of vegetation structure and poor water quality.

Table 6-1 Constraints to achieving the ecological outcomes sought for Greiner's Lagoon

Constraint	Impact	Mitigation measure
Drainage diversion licence on Wetland 1 allows up to 228 ML of water to be taken per year	Water delivered for environmental purposes is extracted for consumptive use resulting in desired water regime not being met.	Before delivering water, enter an agreement with landholder to ensure environmental water is not extracted. Review the conditions of the diversion licence, including metering so that extraction can be measured.
Livestock access to Greiner's Lagoon results in damage to vegetation and adversely impacts on water quality	Livestock adversely impact wetland vegetation, soil surface, and seed bank, and hence re-growth potential: they also drive species composition towards unpalatable species (such as *Juncus ingens*). Livestock access to the lagoon may limit the achievement of ecological objectives, including grazing on River	Develop a grazing management agreement with the adjacent landholder prior to delivering water to the lagoon. Investigate other supporting management actions including exclusion fencing and restoration of buffer zones.

Constraint	Impact	Mitigation measure
	Swamp Wallaby-grass which is palatable to stock. Loss of water quality due to increased turbidity and nutrients may impact on plant growth or favour excessive growth of some species.	

6.2 Risks

Table 6-2 outlines the likely risks, limiting factors and potential impacts associated with the provision of mitigation water as a component of the desired water regime that need to be considered by GMW Connections Project and the environmental water manager.

A range of other risks and limiting factors which may arise as a direct result of, or in association with, implementing the desired water regime at Greiner's Lagoon is provided as Appendix C and will be further addressed in the Yambuna Wetlands Environmental Water Management Plan (in preparation).

Mitigation measures have been recommended to minimise the likelihood or the risk occurring and/or its potential impact.

Table 6-2 Risks, limiting factors and potential impacts associated with provision of mitigation water to Greiner's Lagoon

Risk/limiting factor	Impact	Mitigation measure
Governance		
Conflicting management objectives for the lagoon between Victorian agencies, the landholder and Murray Darling Wetlands Working Group (MDWWG)	Conflicting management strategies between the GMWCP (through this EWP), MDWWG and the private landholder limits the achievement of objectives set out in this plan.	Deployment of water to be coordinated through the Victorian Environmental Water Holder (VEWH) consistent with the objectives of this plan. Before providing consent to deliver water, the VEWH will ensure appropriate agreements are in place with the private landholder. Develop a grazing management agreement with the adjacent landholder. Develop agreement between Parks Victoria and the adjacent landholder regarding the operation and maintenance of the gated pipe between Greiner's Lagoon and wetland 2.
Factors that threaten the provision of the required water regime		
Water balance model underestimates seepage losses leading to a shorter duration of ponding than expected	Reduced duration of inundation may be insufficient for the target EVCs limiting the achievement of ecological objectives.	Undertake water level monitoring and adaptively manage water regime e.g. provide additional top ups in some years.
Climatic conditions impact on the ability to achieve the desired flow regime	Low water allocations in dry periods may limit the amount of water available for environmental use. Recurrent floods may exceed the desired frequency of	Adaptively manage water regime. The water regime provides a recommended frequency over a ten year cycle. During drier conditions, the timeframe between recurrent events may be

Risk/limiting factor	Impact	Mitigation measure
	flooding or caused unseasonal inundation.	extended and still remain within the maximum dry phase of two years.
Timing of delivery is constrained by access to water from the CG 5/27/6 channel within the irrigation season	Channel constraints may restrict when water can be delivered resulting in a timing skew toward the cooler winter months when irrigation demand is less. This may reduce the variability in managed flow regimes and favouring the growth of some species over others.	Adaptively manage water regime. Access rainfall runoff flows in channel when feasible.
The gated pipe in the embankment between Greiner's Lagoon and wetland 2 remains or is opened.	Target water levels in Greiner's Lagoon are not achieved due to loss of water through the gated pipe during managed deliveries, failing to meet the water requirements of vegetation communities in the outer margins of the lagoon.	Enter agreement with landholder to ensure the pipe gate remains closed, with contingency measures in place should rainfall rejections or flooding occur. This may include using formal instruments through Parks Victoria regarding the operation of infrastructure within the parks estate.
Factors that threaten the expression of the required water regime		
Presence of Common Carp in the lagoon limits the ability to achieve vegetation objectives	Carp disturb wetland sediments blocking light needed for growth or feed on wetland vegetation.	Implement drying phases to eliminate carp that have entered the wetlands through riverine flooding or environmental water deliveries.
Growth of aquatic weeds, particularly water couch, may limit the ability to achieve vegetation objectives	Aquatic weeds compete with native plants limiting the desired ecological response.	Adaptively manage water regime.
Nutrient runoff from adjacent farmland	Impact to water quality in the wetland, excessive algal growth.	Water quality monitoring to assess any impact. Visual observations. Develop grazing management plan and investigate opportunities to establish buffer zones.

7. Water delivery arrangements

7.1 Delivery infrastructure

Prior to the upgrade through the GMW Connections Project, Greiner's Lagoon was connected to the irrigation system via the Central Goulburn No. 5/27/6 channel outfall (ME016770 / RN2199), approximately 500 m south of the lagoon (Figure 7-1). The capacity of the channel at this point is 35 ML/day. Flow into the channel was limited by the operating capacity of the 630 mm fixed height outfall pipe of approximately 5 ML/day (pers. comms. Mark Halden, GMW).

