Department of Sustainability and Environment

Yarriambiack Creek and Beulah Weir Pool Environmental Water Management Plan

Mallee Catchment Management Authority

Beulah Weir pool April 2012

mallee catchment management authority

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EXECUTIVE SUMMARY

Environmental water management plans have been developed for key sites in the Mallee region by the Mallee Catchment Management Authority (CMA) in partnership with the Victorian Department of Sustainability and Environment. These plans have been developed to guide future environmental water events at selected sites.

The Yarriambiack Creek is a distributary of the Wimmera River and flows 120 km north through Warracknabeal, Brim and Beulah before discharging into Lake Corrong and Lake Lascelles at Hopetoun. Whilst most of the Yarriambiack Creek is within the Wimmera CMA region, this plan focuses on a section of the Yarriambiack Creek within the Mallee CMA region at the township of Beulah. This plan outlines the proposed infrastructure options to mitigate flood risk to the town as well as enhance use of the current water entitlement to inundate a section of the creek upstream of the weir pool, as well as introducing variations in weir pool levels. This will increase the area inundated from 3.1 ha (the current weir pool area) up to 4.6 ha (the weir pool and creek target area).

Environmental values for the Yarriambiack Creek and Beulah weir pool includes a range of water dependent flora and fauna species including the Eastern Great Egret, *Ardea modesta*, listed as vulnerable under state legislation. The area also contains depleted and vulnerable water dependent ecological vegetation classes and is classified as a High Value reach in the Mallee River Health Strategy. The target area has significant social values for the local community and the local indigenous community has strong connections to the area.

Yarriambiack Creek management goal
To maintain and enhance the Black Box woodlands fringing the creek

Beulah weir pool management goal:
To introduce weir pool variations, whilst maintaining refuges for native fish and recreational use.

To achieve these objectives, a long-term watering regime will be developed. The weir pool objectives will be refined once further knowledge on the fish and flora populations have been investigated. The weir pool and creek have the ability to be managed independently to address different management goals.

Minimum watering regime

Beulah weir pool
Inundate the weir pool each year during spring and summer and drawdown the level at intervals at other times of the year. Maintain a ponded area for fish refuge all year round.

Yarriambiack Creek
Inundate the target area of the creek two in every ten years with a maximum interval of seven years between events. Maintain the water in the creek line for at least two months.

Optimal watering regime

Beulah weir pool
Inundate the weir pool each year during spring and summer and drawdown the level at intervals at other times of the year. Maintain a ponded area for fish refuge all year round.

Yarriambiack Creek
Inundate the target area of the creek three in every ten years with a maximum interval of three years between events. Maintain the water in the creek line for two-four months.

Maximum watering regime

Beulah weir pool
Inundate the weir pool each year during spring and summer and drawdown the level at intervals at other times of the year. Maintain a ponded area for fish refuge all year round.

Yarriambiack Creek
Inundate the target area of the creek every other year with a minimum interval of one year between events. Maintain the water in the creek line for no more than five months.

The constraints on the current ability to water a larger section of the Yarriambiack Creek at Beulah is a levee bank with a regulator on the mid-section of the target area (upstream regulator), currently used to maintain a pool level in the town.

Four possible options to manage water are proposed:

- Remove upstream regulator and install a low spillway
- Remove upstream regulator only
- Remove upstream regulator and place a small structure 800m upstream
- No changes.

Each of these options requires further investigation before implementation.

The volume of water required to inundate the maximum proposed target area using available bulk water entitlement for the weir pool (see section 2.4) is 55 ML. This will inundate both the creek and weir pool. The area inundated could be increased from 3.1 ha (area of the weir pool) to 4.6 ha depending on which of the four options for infrastructure changes are implemented.

Water management infrastructure on the weir pool is driven by the need to protect homes and agricultural infrastructure within Beulah during flood events (Water Technology 2012). Social and recreational use of the weir pool is also a major consideration.

A full aquatic flora and fauna survey and detailed designs for the proposed works are the top two knowledge gaps and recommendations for the site.

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ABBREVIATIONS AND ACRONYMS

CAMBA	China-Australia Migratory Bird Agreement
CMAs	Catchment Management Authorities
DEH	Department of Environment and Heritage
DSE	Department of Sustainability and Environment
EVC	Ecological Vegetation Class
EWaMP	Environmental Water Management Plan
EWH	Environmental Water Holder
FSL	Full Supply Level
GWMW	Grampians Wimmera Mallee Water
JAMBA	Japan-Australia Migratory Bird Agreement
MDBA	Murray-Darling Basin Authority (formally Murray-Darling Basin Commission, MDBC)
Ramsar	Global treaty adopted in the Iranian city of Ramsar in 1971 that focuses on the conservation of internationally important wetlands
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
RRG	River Red Gum
TLM	The Living Murray Initiative
TSL	Targeted Supply Level
VEWH	Victorian Environmental Water Holder

1. INTRODUCTION

1.1. Background

Environmental water management in Victoria is entering a new phase as ongoing water recovery sees significant volumes of water being returned to the environment. The increasing environmental water availability is providing new opportunities to protect, restore and reinstate high value ecosystems throughout northern Victoria. The spatial coverage of environmental watering has expanded considerably in recent years and this trend will continue into the future.

Environmental watering in Victoria has historically been supported by management plans which document key information such as the watering requirements of a site, predicted ecological responses and water delivery arrangements. State and Commonwealth environmental watering programs now have the potential to extend beyond those sites which have been watered in the past. Therefore, new plans are required to provide a transparent and informed approach to environmental water delivery across new environmental watering sites.

The Beulah weir pool has water piped to it for recreational use for the town as part of a water allocation using the Wimmera Mallee Pipeline. This maintains the water level year round and does not rely on water being delivered by the Yarriambiack Creek. During January 2011 the catchment witnessed a greater than 100 year average recurrence interval (ARI) rainfall event. Mitigation measures were put in place during the flooding including excavations of structures at the weir pool to prevent flood inundation of homes and agricultural infrastructure around Beulah. Planning is underway to re-instate infrastructure to mitigate future flooding of the town. The Beulah community has recognised this as an opportunity to develop options that would also have environmental benefits (Water Technology 2012).

1.2. Purpose

The Victorian catchment management authorities (CMAs) and Department of Sustainability and Environment (DSE) are working together to develop new Environmental Water Management Plans for both current and future environmental watering sites throughout northern Victoria. The primary purpose of the plans is to provide a consistent set of documents that support the Seasonal Watering Proposals to be submitted by CMAs to the Victorian Environmental Water Holder (VEWH) each year. The supporting information includes:

- water dependent environmental, social and economic values;
- water dependent environmental condition, threats and objectives;
- long-term water regime requirements to meet environmental objectives, under a range of climatic conditions;
- environmental watering management responsibilities;
- recent records of water delivery;
- opportunities for improved efficiency or capacity through structural works or other measures; and
- scientific knowledge gaps and recommendations for future work.

For the Beulah weir pool, the primary purpose of this plan is floodplain management to mitigate future flood damage to the township of Beulah while also maximizing environmental benefits. The community acknowledges that an opportunity exists to design flood mitigation measures and alter the infrastructure of the Beulah weir pool that will also allow ecological outcomes to be addressed in the weir pool and a section of the Yarriambiack Creek.