Figure 7-1 Outfall drain looking south from Yambuna Bridge Road

In 2018, the fixed outfall pipe was replaced with a gated regulator (Figure 7-2) providing greater control over drainage outfalls into the wetlands. Water delivered through the regulator outfalls into the drain which passes beneath Yambuna Bridge Road and enters the Yambuna Wetlands through a piped culvert located in the levee at the southern end of Greiner's Lagoon (Figure 7-3).

Figure 7-2 Regulator upgrade on the CG 5/277/6 channel constructed as part of the GMW Connections Project

Figure 7-3 Culvert in the levee on the southern boundary of the Yambuna Wetlands

The road and levee culverts limit the delivery of water to the wetlands to 5 to 7 ML/day if flooding of the Yambuna Bridge Road is to be avoided. This is not considered to be a constraint to the delivery of mitigation water to the wetlands, as the duration of deliveries are within the tolerances of the proposed water regime.

7.2 Metering and measurement

Channel outfall volumes from the irrigation system prior to 2003/04 were measured using a set of bars and manually recorded once daily. From 2003/04 onwards, channel outfalls were measured using a Mace meter. Improved measurement was installed with the upgrade of the regulator in 2018. All flow into the outfall channel is now monitored and a service point (RN 821) has been established for environmental deliveries. There is no ability to measure inflows to the wetlands beyond this point, which is 500 metres from the lagoon.

A drainage diversion licence allows up to 228 ML per year to be extracted from Greiner's Lagoon, representing a large volume of water relative to the capacity at full supply level (approximately four times greater). There is currently no allowance for measuring the volume of water taken under this licence. It is recommended that Goulburn-Murray Water investigate options to allow measurement of future extractions.

7.3 Further system modifications and improvements

At present, Greiner's Lagoon has the delivery infrastructure required to provide water from the irrigation system at a rate of 5-7 ML/d via the 5/27/6 channel. The capacity of the existing infrastructure, if operating at full capacity, would allow the wetland to be filled in approximately 12 days (assuming no losses and adequate capacity is available in the 5/27/6 channel). The current delivery infrastructure is considered adequate to deliver the desired water regime and no infrastructure upgrades are required as part of the GMW Connections Project apart from improved metering at the channel outfall.

A road embankment constructed between Greiner's Lagoon and Wetland 2 blocks the natural flow path between the wetlands, possibly raising the full supply level of Greiner's Lagoon. The embankment, located in the National Park, was likely constructed to retain water in Greiner's Lagoon for the visual amenity of adjacent landholders and/or to facilitate the extraction of water. As previously discussed, water can leave Greiner's Lagoon through a gated pipe installed in the embankment. Given through flow provisions are not part of the proposed water regime this embankment does not impact the implementation of this EWP.

7.4 Potential future works

The mitigation water requirements do not meet the water requirements of Wetlands 2, 3 and 4. As such, the Goulburn Broken Catchment Management Authority may wish to explore options to deliver environmental water to these wetlands. Delivery options may involve direct pumping from the river or delivery via the 5/27/6 channel. Based on an estimated 202 ML to fill the entire wetland complex (Table 4-2), a delivery time of around 35 days would be required. Delivery of water to Wetlands 2, 3 and 4 is outside the scope of this EWP.

Any additional infrastructure requirements to deliver additional environmental water beyond the mitigation water requirement will be addressed in the Yambuna Wetlands Environmental Water Management Plan (in preparation) and are outside the responsibility of the GMW Connections Project.

8. Adaptive management

8.1 Framework for adaptive management

A key GMW Connections Project principle is that an adaptive management approach is adopted to ensure an appropriate response to changing conditions (Section 9.4; GMW, 2018).

Adaptive management is a continuous management cycle of assessment and design, implementation, monitoring, review and adjustment. Adaptive management adjustments are made to operations on the basis of a modified management hypothesis created in response to developments in our understanding of cause/effect relationships between hydrology and ecological responses and evidenced by ecological objectives and outcomes

Table 8-1 shows how the adaptive management approach will be applied in the context of this EWP.

Table 8-1 Adaptive management framework

Adaptive management phase	Application to this EWP (responsible agency)	When
Assessment and design	Assessment identifies environmental values, their water dependencies, and the potential role of incidental water. Design determines the desired water regime to support environmental values and determines any mitigation water commitment. Details of both these phases are documented in this EWP. (GMW Connections Project)	2019
Implementation	Implementation is the active management of environmental water, of which mitigation water may form a portion, consistent with this EWP. (Goulburn Broken CMA)	Continuous
Monitoring (and reporting)	Monitoring is gathering relevant information to facilitate review and enable any reporting obligations to be met. Two types of monitoring are required. Compliance monitoring is checking that the intended water regime is applied. Performance monitoring is used to inform the review of the effectiveness of the mitigation water contribution to achieving the water management goal by monitoring individual ecological objectives. (Goulburn Broken CMA).	Annual
Review	Review is evaluating actual results against objectives and identifying any improvement opportunities which may be needed. (GMW Connections Project, until responsibilities transferred to other agencies)	2025, 2030, 2035 etc
Adjustment	Adjustment is determining whether changes are required following review or after considering any new information or scientific knowledge and making any design changes in an updated version of the EWP. (GMW Connections Project, until responsibilities transferred to other agencies, adjustment is limited to the extent that the new information relates to the impact of the GMW Connections Project at the time of the impact occurred, and only insofar as the new information could change the mitigation outcomes).	2025, 2030, 2035 etc

8.2 Monitoring and reporting

It is assumed that if mitigation water is supplied in accordance with the desired water regime proposed within the EWP then environmental values potentially impacted by GMW Connections Project will be maintained.

GMW Connections Project will report, annually, on the contribution, or provision, of "GMW Connections Project Mitigation Water" towards achieving the water regime (Section 18, GMW 2018).

This will be done through liaison with other agencies in relation to monitoring and then reporting whether:

- Mitigation water was available for delivery to the wetland or waterway
- A decision was made the water was required for the wetland or waterway in that year
- Mitigation water was delivered to the wetland or waterway in accordance with the desired water regime proposed within the EWP (i.e. quantity, timing, duration, frequency).

It is expected the CMA will monitor environmental water delivery (i.e. quantity, timing, duration and frequency). GMW Connections Project will not implement a detailed monitoring program. It is beyond the scope of this EWP to provide a detailed monitoring program to determine the effectiveness of the desired water regime in achieving ecological objectives and the water management goal.

A program for monitoring progress toward the achievement of the ecological objectives (and ultimately the overall management goal) will be developed as part of the Yambuna Wetlands Environmental Water Management Plan (in preparation).

8.3 Review and adjustment

Periodic reviews provide the opportunity to evaluate monitoring results in terms of compliance, ecological objectives and to learn from implementation. As per the requirement of the WCMF, it is expected this EWP will be reviewed in 2024 and every five years thereafter, or at any time, if requested by the Victorian Minister for Water or the Commonwealth Minister with responsibility for the Environment (Sections 15 and 19, GMW 2018). The GMW Connections Project is responsible for review until such time as responsibility is transferred.

Changes may be made to:

- Operational management
- Management hypotheses and, perhaps, to ecological objectives
- Cope with unexpected issues.

These changes will be incorporated into the EWP if necessary.

9. Ongoing management and governance arrangements

9.1 Roles and responsibilities of key agencies

A summary of the roles and responsibilities of the various agencies relating to the delivery and review of management and mitigation measures is provided in Table 9-1.

Table 9-1 Roles and responsibilities

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during GMW Connections Project implementation
GMW Connections Project (until such time as responsibility is transferred)	▪ Identify and account for water savings, subject to audit by DELWP accredited auditor ▪ Lead the assessment and development processes for management and mitigation measures including developing and gaining approval to the WCMF (which guides the development of EWPs and the assessment of mitigation water). ▪ Maintain short-list of all wetlands, waterways and groundwater dependent ecosystems for mitigation. ▪ Identify and source mitigation water required to implement management and mitigation measures including the adaptive development of EWPs. ▪ Retain or provide infrastructure to deliver water to wetlands and waterways. ▪ Convene and chair the Environmental Technical Advisory Committee. ▪ Convene the Expert Review Panel	▪ Apply, review and, as necessary, develop amendments and gain approval to updated versions of the WCMF. ▪ Provides resources to enable monitoring and review of management and mitigation measures ▪ Establish protocols for transfer of responsibility to relevant agencies. ▪ Coordinate with other agencies to deliver management and mitigation measures. ▪ Arrange for the provision of delivery and measurement infrastructure including capacity and operational flexibility for mitigation water.
Goulburn Broken Catchment Management Authority	▪ Identify and inform GMW Connections Project of opportunities for best practice. ▪ Inform GMW Connections Project of its infrastructure requirements to deliver environmental water. ▪ Participate in the Environmental Technical Advisory Committee. ▪ Agree to implement relevant components of Environmental Watering Plans. ▪ Agree to implement other relevant regional management and mitigation measures required due to the implementation of GMW Connections Project.	▪ Advise Environmental Water Holder and system operator on priorities for use of environmental entitlements (including mitigation water) in line with recommendations outlined in the EWPs ▪ Implement the relevant components of Environmental Watering Plans. ▪ Operate, maintain and replace, as agreed, the infrastructure required for delivery of mitigation water, where the infrastructure is not part of the GMW irrigation delivery system. ▪ Report on environmental outcomes (e.g. wetland or waterway condition) from the delivery of the water, in the course of normal reporting on catchment condition.

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during GMW Connections Project implementation
		▪ Where agreed conduct the periodic review of EWPs and report results to GMW Connections Project. ▪ Manage and report on other relevant catchment management and mitigation measures required due to the implementation of GMW Connections Project.
Land Manager (Public and private)	▪ Identify and inform GMW Connections Project of opportunities for best practice. ▪ Participate in the Environmental Technical Advisory Committee. ▪ Agree to implement relevant components of Environmental Watering Plans. ▪ Agree to implement other relevant regional management and mitigation measures required due to the implementation of GMW Connections Project.	▪ Implement the relevant components of Environmental Watering Plans. ▪ Operate, maintain and replace, as agreed, the infrastructure required for delivery of mitigation water, where the infrastructure is not part of the GMW irrigation delivery system. ▪ Where agreed, participate in the periodic review of relevant EWPs. ▪ Manage and report on other relevant catchment management and mitigation measures required due to the implementation of GMW Connections Project.
System operator (GMW)	▪ Identify and inform GMW Connections Project of opportunities for best practice. ▪ Participate in the Environmental Technical Advisory Committee. ▪ Agree to implement relevant components of Environmental Watering Plans.	▪ Implement the relevant components of Environmental Watering Plans, namely delivery of mitigation water. ▪ Operate, maintain and replace, as needed, the infrastructure required for delivery of mitigation, or other, water, where the infrastructure is part of the GMW irrigation delivery system. ▪ May negotiate transfer of ownership of infrastructure to the environmental water/land manager for provision of mitigation water if it is no longer required for the public distribution system, in accordance with the principles set out in the WCMF.
DELWP	▪ Identify and inform GMW Connections Project of opportunities for best practice. ▪ Participate in the Environmental Technical Advisory Committee. ▪ Arrange funding to enable environmental water manager, catchment manager and land manager to deliver agreed measures.	▪ Participate in the periodic review of the Water Change Management Framework and relevant EWPs.
Victorian Environmental Water Holder		▪ Hold and manage environmental entitlements, including mitigation water that becomes a defined entitlement. ▪ Consult with CMAs in identifying priority wetlands, waterways and groundwater systems for