1.3. Site location

The Mallee CMA is situated in the north-west of Victoria. The area of responsibility is close to 43,000km^2 (3.9 million ha), with a regional population estimated to be 65,000. Population centres include Mildura, Birchip, Sea Lake, Ouyen, Robinvale, Red Cliffs and Merbein.

The boundaries of the Mallee CMA region cover almost one fifth of Victoria, making it the largest area managed by a Catchment Management Authority in the state.

Approximately 40% of the land area within the Mallee CMA boundary is public land, consisting mainly of National Parks, reserves, wilderness areas and large tracts of riverine and dryland forests. The other 60% is predominantly dryland cropping by area, but there is also a significant investment in irrigation of grapes, citrus, almonds, olives, and vegetables along the Murray River corridor which contributes over 40% of the value of agricultural production for the region.

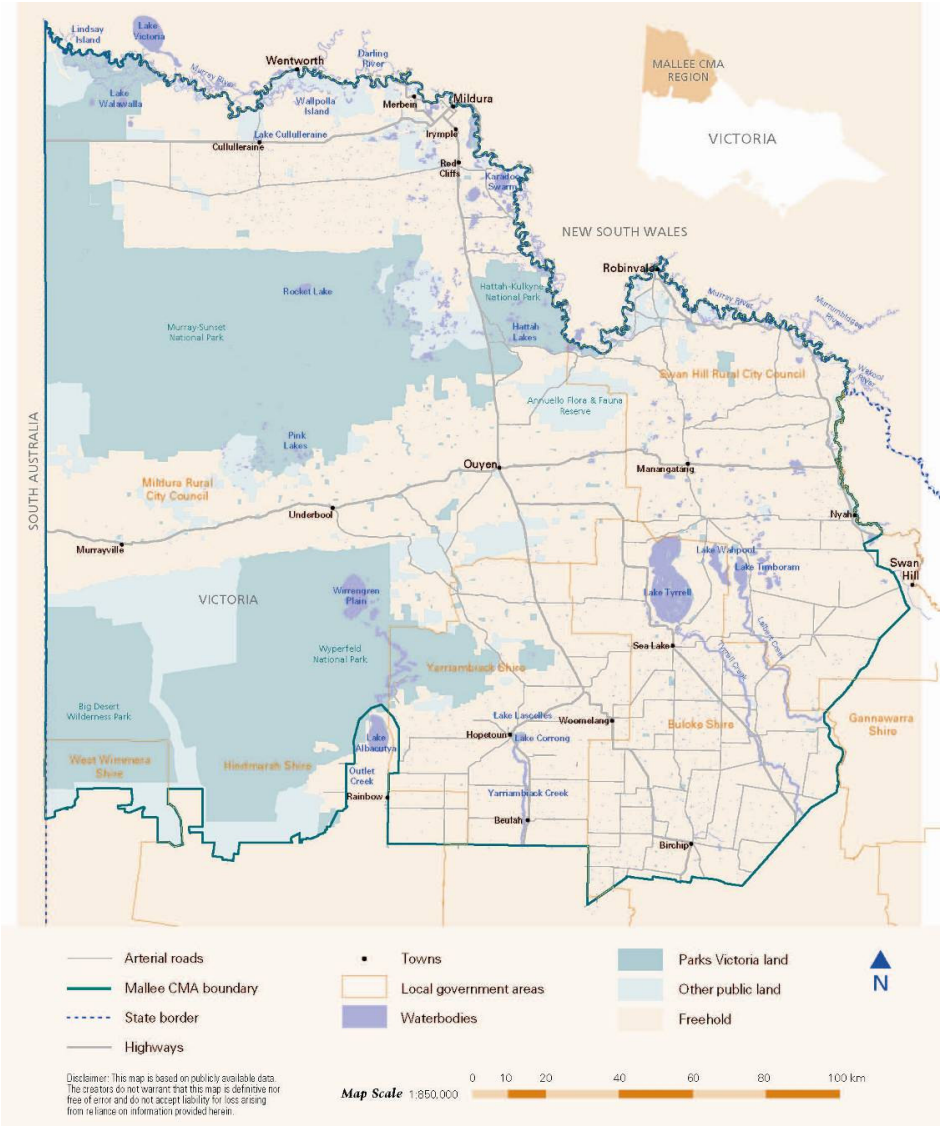

Figure 1 Map of the CMA region

The site for this plan is the Beulah weir pool as well 1.3 km of the Yarriambiack Creek extending upstream from the weir pool. Beulah is 216 km south of Mildura. (see Figure 2).

1.4. Consultation

This Plan was developed in collaboration with key stakeholders namely the Beulah Weir Pool Committee of Management, Yarriambiack Creek Advisory Committee, Wetlands Evaluation Team and Grampians Wimmera Mallee Water (GWM Water). The Wetland Evaluation Team consists of membership from GWMW, the Mallee CMA, Department of Sustainability and Environment and the Birchip Landcare Group.

Table 1 Consultation Process for development of the Yarriambiack Creek and Beulah Weir Pool Environmental Water Management Plan

Meeting Date	Stakeholders	Details
28 March 2012	Wetland Evaluation Team	Presentation of draft Flood Study. Discussed changes to the Beulah Weir pool and concerns raised by the group
26 April 2012	Beulah Weir Pool Committee of Management	Presentation of final Flood Study report and early draft of Environmental Water Management Plan for comment.
2 May 2012	Yarriambiack Creek Advisory Committee	Presentation of final Flood Study report and early draft of Environmental Water Management Plan for comment. Discussed changes to the Beulah Weir pool and concerns raised by the group
9 May 2012	GWM Water and Wetland Evaluation Team	Discussed changes to the Beulah Weir pool and concerns raised by the group
1 August 2012	Yarriambiack Creek Advisory Committee	Presentation of draft Environmental Water Management Plan and discussion of options for infrastructure upgrade.

1.5. Information sources

Information used in the development of this Plan was compiled from various sources (References, Section 10) including river health and catchment strategies, consultant reports and wetland and park management plans. A number of state-wide data sets and digital mapping layers were used including the:

- Flora Information System of Victoria;
- Atlas of Victorian Wildlife;
- Bioregional Conservation Status of Ecological Vegetation Classes;
- Wetland Environments and Extent up to 1994; and
- Aerial photography
- Digital Elevation and LiDAR modelling
- Local knowledge

This information was supplemented by discussions with people with an intimate knowledge of the study area, its environmental values and the management and operation of the Beulah Weir Pool.

1.6. Limitations

The information sources used in the development of this report have a number of limitations. These limitations include that the data contained in the Flora Information System and the Atlas of Victorian Wildlife comes from a combination of incidental records and systematic surveys. The data varies in accuracy and reliability due to the distribution and intensity of survey efforts. In addition, the lack of knowledge about the distribution and characteristics of invertebrates and non-vascular plant species means the data is weighted towards the less cryptic elements of flora and fauna, i.e. vascular flora and vertebrates. This report also draws on material collated from management plans, research documents and published literature. These sources vary in their age and hence the degree to which they reflect the current situation. However, the Plan is intended to be a live document and will be amended as new information becomes available.

2. SITE OVERVIEW

2.1 Catchment setting

The Yarriambiack Creek at Beulah is north flowing and located in the Murray Mallee bioregion within the Mallee CMA region 216 km south of Mildura. The Murray Mallee bioregion is characterised by calcareous material in the form of a broad undulating sandy plains that is often associated with linear, west-east aligned, low sand dunes with intervening heavier textured swales developed from Cainozoic deposits of alluvial, aeolian and swampy deposits. The vegetation is dominated by East/West-Dune Mallee with some Chenopod Mallee and Shallow-Sand Mallee.

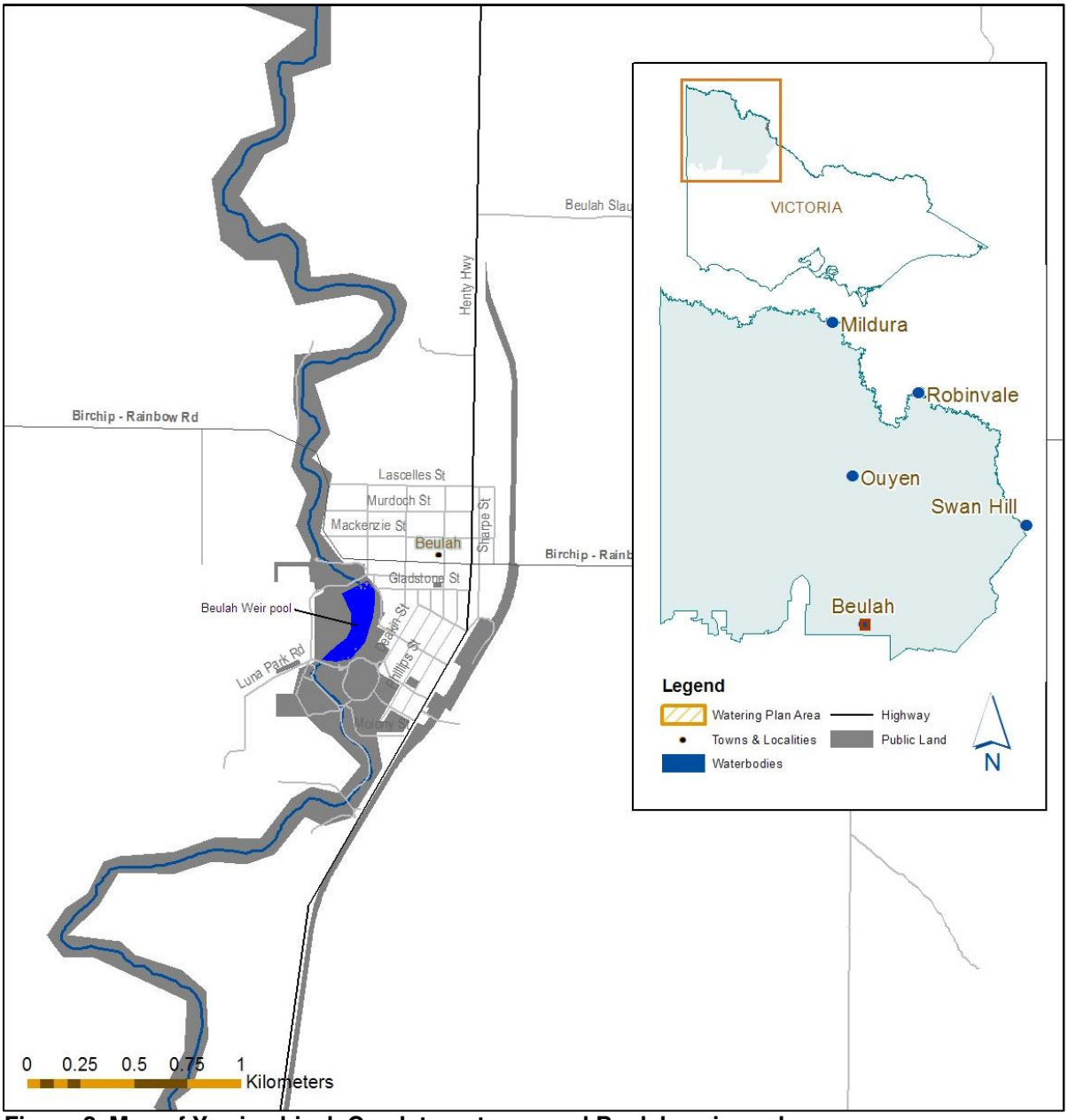

Figure 2 Map of Yarriambiack Creek target area and Beulah weir pool

The Beulah weir pool and the Yarriambiack Creek target area is a 4.6 ha site, as shown in Figure 3. This target area is the extent to which the Wimmera and Glenelg Bulk entitlement water is able to be managed with the proposed infrastructure in place. Constraints and proposed infrastructure are discussed fully in Sections 4.1 and 8.2. Expansion of this target area would require larger volumes of water, which are currently not available to the site.

Figure 3 Target area showing achievable inundation extent of Beulah Weir Pool and Yarriambiack Creek target area

2.2 Land status and management

The Beulah Weir Pool area has recently been managed by Grampians Wimmera Mallee Water as a recreational water body. The surrounding land is jointly managed by DSE, Yarriambiack Shire Council and the Beulah Weir Pool Committee of Management. The Beulah Weir Pool Committee of Management represent community views and provide advice to GWM Water regarding the management of recreation water and the allocation of future recreational water in accordance with the Bulk Entitlement Order (GWMWater 2009).

The Yarriambiack Creek at Beulah is managed as public park and recreation zone, within the township and public conservation and resource zone south of the town. The area is popular for recreation activities such as walking, camping and fishing.

Table 2 Stakeholders for the Beulah Weir Pool and Yarriambiack Creek target area:

Group	Role
Mallee CMA	Regional environmental and waterway management
Department of Sustainability and Environment	State level environmental management
Grampians Wimmera Mallee Water	Water Authority
Yarriambiack Shire Council	Local Government
Beulah Weir Pool Committee of Management	Weir pool management
Beulah Community	Educational, social and recreational users

2.3 Wetland characteristics

A brief overview of the main characteristics of the target area is given in Table 3.

Table 3 Summary of target area characteristics

Characteristics	Description
Name	Beulah Weir Pool and Yarriambiack Creek target area
Mapping ID within area	277215 (Beulah Weir Pool)
Area	3.1 ha (Beulah Weir Pool) 1.5 (Yarriambiack Creek target area)
Bioregion	Murray Mallee
Conservation status	Vulnerable
Land status	Public Park and Recreation Zone and Public Conservation and Resource Zone
Land manager	Beulah Weir Pool Committee of Management
Surrounding land use	Residential areas of Beulah, recreational areas and dryland farming enterprises.
Water supply	The Yarriambiack Creek receives flows from the Wimmera River. Water for this project is piped from Wimmera Mallee pipeline.
Wetland Category	Open Water
Wetland Subcategory	Impoundment
Waterway depth at capacity	2.5 m (Beulah Weir Pool) 1 m (Yarriambiack Creek target area)

2.4 Wimmera - Glenelg Bulk Entitlement

The Wimmera Mallee Pipeline Project (WMPP) replaced 18,000 km of inefficient earthen channel with 9,159 km of pressurized pipeline and associated structures. The pipeline saves on average 103 gigalitres (GL) of water a year and provides continuous water supply to farms and towns across the Wimmera and Mallee. The 103 GL is now a bulk water entitlement to water authorities with 83 GL of water a year going to the region's river systems and 20 GL for regional growth water for towns.