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during GMW Connections Project implementation
		environmental watering. Plan and report on the use of environmental entitlements. ▪ Negotiate with Commonwealth Environmental Water Holder to arrange delivery of Commonwealth environmental water.

The Murray-Darling Wetlands Working Group may continue to play an active role in the delivery of environmental water to Greiner's Lagoon in collaboration with the Goulburn Broken Catchment Management Authority, the Victorian Environmental Water Holder and in partnership with the private landowner.

9.2 Framework for operational management

The obligation to annually reserve and supply mitigation water will be established by amendment to the River Murray and Goulburn System Bulk Entitlements held by GMW. This arrangement is legally binding and reflects the commitments of the GMW Connections Project to provide water to mitigate potential impacts to high value environmental assets. The arrangements require GMW to set aside water in the Goulburn and Murray Systems to meet the mitigation water needs, calculated in accordance with the methods in the Water Change Management Framework, for future use at wetlands and waterways that have an approved EWP.

Mitigation water will be able to be carried over in line with other entitlements and will only be supplied to those wetlands where a mitigation water requirement has been identified. The specification of the volume and use of mitigation water will be the same regardless of whether it is established via bulk entitlement or contract.

Delivery of environmental water to Greiner's Lagoon requires the coordination of information, planning and monitoring among a number of agencies.

A framework for operational management outlining the relevant roles and responsibilities is presented in Figure 9-1. This has been developed to describe the decision-making process required to coordinate implementation of the recommended water regime for Greiner's Lagoon. The various government bodies and their roles will change over time. Therefore, this framework should be taken as a guide only.

The main components are:

- Assessment of current conditions i.e. wetland phase, climatic conditions etc.
- Identification of potential water sources and preparation of relevant information of submission of water bid
- Coordination of the environmental water delivery and adaptive management process.

9.3 Other interested parties

Other organisations and groups are interested in the management of water at Greiner's Lagoon, outside of the formal roles and responsibilities documented in Table 9-1 above.

The Yorta Yorta National Aboriginal Corporation (YYNAC) is the Registered Aboriginal Party for the region surrounding the Yambuna Wetlands. In 2010, the Yorta Yorta people were formally recognised as the traditional owners under the Traditional Owner Settlement Act 2010. Among other things, the agreement recognises the Yorta Yorta people's rights to access Crown land to hunt, fish, camp, and gather natural resources. Opportunities to strengthen partnerships and align goals with YYNAC will be further explored through the Yambuna Wetlands Environmental Water Management Plan.

The Murray Darling Wetlands Working Group have previously delivered environmental water to Greiner's Lagoon. Opportunities to continue to work with the group will also be considered in the development of the Environmental Water Management Plan.

Figure 9-1: Operational management framework

9.4 Environmental water management plan

Environmental Water Management Plans are developed as a partnership between the Victorian CMAs, DELWP and the Victorian Environmental Water Holder (VEWH) to guide current and future environmental watering at a site scale across Victoria. The primary purpose of the plans is to provide a consistent set of documents that support Seasonal Watering Proposals submitted by CMAs to the VEWH annually.

Similar to this plan, an EWMP is a scientifically-based management plan that describes the:

- ecological values of a particular wetland or river system
- long-term goal for the site

- selected (priority) ecological objectives for the system that environmental watering will support or improve, and which should become the subject of a quantitative monitoring program
- watering requirements of these objectives over the long-term (typically a ten year cycle).

EWMPs outline the 5 to10 year management intentions, based on both scientific information and stakeholder consultation, that can be used by DELWP and the VEWH for both short and longer-term environmental water planning. This watering plan is not a holistic management plan for the site it is limited to issues related to the management of water dependent values and environmental water.

EWPs differ from EWMPs in that it is a special purpose plan aimed at remediating an action (in this instance the impact of reducing irrigation outfalls to Greiner's Lagoon) and is driven by the requirements of the Water Change Management Framework. The water goal, the ecological objectives and hydrological requirements of the EWP should be expressed about the site. The EWMP is bigger in scope: it can consider regional priorities, river flows and is likely have a different suite of objectives.

10. Knowledge gaps

The Yambuna Wetlands EWP has been developed using the best available information. However, a number of information exist which may impact on recommendations and/or information presented in the EWP. A key knowledge gap pertains to the water balance model which was developed for Greiner's Lagoon

The groundwater/surface water relationship is poorly understood due to a lack of groundwater monitoring data. It is possible that water may drain out to the Goulburn River through the subsurface more quickly than predicted by the water balance model. Monitoring of wetland drawdown during an environmental watering event or installation of depth gauges or groundwater monitoring bores at or near Greiner's Lagoon would help to improve understanding of the groundwater/surface water interactions and would allow refinement of the water balance model to recalculate the volume of water needed to achieve vegetation objectives.