As a result of the pipeline, GWM Water has been allocated 3 GL of water to supply recreational lakes formerly supplied by the channel. The Beulah weir pool is a recreational lake supplied water through a pipeline under this scheme. Recreational lake water levels are collected at the end of each month and uploaded to the GWM Water website http://www.gwmwater.org.au/information/recreational-lakes.

Table 4 Summary of water sources available to the Beulah Weir Pool and Yarriambiack Creek target area

Water Entitlement	Responsible Agency
Wimmera - Glenelg Bulk Entitlement (Recreational Water)	Grampians Wimmera Mallee Water

Other sources of water may become available through water trading or changes in water entitlements.

2.5 Legislative Policy Framework

There is a range of international treaties, conventions and initiatives, as well as National and State Acts, policies and strategies that determine management of the target area. Those with particular relevance to the site and the management of its environmental values are listed in Table 5. For the functions and major elements of each refer to Appendix 2.

Table 5 Legislation, agreements, convention and listings relevant to the target area

Legislation, Agreement or Convention	Jurisdiction
FFG	State
DSE advisory lists	State

2.6 Related Plans and Activities

The Yarriambiack Creek and Beulah Weir Pool has been the subject of various investigations. These include:

The Yarriambiack Creek Management Plan developed by the Mallee and Wimmera CMAs, Yarriambiack Shire Council, DSE and the Yarriambiack Creek Advisory Committee in 2004. Other studies include flood and hydrology, flora and fauna and Aboriginal Heritage investigations. The Yarriambiack Creek is also included in the Mallee CMA's River Health Strategy.

The Yarriambiack Creek (reach 24) was assessed using the Index of Stream Condition (ISC) surveys. Some areas in the north were not scored due to insufficient data, whist the southern reach had a moderate environmental condition score. The Mallee and Wimmera CMA Waterwatch programs have been conducted on the Yarriambiack Creek (Mallee CMA 2006).

The *Beulah Flood Investigation* was completed by Water Technology in 2012. The primary objective of this study is to develop a flood model incorporating changes to key infrastructure post January 2011 and make recommendations for future management options in the event of floods. This work also looked at how on ground works could maximise the environmental values of future floods (Water Technology 2012).

3. WATER DEPENDENT VALUES

3.1 Environmental

Wetlands and waterways on the floodplain are a vital component of the landscape which support a vast array of flora and fauna which may vary greatly with the type of wetland/waterway system. The habitat provided by vegetation communities around wetlands is essential for maintaining populations of water dependent fauna species. Other ecological functions provided by floodplain complexes include water filtration, slowing surface water flow to reduce soil erosion, flood mitigation and reducing nutrient input into waterways. Protecting the ecological functioning of wetlands ensures these vital services are maintained.

In 2006 a flora and fauna survey was undertaken along the Yarriambiack Creek, Lake Lascelles and Lake Corrong. Two sites at Beulah were near to the target area (Birchip-Rainbow Rd, Beulah and Beulah water storage). Flora surveys were not undertaken at the Beulah Weir Pool. Seven native and seven introduced flora species were recorded at the Birchip-Rainbow Rd site. The vulnerable DSE listed Cane Grass, *Eragrostis australasica* was recorded (UOB 2006).

3.1.1 Listings and significance

Fauna

The Yarriambiack Creek at Beulah provides habitat for a range of fauna. Native species recorded at Beulah are listed in Appendix 3. This list includes a range of terrestrial species and one listed water dependent species. There has been relatively little survey effort in the region, which is reflected in the number of specie recorded. Of special interest and responsibility is the Eastern Great Egret, *Ardea modesta*, a water dependent species listed under the *Flora and Fauna Guarantee Act* and on the DSE Advisory list.

Table 6 Listed fauna recorded at the site

Common name	Scientific name	Type	International agreements	EPBC status	FFG status	DSE status
Eastern Great Egret	*Ardea modesta*	B	NL	NL	L	V

Legend
Type: Invertebrate, Fish, Amphibian, Reptile, Bird, Mammal
EPBC status: EXtinct, CRitically endangered, ENdangered, VUlnerable, Conservation Dependent, Not Listed
FFG status: Listed as threatened, Nominated, Delisted, Never Listed, Ineligible for listing
DSE status: presumed EXtinct, Regionally Extinct, Extinct in the Wild, CRitically endangered, ENdangered, Vulnerable, Rare, Near Threatened, Data Deficient, Poorly Known, Not Listed

In order to provide breeding opportunities and drought refuge habitat elements within the area such as emergent macrophytes and fringing vegetation of eucalypt, acacia and lignum swamps (Marchant & Higgins 1990) communities must be maintained in good condition.

Vegetation communities

Within the target area of the, the most extensive EVCs are Lignum Swampy Woodland and Riverine Chenopod Woodland.

For details on each EVC see Appendix 4. The EVCs within the target area and their conservation status can be seen in

Table 7.

Figure 4 EVCs within the target area of the Yarriambiack Creek.

Table 7 Conservation status of water dependent EVCs in the target area of the Yarriambiack Creek

EVC no.	EVC name	Bioregional Conservation Status
		Murray Mallee Bioregion
823	Lignum Swampy Woodland	Vulnerable
103	Riverine Chenopod Woodland	Depleted

Flora species

A full list of flora recorded at the Yarriambiack Creek at Beulah site can be found in Appendix 3. There were no water dependent flora species listed in the various acts and agreements which have been recorded in the Yarriambiack Creek at Beulah. Water dependant species recorded within 10 km of the site are listed in Table 8. Species which are typical of the Lignum Swampy Woodland EVC (DSE website) are listed in Table 9. These lists could provide a starting point for any revegetation of the riparian land within the site.

Table 8 Listed flora species recorded at the site

Common name	Scientific name
Lesser Joyweed	*Alternanthera denticulata s.l.*
Knob Sedge	*Carex inversa*
Common Sneezeweed	*Centipeda cunninghamii*
Common Spike-sedge	*Eleocharis acuta*
Small Loosestrife	*Lythrum hyssopifolia*
Common Nardoo	*Marsilea drummondii*
Tangled Lignum	*Muehlenbeckia florulenta*
Brown-back Wallaby-grass	*Rytidosperma duttonianum*
River Bluebell	*Wahlenbergia fluminalis*

Table 9 Species typical of at least part of Murray Mallee Lignum Swampy Woodland EVC

Common Name	Scientific Name
Tangled Lignum	*Muelenbekia florulenta*
Nitre Goosefoot	*Chenopodium nitrariaceum*
Tangled Lignum	*Muehlenbeckia florulenta*
Flat-top Saltbush	*Atriplex lindleyi*
Five-spined Bassia	*Sclerolaena muricata*
Dock	*Rumex spp.*
Common Nardoo	*Marsilea drummondii*
Variable Daisy	*Brachyscome ciliaris*
Annual Cudweed	*Euchiton sphaericus*
Buttercup	*Ranunculus spp.*
Twin-leaf Bedstraw	*Asperula gemella*
Cane Grass	*Eragrostis australasica*
Summer-grass	*Setaria jubiflora Warrego*
Brown-back Wallaby-grass	*Austrodanthonia duttoniana*
Short Rat-tail Grass	*Sporobolus mitchellii*
Bristly Love-grass	*Eragrostis setifolia*
Barren Cane grass	*Eragrostis infecunda*
Common Spike-sedge	*Eleocharis acuta*
Small Spike-sedge	*Eleocharis pusilla*

Wetland depletion and rarity

Victoria's wetlands are currently mapped and are contained within a state wetland database, using an accepted statewide wetland classification system, developed by Andrew Corrick from the Arthur Rylah Institute. Mapping was undertaken from 1981 using 1:25,000 colour aerial photographs, along with field checking. This database is commonly known as the 1994 wetland layer and contains the following information:

- categories (primary) based on water regime and
- subcategories based on dominant vegetation

None of the post-1994 wetland mapping is contained within this State wetland database.