The Goulburn Broken CMA in its capacity as environmental water manager is responsible, where funding and resourcing allow, for addressing these knowledge gaps.

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Appendix A. Consultation as part of EWP development

Formal consultation activities during the development of this EWP is summarised below and excludes ad hoc phone and email conversations.

Activity	Purpose	Date
Meeting with GMW Connections Program -environmental management team	Project inception	January 2019
Site visit with representatives from Parks Victoria, GMW Connections Program, GMW, Goulburn Broken CMA, MDWWG and Jamie McMaster	Site inspection	January 2019
Workshop with representatives from Parks Victoria, DELWP, Goulburn Broken CMA and ARI	Objective setting	January 2019
Workshop with the Goulburn Broken CMA Wetlands Technical Working Group (Damien Cook, Rhonda Butcher and Wayne Koster)	Objective setting	January 2019
Teleconference with Ray Ahmet of Yorta Yorta Nation Aboriginal Corporation	Objective setting and scope of the plan	February 2019
Meeting with Expert Review Panel (Terry Hillman and Jane Roberts) and GMW Connections Program	Objective setting and draft plan structure	March 2019
Meeting #56 of the GMW Connections Program – Environment Technical Advisory Committee	Presentation and feedback on draft EWP	September 2019
Meeting #57 of the GMW Connections Program – Environment Technical Advisory Committee	Revised draft EWP including updated water balance model	December 2019
Meeting with Expert Review Panel (Terry Hillman and Jane Roberts) and GMW Connections Program	Discuss feedback from review of draft EWP	January 2020
Meeting #58 of the GMW Connections Program – Environment Technical Advisory Committee	Progress update	February 2020
Meeting with Expert Review Panel (Terry Hillman and Jane Roberts) and GMW Connections Program	Discuss feedback from review of final draft EWP	April 2020
Meeting #59 of the GMW Connections Program – Environment Technical Advisory Committee	Discuss feedback from ERP, including specific issues associated with private land management	April 2020
Meeting #60 of the GMW Connections Program – Environment Technical Advisory Committee	Presentation and feedback on final draft EWP. Specific discussion on drainage extractions at direction of ERP.	June 2020
Meeting #61 of the GMW Connections Program – Environment Technical Advisory Committee	Endorsement Final EWP	July 2020
Expert Review Panel	Endorsement of Final EWP	September 2020

Appendix B. Flora and fauna species list

Sources: Rakali (2015), SKM (2011)

Data source: NatureKit Database. Department of Environment, Land, Water and Planning. Available at: http://naturekit.biodiversity.vic.gov.au/ Accessed: March 2019

Common Name	Scientific Name
Birds – native	
Australian Hobby	*Falco longipennis*
Australian magpie	*Cracticus tibicen*
Australian pelican	*Pelecanus conspicillatus*
Australian raven	*Corvus coronoides*
Australian Shelduck	*Tadorna tadornoides*
Australian White Ibis	*Threskiornis molucca*
Australian Wood Duck	*Chenonetta jubata*
Barking Owl	*Ninox connivens connivens*
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*
Brown Falcon	*Falco berigora*
Brown Quail	*Coturnix ypsilophora australis*
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*
Brown-headed Honeyeater	*Melithreptus brevirostris*
Buff-rumped Thornbill	*Acanthiza reguloides*
Clamorous Reed Warbler	*Acrocephalus stentoreus*
Crested Shrike-tit	*Falcunculus frontatus*
Crimson Rosella	*Platycercus elegans*
Dusky Moorhen	*Gallinula tenebrosa*
Eastern Great egret	*Ardea modesta*
Eastern Rosella	*Platycercus eximius*
European Goldfinch	*Carduelis carduelis*
Fairy Martin	*Petrochelidon ariel*
Freckled duck	*Stictonetta naevosa*
Galah	*Eolophus roseicapillus*
Golden Whistler	*Pachycephala pectoralis*
Grey Fantail	*Rhipidura albiscapa*
Grey Shrike-thrush	*Colluricincla harmonica*
Grey Teal	*Anas gracilis*
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*
Jacky Winter	*Microeca fascinans*
Laughing Kookaburra	*Dacelo novaeguineae*
Little Friarbird	*Philemon citreogularis*
Little Pied Cormorant	*Microcarbo melanoleucos*
Little Raven	*Corvus mellori*
Long-billed Corella	*Cacatua tenuirostris*
Magpie-lark	*Grallina cyanoleuca*
Masked Lapwing	*Vanellus miles*
Mistletoebird	*Dicaeum hirundinaceum*
Nankeen Night Heron	*Nycticorax caledonicus hillii*
Noisy Friarbird	*Philemon corniculatus*
Olive-backed Oriole	*Oriolus sagittatus*