At the same time, an attempt was made to categorise and map wetland areas occupied prior to European settlement. This was largely interpretive work and uses only the primary category, based on water regime. This is known as the 1788 layer.

It has been possible to determine the depletion of wetland types across the state using the primary category only, based on a comparison of wetland extent between the 1788 and 1994 wetland layers.

Comparison between the wetland layers has demonstrated the impact of European settlement and development on Victorian wetlands. This has been severe, with approximately one-third of the state's wetlands being lost since European settlement; many of those remaining are threatened by continuing degradation from salinity, drainage and agricultural practices (ANCA 1996).

Across the state, the greatest decreases in original wetland area have been in the freshwater meadow (43 per cent decrease), shallow freshwater marsh (60 per cent decrease) and deep freshwater marsh (70 per cent decrease) categories (DNRE 1997).

The Beulah Weir Pool has been classified on the DSE interactive map 1994 wetland category wetland classification system as Open water (Table 10). Using the Corrick Norman wetland classification system this would fit within the Permanent open freshwater category. This category of wetlands has seen a 73% increase in area from 1788 to 1994 in the Murray Mallee bioregion. This is due to areas permanently inundated due to weir pools, drainage basins and water storages, in a landscape which would have had mainly ephemeral wetlands.

Table 10 Changes in area of the wetlands in the target area by Corrick classification

Category	No of Wetlands in target area	Total area (ha)	Decrease in wetland area from 1788 to 1994		
			% Change in area in Victoria	% Change in area In Mallee CMA	% Change in Murray Mallee
Permanent Open Freshwater	1	3.1	-6	5	73

Source: DSE Biodiversity interactive maps, Mallee Wetland Strategy

Ecosystem functions

Healthy waterways and floodplains are fundamental to the region's environmental, social and economic future and provide a range of values including:

- Important ecosystem services, such as the provision of aquatic habitat and water for wetlands and floodplain ecosystems, nutrient recycling and water purification;
- Extensive indigenous cultural values dating back thousands of years and more recent historic values from early European settlement of the region;
- Extensive water supplies for irrigation, industrial, stock and domestic use; and
- A rich and diverse landscape for tourism and recreational opportunities.

Ecosystems support distinctive communities of plants and animals and provide numerous ecosystem services to the community (DSE 2005). Floodplain wetlands perform important functions necessary to maintain the hydrological, physical and ecological health of river systems. These ecosystem functions include:

- enhancing water quality through filtering sediments and re-using nutrients;
- absorbing and releasing floodwaters;
- providing organic material to rivers to maintain riverine food chains; and
- providing feeding, breeding and drought refuge sites for an array of flora and fauna, especially waterbirds and fish.

The Yarriambiack Creek is an intermittent stream which terminates in a number of large wetland complexes (Mallee CMA 2006). Altered water regimes in the target area due to regulation and dry conditions have seen a decrease in the frequency of inundation in other floodplain wetlands and therefore a decrease in the ability for these wetlands to perform valuable ecosystem functions.

3.1 Social

3.1.1 Cultural heritage

Yarriambiack Creek is an important cultural site for the local indigenous people and is located with the traditional territories of the Jardwadjali (in the south) and Wergaia (in the centre and north) clans (Kamminga & Grist 2000). The target area at Beulah is within Wergaia territory. Yarriambiack Creek is likely to have been an important meeting place and source of food. Scar trees, artefact scatters, burial sites and mounds are found along the creek line (KBR 2004).

The establishment of pastoral properties in around 1869 began to dispossess the Wergaia and Jardwadjali of virtually all their better land. Numbers of Aboriginal people declined throughout the 19th century. Aboriginal people were employed on stations and were moved to the Ebenezer and Lake Condah missions (Kamminga & Grist 2000).

European heritage reflects the pioneering history of the area. The first British explorer to the region was Major Thomas Mitchell in 1836, who followed the course of the Wimmera River. In the early 1840s the first squatters began to settle the area as large pastoral properties. The Yarriambiack Creek was gradually settled from south to north. In the 1860s large areas of Crown Land were offered for sale as freehold.

3.1.2 Recreation

Yarriambiack Creek is the only natural watercourse in the area and is therefore an important recreational area, especially to the townspeople of Beulah (KBR 2004).The weir pool is popular for swimming, fishing, boating water skiing, picnicking area, and has access to a walking trail along the creek (Water Technology 2012). The community have also been involved in tree planting and Waterwatch activities along the creek.

3.2 Economic

The Yarriambiack Creek at Beulah has been used for irrigation and stock and domestic water supply in the past. Water within the weir pool is also used to irrigate local sporting grounds.

3.3 Significance

The environmental, social and economic values outlined indicate the significance of this site. While these values do not constitute Yarriambiack Creek at Beulah being a unique or pristine site, the riparian and floodplain communities of the Yarriambiack Creek are important to the functioning of the creek system, the community and its sustainability. The area is rich in biodiversity, essential as habitat to native species and a refuge for listed fauna species. The cultural importance of this site is considered very significant as these social and cultural values are important to local communities of the area. The values contained within the Yarriambiack Creek and specifically the target area for this plan makes this area a priority for protection and enhancement through environmental water management. Of particular significance are the, Black Box and Tangled Lignum communities which line the weir pool. These form the basis for the functioning ecological system and are the primary focus of this plan.

4. HYDROLOGY AND SYSTEM OPERATIONS

Wetland hydrology is the most important determinant in the establishment and maintenance of wetland types and processes. It affects the chemical and physical aspects of the wetland which in turn affects the type of flora and fauna that 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 in DSE 2005). Duration, frequency and seasonality (timing) are the main components of the hydrological regime for wetlands, rivers and creeks.

The target area at Beulah is located on the Yarriambiack Creek which does not have streamflow data (GHD 2011). The creek has no natural base flow and would only receive water when the Wimmera River has high flows (KBR 2004). The construction of large water storages in the upper Wimmera catchment has resulted in reduced entering the Yarriambiack Creek (UOB 2006). Permanent water supply is now delivered to the weir pool via the Wimmera Mallee pipeline.

4.1 Water management and delivery

4.1.1 Pre-regulation

Yarriambiack Creek is an distributary of the Wimmera River and flows in a generally northerly direction past Beulah. Flows within the Yarriambiack Creek are dependent on flows within the Wimmera River, and are relatively slow due to the flat grade. Significant flood events have occurred in 1894, 1909, 1915, 1974, 2011 and lesser events in 1981 and 1983. Flooding in Beulah is thought to occur in floods a little lower than the 50 year ARI event (GHD 2011).

4.1.2 Post-regulation

The Yarriambiack Creek has been extensively modified since European settlement, with regulating structures, weir pools and diversions (KBR 2004). There are currently regulators at Beulah to maintain the weir pool which may restrict the conveyance of small, medium and large floods. These structures have the ability to pass most flood flows, however current operation practices may not be achieving an equitable balance between recreation, flood protection and flows for the environment (SMEC 2001). The natural flow regime of the Wimmera River has also been substantially altered with approximately 48% of the average annual flow diverted from the river for commercial, irrigation, stock and domestic purposes (SKM 2002). In 1967 a resolution of the State Rivers and Water Supply Commission provided for a 3:1 split of flows between the Wimmera River and the Yarriambiack Creek (KBR 2004).

The use of structures for irrigation, stock and domestic purposes has decreased and these structures are now used to provide the community with water for recreational facilities and to regulate flow. A deep section of the Beulah weir pool in 2003 was one of only two areas that retained water in the Yarriambiack Creek after seven years of drought (KBR 2004). This was prior to the Wimmera Mallee Pipeline program and the pumping of water to maintain the weir pool.

The commence to fill (ctf) for the Yarriambiack Creek is regulated by a structure at the point where the Yarriambiack Creek leaves the Wimmera River (WBM Oceanics Australia 2003).

The current operating pool level of the Beulah weir pool is 85.7 m AHD and it can contain 38 ML of water (extracted from LiDAR). It is currently filled with a 36 ML allocation each year and topped up by GWM Water with approximately 20 ML of water as required.

4.1.3 Flood Mitigation

Extremely heavy rainfall events in January 2011 caused flooding across Victoria. Mitigation measures were put in place following the rain and as the flood waters moved through the area to reduce flooding in the Beulah township. This included:

- Excavation of Beulah weir downstream on Luna Park Road
- Excavation of Beulah weir upstream; and
- Numerous levees and sandbagging.

Following the flooding and excavations for flood mitigation, repair of some existing structures was required. These included:

- The downstream weir at Luna Park Rd. The revised design of the weir lowered the road crest with a removable 'flood wall'. This will allow more water to pass over Luna Park Rd, decreasing the potential flood level in the weir pool.
- An investigation of the upstream weir pool was undertaken to improve the social, economic and environmental attributes of the Yarriambiack creek through Beulah.

Since then, works have been undertaken to reinstate the excavated infrastructure and investigations have been undertaken to look at the feasibility of on ground works to minimise the impact of floods on private and public assets while maximising the environmental opportunities.

5. THREATS AND CONDITION

5.1 Water dependent threats

The values for the target area of the Yarriambiack Creek are described in section 3. Threats to these values are the result of such factors as human intervention and climate variability. Some of the threats which may have an impact on the Beulah Weir Pool and Yarriambiack Creek include:

- Changed water regime, permanent inundation
- Water quality
- Introduction/increase of exotic flora and fauna
- Bank erosion

Permanent inundation, as experienced in the Beulah weir pool typically results in decreased plant species richness. This can eliminate the number of emergent and semi-emergent species, many of which require exposed sediment for germination and establishment (in Boon 2011)

Grazing along the Crown Water Frontages including Yarriambiack Creek can lead to soil disturbance and compaction, increased bank erosion, introduced weed species, and increased runoff of sediments and nutrients to the creek (Mallee CMA 2006).

Bank erosion is typically caused by undermining of the banks and slumping causing banks that are too steep for stability. The undermining is typically caused by wave or current action or a combination of both, possibly aided by local wind effects in some areas. Waves may be caused by the action of the wind blowing across the water surface. Of greater impact are boat wakes that result from vessels plying the waterbody and recreational speed boats.

Trampling and damage to the bush exposes the fragile soils to wave, stream flow and wind action. Trampling may be caused by stock and high volumes of human activity. This includes getting on/off boats in concentrated areas, walking along the bank, picnicking along the bank and mooring vessel to trees. A method of minimising bank erosion is revetments, described in Section 8.2.2.

5.2 Current condition

The Mallee River Health Strategy (Mallee RHS) used the RiVERS database to prioritise high value reaches. RiVERS is a database that uses an asset and threat based approach, incorporating risk management principles. RiVERS holds information on the environmental, social and economic values of river reaches.

The Yarriambiack Creek was the fourth highest ranked reach for social values and the ninth highest for economic values in the Mallee CMA region. For more details see Table 11. Overall it was classified as Priority 1 for management for social and economic values.

Table 11 RiVERS scores for the Yarriambiack Creek

RiVERS Criteria	Score	Rating
Environmental	39	Moderate
Social	40	High
Economic	20	High

The altered water regime is considered the major threat for the Beulah weir pool and is the primary factor behind the development of this environmental water management plan.

6. MANAGEMENT OBJECTIVES

6.1 Seasonally adaptive approach

Victoria has adopted an adaptive and integrated management approach to environmental management. A key component of this approach for environmental watering is the 'seasonally adaptive' approach, developed through the Northern Region Sustainable Water Strategy and incorporated into the Victorian Strategy for Healthy Rivers, Estuaries and Wetlands.

The seasonally adaptive approach identifies the priorities for environmental watering, works and complementary measures, depending on the amount of water available in a given year. It is a flexible way to deal with short-term climatic variability and helps to guide annual priorities and manage droughts. The approach is outlined in Table 12.

The seasonally adaptive approach has been used to guide the watering regime under various climatic scenarios. In drier periods, restricted water resource availability will potentially limit the number of ecological objectives which can realistically be provided through environmental water management. However, these ecological objectives can be achieved in wetter periods as water resource availability increases.

Table 12 The seasonally adaptive approach to river and wetland management (DSE, 2009)

	Drought	Dry	Average	Wet to very wet
Long-term ecological objectives	Long-term objectives to move towards ecologically healthy rivers - set through regional river health strategies and sustainable water strategies and reviewed through the 15-year resource review			
Short-term ecological objectives	• Priority sites have avoided irreversible losses and have capacity for recovery	• Priority river reaches and wetlands have maintained their basic functions	• The ecological health of priority river reaches and wetlands has been maintained or improved	• The health and resilience of priority river reaches and wetlands has been improved
Annual management objectives	• Avoid critical loss • Maintain key refuges • Avoid catastrophic events	• Maintain river functioning with reduced reproductive capacity • Maintain key functions of high priority wetlands • Manage within dry-spell tolerances	• Improve ecological health and resilience	• Maximise recruitment opportunities for key river and wetland species • Minimise impacts of flooding on human communities • Restore key floodplain linkages
Environmental water reserve	• Water critical refuges • Undertake emergency watering to avoid catastrophic events • Provide carryover (for critical environmental needs the following year) • If necessary, use the market to sell or purchase water	• In priority river reaches provide summer and winter baseflows • Water high priority wetlands • Provide river flushes where required to break critical dry spells • Provide carryover (for critical environmental needs the following year) • If necessary, use the market to sell or purchase water	• Provide all aspects of the flow regime • Provide sufficient flows to promote breeding and recovery • Provide carryover to accrue water for large watering events • If necessary, use the market to sell or purchase water	• Provide overbank flows • Provide flows needed to promote breeding and recovery • If necessary, use the market to sell or purchase water
River and wetland catchment activities	• Protect refuges (including stock exclusion) • Increase awareness of the importance of refuges • Enhanced monitoring of high risk areas and contingency plans in place • Investigate feasibility of translocations • Environmental emergency management plans in place • Protect high priority river reaches and wetlands through fencing; pest, plant and animal management; and water quality improvement works • Implement post-bushfire river recovery plans	• Protect refuges • Protect high priority river reaches and wetlands through fencing, revegetation, pest plant and animal management, water quality improvement and in-stream habitat works • Environmental emergency management plans in place • Improve connectivity • Implement post-bushfire river recovery plans	• Protect and restore high priority river reaches and wetlands through fencing, revegetation, pest plant and animal management, water quality improvement and in-stream habitat works • Monitor and survey river and wetland condition • Improve connectivity between rivers and floodplain wetlands	• Protect and restore high priority river reaches and wetlands through fencing, revegetation, pest plant and animal management, water quality improvement and in-stream habitat works • Monitor and survey river and wetland condition • Improve connectivity between rivers and floodplain wetlands • Emergency flood management plans in place • Implementation of post-flood river restoration programs