Common Name	Scientific Name
Pacific Black Duck	*Anas superciliosa*
Peaceful Dove	*Geopelia striata*
Pied Butcherbird	*Cracticus nigrogularis*
Powerful Owl	*Ninox strenua*
Purple Swamphen	*Porphyrio porphyrio*
Red-browed Finch	*Neochmia temporalis*
Rainbow Bee-eater	*Merops ornatus*
Restless Flycatcher	*Myiagra inquieta*
Royal Spoonbill	*Platelea regia*
Rufous Whistler	*Pachycephala rufiventris*
Sacred Kingfisher	*Todiramphus sanctus*
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*
Silvereye	*Zosterops lateralis*
Southern Boobook	*Ninox novaeseelandiae*
Spotted Pardalote	*Pardalotus punctatus*
Straw-necked Ibis	*Threskiornis spinicollis*
Striated Pardalote	*Pardalotus striatus*
Striated Thornbill	*Acanthiza lineata*
Sulphur-crested Cockatoo	*Cacatua galerita*
Superb Fairy-wren	*Malurus cyaneus*
Tawny Frogmouth	*Podargus strigoides*
Varied Sittella	*Daphoenositta chrysoptera*
Weebill	*Smicrornis brevirostris*
Welcome Swallow	*Hirundo neoxena*
Western Gerygone	*Gerygone fusca*
Whistling Kite	*Haliastur sphenurus*
White-backed Swallow	*Cheramoeca leucosternus*
White-bellied sea-eagle	*Haliaeetus leucogaster*
White-faced Heron	*Egretta novaehollandiae*
White-plumed Honeyeater	*Lichenostomus penicillatus*
White-throated Treecreeper	*Cormobates leucophaeus*
White-winged Chough	*Corcorax melanorhamphos*
Willie Wagtail	*Rhipidura leucophrys*
Yellow Rosella	*Platycercus elegans flaveolus*
Yellow Thornbill	*Acanthiza nana*
Yellow-billed spoonbill	*Platalea flavipes*
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*
Flora – native	
Austral Rush	*Juncus australis*
Berry Saltbush	*Atriplex semibaccata*
Blue Devil	*Eryngium ovinum*
Bristly Wallaby-grass	*Rytidosperma setaceum*
Brown-back Wallaby-grass	*Rytidosperma duttonianum*
Clove-strip	*Ludwigia peploides subsp. montevidensis*
Common Blown-grass	*Lachnagrostis filifolia s.l*
Common Cassinia	*Cassinia aculeata*
Common Sneezeweed	*Centipeda cunninghamii*

Common Name	Scientific Name
Common Spike-sedge	*Eleocharis acuta*
Common Swamp Wallaby-grass	*Amphibromus nervosus*
Common Tussock-grass	*Poa labillardierei*
Common Wallaby-grass	*Rytidosperma caespitosum*
Common Wheat-grass	*Anthosachne scabra (glabrous form)*
Cotton Fireweed	*Senecio quadridentatus*
Creeping Knotweed	*Persicaria prostrata*
Creeping Mistletoe	*Muellerina eucalyptoides*
Drooping Cassinia	*Cassinia arcuata*
Finger Rush	*Juncus subsecundus*
Floodplain Fireweed	*Senecio campylocarpus*
Giant Rush	*Juncus ingens*
Gold Rush	*Juncus flavidus*
Grassland Wood-sorrel	*Oxalis perennans*
Grey box	*Eucalyptus microcarpa*
Grey Willow-herb	*Epilobium billardierianum subsp. cinereum*
Hollow Rush	*Juncus amabilis*
Indian Cudweed	*Gnaphalium polycaulon*
Jersey Cudweed	*Helichrysum luteoalbum*
Kangaroo Grass	*Themeda triandra*
Knob Sedge	*Carex inversa*
Lesser Joyweed	*Alternanthera denticulata s.l.*
Narrow-leaf Cumbungi	*Typha domingensis*
Narrow-leaf Dock	*Rumex tenax*
Native Couch	*Cynodon dactylon var. pulchellus*
Native Flax	*Linum marginale*
Nodding Saltbush	*Einadia nutans subsp. nutans*
Pale Flax-lily	*Dianella sp. aff. longifolia (Riverina)*
Pale Knotweed	*Persicaria lapathifolia*
Plains Joyweed	*Alternanthera sp. 1 (Plains)*
Poison Pratia	*Lobelia concolor*
Poong'ort	*Carex tereticaulis*
Rigid Panic	*Walwhalleya proluta*
River Bluebell	*Wahlenbergia fluminalis*
River Mint	*Mentha australis*
River Red-gum	*Eucalyptus camaldulensis*
River Swamp Wallaby-grass	*Amphibromus fluitans*
Robust Water-milfoil	*Myriophyllum papillosum*
Rough Raspwort	*Haloragis aspera*
Silky Browntop	*Eulalia aurea*
Slender Carpet-weed	*Glinus oppositifolius*
Slender Dock	*Rumex brownii*
Slender Knotweed	*Persicaria decipiens*
Small Loosestrife	*Lythrum hyssopifolia*
Small Spike-sedge	*Eleocharis pusilla*
Spreading Sneezeweed	*Centipeda minima subsp. minima s.s.*
Tussock Rush	*Juncus aridicola*
Upright Water-milfoil	*Myriophyllum crispatum*

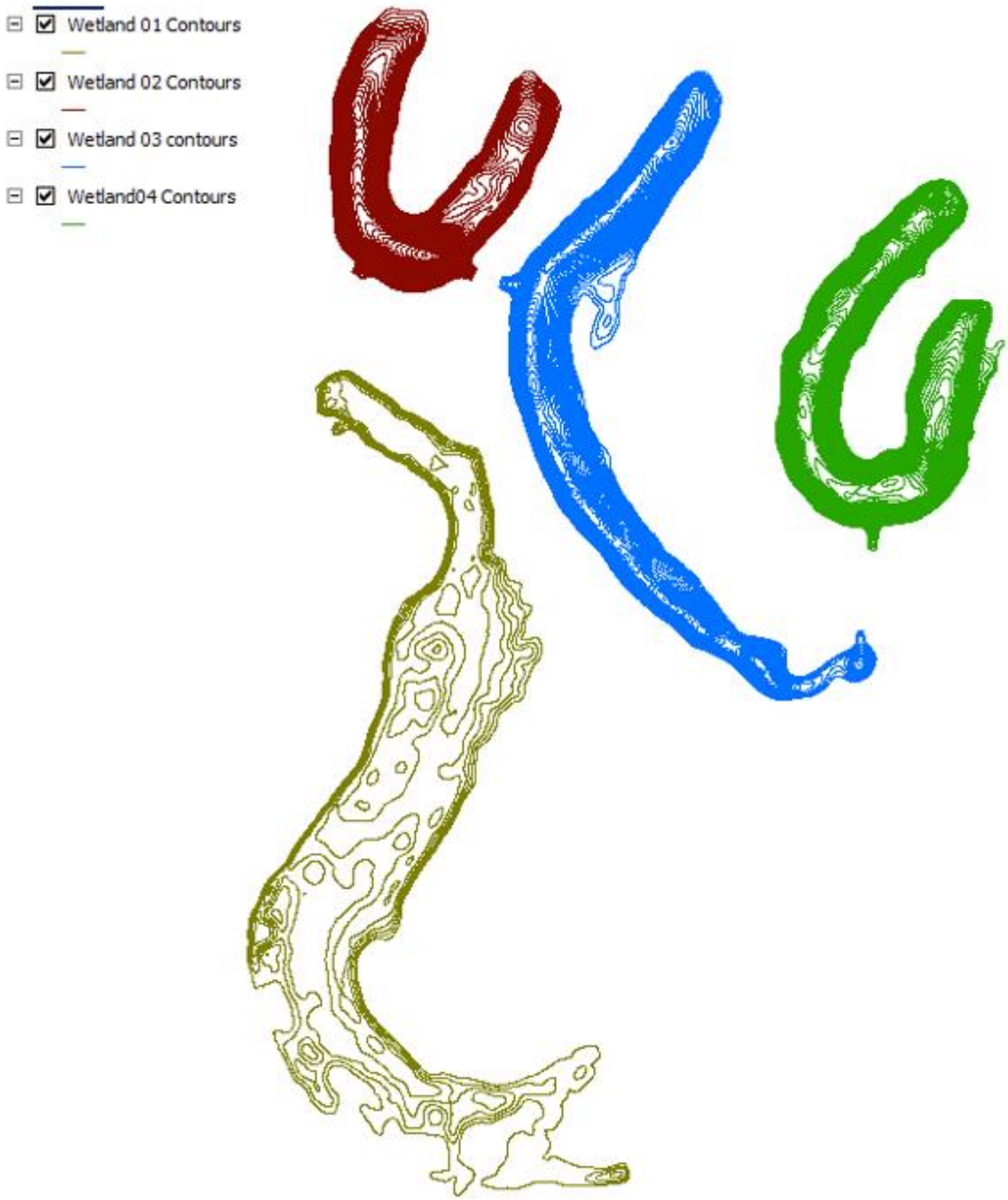
Common Name	Scientific Name
Variable Flat-sedge	*Cyperus difformis*
Warrego Summer-grass	*Paspalidium jubiflorum*
Windmill Grass	*Chloris truncata*
Woodland Swamp-daisy	*Brachyscome basaltica var. gracilis*
Woolly Knotweed	*Persicaria lapathifolia (floccose form)*
Woolly New Holland Daisy	*Vittadinia gracilis*
Flora – exotic	
Annual Beard-grass	*Polypogon monspeliensis*
Aster-weed	*Aster subulatus*
Barley-grass	*Hordeum murinum s.l.*
Bearded Oat	*Avena barbata*
Black Nightshade	*Solanum nigrum s.l.*
Cluster Clover	*Trifolium glomeratum*
Common Sow-thistle	*Sonchus oleraceus*
Common Water-starwort	*Callitriche stagnalis*
Couch	*Cynodon dactylon var. dactylon*
Curled Dock	*Rumex crispus*
Drain Flat-sedge	*Cyperus eragrostis*
Ferny Cotula	*Cotula bipinnata*
Flatweed	*Hypochaeris radicata*
Flaxleaf Fleabane	*Conyza bonariensis*
Great Brome	*Bromus diandrus*
Hairy Hawkbit	*Leontodon taraxacoides subsp. taraxacoides*
Hare's-foot Clover	*Trifolium arvense var. arvense*
Lucerne	*Medicago sativa subsp. sativa*
Mexican Tea	*Chenopodium ambrosioides*
Ox-tongue	*Helminthotheca echioides*
Panic Veldt-grass	*Ehrharta erecta var. erecta*
Prickly Lettuce	*Lactuca serriola*
Rat's-tail Fescue	*Vulpia myuros*
Red-flower Mallow	*Modiola caroliniana*
Rough Sow-thistle	*Sonchus asper s.l.*
Smooth Cat's-ear	*Hypochaeris glabra*
Soft Brome	*Bromus hordeaceus subsp. hordeaceus*
Spear Thistle	*Cirsium vulgare*
Squirrel-tail Fescue	*Vulpia bromoides*
Subterranean Clover	*Trifolium subterraneum*
Suckling Clover	*Trifolium dubium*
Water Couch	*Paspalum distichum*
Water Plantain	*Alisma lanceolata*
White Clover	*Trifolium repens var. repens*
Willow-leaf Lettuce	*Lactuca saligna*
Wimmera Rye-grass	*Lolium rigidum*

Appendix C. Additional risks and limiting factors

The following risks are to be managed by the relevant organisations and agencies as stipulated through their current roles and as is legislated.