6.2 Management goal

The overall goal proposed for the Beulah weir pool and Yarriambiack Creek target area has been developed through consultation with various experts and stakeholders including the Beulah Weir Pool Committee of Management, the Wetland Evaluation Team and local residents. The goal considers the values the wetland supports and the potential threats that need to be managed. This includes consideration of the values the wetland has historically supported and the likely values it could support into the future.

Yarriambiack Creek management goal
To maintain and enhance the Black Box woodlands fringing the creek

Beulah weir pool management goal:
To introduce weir pool variations, maintain ponded areas for native fish refuges and recreational use

6.3 Ecological and hydrological objectives

6.3.1 Ecological objectives

Ecological objectives represent the desired ecological outcomes of the site based on the key values outlined in section 3. In line with the draft policy Victorian Strategy for Healthy Rivers, Estuaries and Wetlands (VSHREW) the ecological objectives are expressed as the target condition or functionality for each key value. The ecological objectives involve establishing one of the following trajectories of each key value, which is related to the present condition or functionality of the value:

- maintain
- improve
- protect
- re-instate

The hydrological objectives are based on principles that are broadly applicable to many floodplain wetlands in south-eastern Australia.

1. Maintaining stable, high water levels is generally incompatible with the maintenance of high ecological values; and
2. Water levels need to fluctuate seasonally.

Fluctuating water levels allow a wide range of vegetation types to develop, as rising and falling water alternately exposes and inundate different parts of shorelines. Fluctuating water levels also facilitate the creation of shallow fringing areas which allow wading birds to feed and submerged aquatic plants to maintain photosynthetic organs in the photic zone (from Boon 2011).

Table 13 Ecological objectives for the site

Site	Ecological objective	Justification (value based)
Yarriambiack Creek	Improve health of Black Box community	Large trees contain hollows and cracks which provide habitat for a range of species, including Carpet Python, bats and nesting birds.
Beulah Weir Pool	Introduce water level fluctuations whilst, maintaining refuges for native fish	Fluctuating water levels allow a range of vegetation and habitat types to develop for both terrestrial and aquatic species.

As more is learnt about the area and the response to the watering events are monitored the principles of adaptive management along with availability of environmental water sources will guide future requirements and management actions at this and other environmental watering sites.

Once a more natural wetting and drying regime is established in the weir pool an opportunity arises for native flora species of local providence to be re introduced.

6.3.2 Hydrological objectives

Hydrological objectives describe the components of the water regime required to achieve the ecological objectives at this site. The ecological objectives at this site are centred on improving the Black Box community along the Creek and maintaining the weir pool as a refuge for the current fish population. Two hydrological scenarios are presented: one for the weir pool and one for the creek (Table 14). The hydrological objectives are based on the assumption that the current water allocation for the weir pool will be available for both the weir pool and the creek annually. A maximum volume of 75 ML is required to fill and top up both the weir pool and creek (with infrastructure recommendations in place) without lowering the current water level.

The water requirements to maintain adult Black Box has been summarised in Rogers (2011) as follows:

Ideal flood frequency	1 in 2-5 years
Ideal flood duration	2-4 months
Maximum flood duration	5 months
Ideal flood timing	Not Important
Ideal interflood dry period	Variable
Maximum interflood dry period	Unknown

These requirements have been used to develop hydrological objectives for the Yarriambiack Creek.

The volumes given are dependent on whether the infrastructure proposed to allow inundation of the target area will be in place or not.

Table 14 Hydrological objectives for the Beulah weir pool and Yarriambiack Creek target area

Ecological objective	Water management area	Hydrological Objectives														
		Mean frequency of events (number per 10 years)			Tolerable interval between events (years)		Duration of ponding (months)			Preferred timing of inflows	Target supply level (m)	Volume currently allocated (ML)	Volume to fill to TSL (ML)	Volume to maintain at TSL (ML)	Total volume per event (ML)	
		Min	Opt	Max	Min	Max	Min	Opt	Max						Min	Max
Improve Black Box Health	Yarriambiack Creek	**2**	**3**	**5**	**1**	**10**	**2**	**3**	**5**	**Spring**	**1**	**0**	**55**	**N/A**	**48**	**55**
Maintain refuges for native fish	Beulah Weir Pool	**10**	**10**	**10**	**0**	**0**	**12**	**12**	**12**	**Spring**	**2.5**	**38**	**38**	**20**	**38**	**58**

6.3.3 Watering regime

The wetland watering regime has been derived from the ecological and hydrological objectives. To allow for adaptive and integrated management, the watering regime is framed using the seasonally adaptive approach. This means that a watering regime is identified for optimal conditions, as well as the maximum and minimum tolerable watering scenarios. The minimum watering regime is likely to be provided in drought or dry years, the optimum watering regime in average conditions and the maximum watering regime in wet or flood years.

The optimal, minimum and maximum watering regimes are described below. Due to the inter-annual variability of these estimates (particularly the climatic conditions), determination of the predicted volume requirements in any given year will need to be undertaken by the environmental water manager when watering is planned.

Minimum watering regime

Beulah weir pool
Inundate the weir pool each year during spring and summer and drawdown the level at intervals at other times of the year. Maintain a ponded area for fish refuge all year round.

Yarriambiack Creek
Inundate the target area of the creek two in every ten years with a maximum interval of seven years between events. Maintain the water in the creek line for at least two months.

Optimal watering regime

Beulah weir pool
Inundate the weir pool each year during spring and summer and drawdown the level at intervals at other times of the year. Maintain a ponded area for fish refuge all year round.

Yarriambiack Creek
Inundate the target area of the creek three in every ten years with a maximum interval of three years between events. Maintain the water in the creek line for two-four months.

Maximum watering regime

Beulah weir pool
Inundate the weir pool each year during spring and summer and drawdown the level at intervals at other times of the year. Maintain a ponded area for fish refuge all year round.

Yarriambiack Creek
Inundate the target area of the creek every other year with a minimum interval of one year between events. Maintain the water in the creek line for no more than five months.

7. POTENTIAL RISKS OF AND MITIGATION MEASURES FOR ENVIRONMENTAL WATERING

A table of potential risks and means for mitigating these is used as the basis for assessing the risk of environmental water delivery at this site. The terms for values that may be impacted come from the Aquatic Value Identification and Risk Assessment (AVIRA) Report (Peters, 2009).