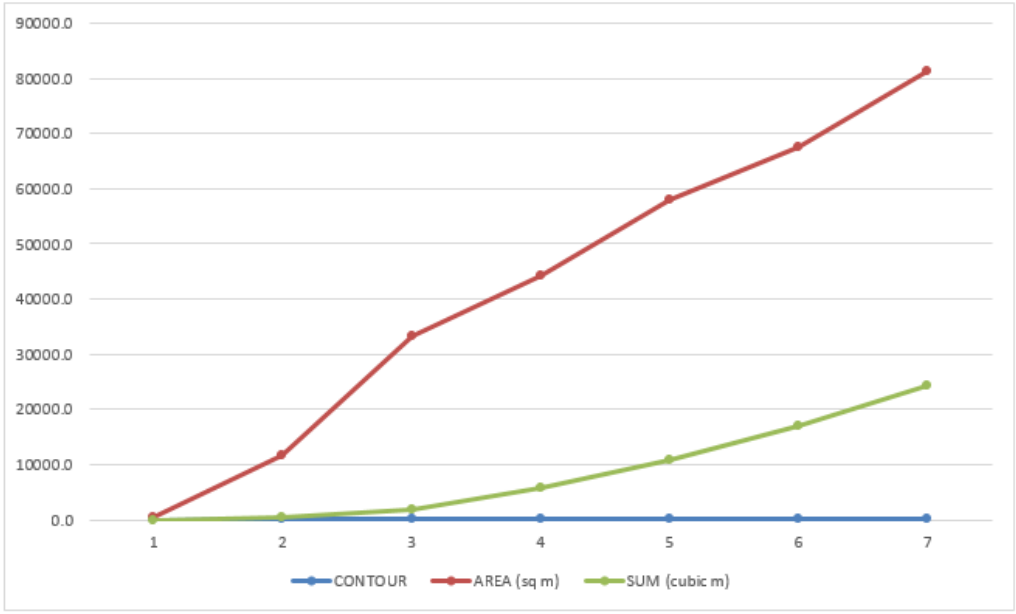
Risk/Limiting Factors	Impacts	Mitigation Measures
Delivery of Water		
Poor water quality (i.e. temperature fluctuations, blackwater events, high turbidity, salinity and nutrient levels)	Reduced primary production (turbid water), limiting food resources for aquatic invertebrates and waterbirds, excessive algal growth	Adaptively manage water regime and delivery. Development a grazing management plan with the adjacent landholder.
Groundwater response to water management at the site and vicinity	Local effects that are the result of the adopted water management regime	Review of the groundwater related aspects of the site at least every seven years or sooner if the watering regime is changed or regional groundwater levels rise. Adaptive management of water regime.
Lack of connection between wetlands, river and floodplain	Altered flow regime (continued lack of flood flows)	Investigate opportunities to remove barriers to flow on the primary effluents and between Wetlands 1 and 2.
Flooding of adjacent landowners and/or Yambuna Bridge Rd	Community angst, safety, liability	Deliveries not to exceed 7 ML/day
Ecological response		
Encroachment or dominance of native flora species	Loss in species diversity, habitat loss	Active management (spraying, slashing, cool burning etc). Seasonal water delivery, regular monitoring and adaptive management of water regime.
Proliferation of invasive plants and animals	Reduced habitat and resource availability, predation, limited establishment of native vegetation	Regular monitoring, active management (invasive plant and animal control)
Lack of seedbank viability (native wetland species)	Emergence of unexpected exotic species, reduced diversity	Monitoring (e.g. IWC) and active management (reintroduction of viable seed)
Other		
Fire	Habitat and resource loss, Deteriorating water quality	Monitor extent of issue and consider strategies to reduce fuel load and fire intensity if required.

Appendix D. Wetland contours derived from DEM



Appendix E. Bath tub model outputs Wetland 1

CONTOUR	COUNT	AREA	MIN	MAX	RANGE	MEAN	STD	(cubic metres)
95.70	813	813	0	0.0512314	0.051231	0.0129525	0.011384	10.53
95.80	11801	11801	0	0.1512375	0.151237	0.0520779	0.032087	614.57
95.90	27499	27499	0	0.251236	0.251236	0.0944009	0.058359	2,595.93
96.00	42377	42377	0	0.3512344	0.351234	0.1437288	0.0851	6,090.80
96.10	57635	57635	0	0.4512329	0.451233	0.1938381	0.111603	11,171.86
96.20	66314	66314	0	0.5512314	0.551231	0.2631928	0.131092	17,453.37
96.30	79736	79736	0	0.6512375	0.651237	0.30969	0.169096	24,693.44
96.40	97676	97676	0	0.751236	0.751236	0.3441507	0.206421	33,615.27
96.50	60	60	0	0.0519714	0.051971	0.0225946	0.01494	1.36
96.60	120728	120728	0	0.9512329	0.951233	0.4621537	0.252244	55,794.89



Column Heading	Description
CONTOUR	Contour Interval value
COUNT	Count of Cells
AREA	Area of Cells
MIN	Minimum value (volume)
MAX	Maximum value (volume)
RANGE	Range (volume)
MEAN	Mean (volume)
STD	Standard deviation (volume)
SUM	Sum of Volume