The table identifies potential risks, events that could cause such risks, the outcomes of such risks, and the actual values that could subsequently be impacted by each risk. Mitigation strategies for each event are also identified.

Table 15 Potential risks associated with environmental water delivery

#	Risk	Description	Potential Impacts								Mitigation
			Environmental					Social		Economic	
			Fish *Water regime does not support breeding and feeding requirements*	**Birds** *Water regime does not support breeding and feeding requirements*	**Amphibians** *Water regime does not support breeding and feeding requirements*	**Invertebrate** *Water regime does not support breeding and feeding requirements*	**Native aquatic flora** *Watering requirement does not support establishment and growth.*	Reduced public access and use	Degradation of cultural heritage sites	Flooding of adjacent land	
1	Required watering regime not met	Flood duration too long or short	✓	✓	✓		✓	✓		✓	Determine environmental water requirements based on seasonal conditions and to support potential bird breeding events Monitor flood duration to inform environmental water delivery Monitor the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		Flood timing too late or early	✓	✓	✓		✓	✓		✓	Liaise with Grampians Wimmera Mallee Water to seek optimum timing of water delivery Monitor flood timing to inform environmental water delivery Monitor the ecological response of the wetland to flooding
		Flooding depth too shallow or deep	✓	✓			✓	✓	✓	✓	Determine environmental water requirements based on seasonal conditions and to support potential bird breeding events Monitor flood depth to inform environmental water delivery Liaise with adjoining landowners prior to and during the delivery of environmental water to discuss and resolve potential or current flooding issues Add or drawdown water where appropriate or practical
		Flood frequency too long or short	✓	✓	✓	✓	✓	✓			Prioritise water requirements of wetlands in seasonal watering proposals according to their required water regimes and inundation history Monitor the condition of the wetland Monitor the ecological response of the wetland to flooding

2	Poor water quality	Low dissolved oxygen	✓	✓			✓				Monitor dissolved oxygen levels and the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		High turbidity	✓				✓				Monitor turbidity levels and the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		High water temperature	✓				✓				Monitor water temperature and the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		Increased salinity levels	✓		✓	✓	✓				Monitor salinity levels and the ecological response of the wetland to flooding Add or drawdown water where appropriate or practical
		Increased nutrient levels									Monitor nutrient and Blue Green Algae levels, and the ecological response of the wetland to flooding Place public warning signs at the wetland if BGA levels are a public health risk Add or drawdown water where appropriate or practical
		Increased organic matter	✓				✓				Implement the required water regime
3	Pest aquatic plant and animal invasion	Introduction of pest fish	✓		✓	✓	✓				Monitor the ecological response of the wetland to flooding Install a carp screen Implement an appropriate drying regime
		Growth and establishment of aquatic pest plants	✓	✓	✓	✓	✓				Monitor the abundance of native and pest aquatic plants Control pest plants in connected waterways Spray or mechanically remove pest plants Implement an appropriate drying regime

8. WATER DELIVERY INFRASTRUCTURE

8.1 Constraints

Beulah weir pool has an operating pool level of 85.7 m AHD. At this level the weir pool contains around 38 ML[1]. This is contained by weirs on the downstream and upstream ends of the weir pool.

The existing arrangements (Section 4.1) limit the extent of area of the Beulah weir pool and Yarriambiack Creek which can be inundated by regulated water delivery.

Current infrastructure includes:

- An upstream weir structure that provides a substantial blockage to Yarriambiack Creek when floods occur. This causes flooding south of the town (downstream).
- Culverts on the downstream end at the Birchip Rainbow Rd crossing of Yarriambiack Creek. The existing culverts have been upgraded to a larger size to reduce local water levels and flooding of agricultural land (Water Technology 2012).

[1] Volume extracted from LiDAR

Figure 5 Current inundation extent of Beulah Weir Pool and Yarriambiack Creek target area

8.2 Infrastructure recommendations

8.2.1 Water Management Infrastructure

Following the investigation completed by Water Technology (2012) and further community consultation through the Beulah weir pool committee of management; four options remain in consideration for the management of the structures at the Beulah weir pool:

Option 1
Remove the upstream regulator structure and install a low (~1m) spillway approximately 130 m upstream from the current structure. It is proposed that this low structure would maintain the current depth in the weir pool for recreational boating and would decrease the

obstruction to water movement through the weir pool in high flow events. It would also allow environmental water pumped into the weir pool to spill over the new structure and provide water for the upstream vegetation for a distance of up to 1.3km depending on volumes available.

Figure 6 Map of changes required at Beulah weir pool for Option 1

Option 2

Remove the current upstream regulator structure only. This option would see a decrease in the operating pool level of 20cm and allow water to inundate the upstream reach of the creek by up to 1.3km depending on the volume of environmental water available. Mitigation of high flows inundating the town would be achieved according to the Water Technology report (2012).

Option 3

Remove the upstream regulator structure as per Option 2 and place a small (0.5 – 1.0m) structure along side the private access track (~800 m upstream from current structure) to allow environmental water upstream of the weir pool to be held at a higher level to maintain the current operating level of the weir pool. This option reduces the flexibility for environmental and recreational water use but removes any flood inundation of houses in major floods.

Figure 7 Map of changes required at Beulah weir pool for options 2 and 3

Option 4

No change to infrastructure. This does not resolve the town flooding issue or allow for significant environmental water events upstream of the weir pool. It would maintain the recreational boating conditions currently in place.

Further investigations

Each of these options would require further studies and/or modelling to be undertaken prior to implementation to evaluate the level of flood mitigation, environmental impacts and detailed design and costing. Monitoring and evaluation of any changes would be required.

Assessment of the holding capacity of the weir pool is also recommended as volumes delivered to the weir pool have far exceeded the stated capacity of 38ML and expected evaporation losses of approximately 10ML/ha/yr. Grampians Wimmera Mallee Water expected to deliver 70ML to the Beulah weir pool between September and November 2010 (GWM Newsletter Aug 2010).

8.2.2 Bank Stabilisation Infrastructure

The use of power boats in the weir pool has led to some bank erosion. It is suggested that revetments be put in place to manage this impact. Revetments are structures built along the shoreline to stop the advance of erosion into the river bank.

The principles of designing revetments are that they should:

- Be located parallel to the shore
- Be constructed of a material to in in reasonable harmony with the surrounding riverside, and not be of a contrasting colour.
- Avoid vertical walls
- Avoid highly wave reflective surfaces
- Avoid impermeable surfaces
- Avoid overtopping by waves.

The preferred construction should take in the following principles:

- A slope no steeper than 1 vertical to 2 horizontal to help reduce wave reflections
- Surface should be rough and permeable to help diminish wave run-up and reflections
- Toe of the revetment well buried and be below the maximum erosion level, plus an allowance for possible local river bed scour that may result once the structure is constructed
- The crest (top) of the revetment should be above the wave runup level to avoid damaging overtopping. Measured vertically from the still water this is typically at least 2 to 3 wave heights, depending on the design.
- Typical materials include sand filled geotextile bags, placed large rock, concrete crib type walls, and special concrete interlocking units laid over a heavy weight geotextile and often a secondary filter layer. Timber, concrete rubble or rubber tyres are typically not suitable materials

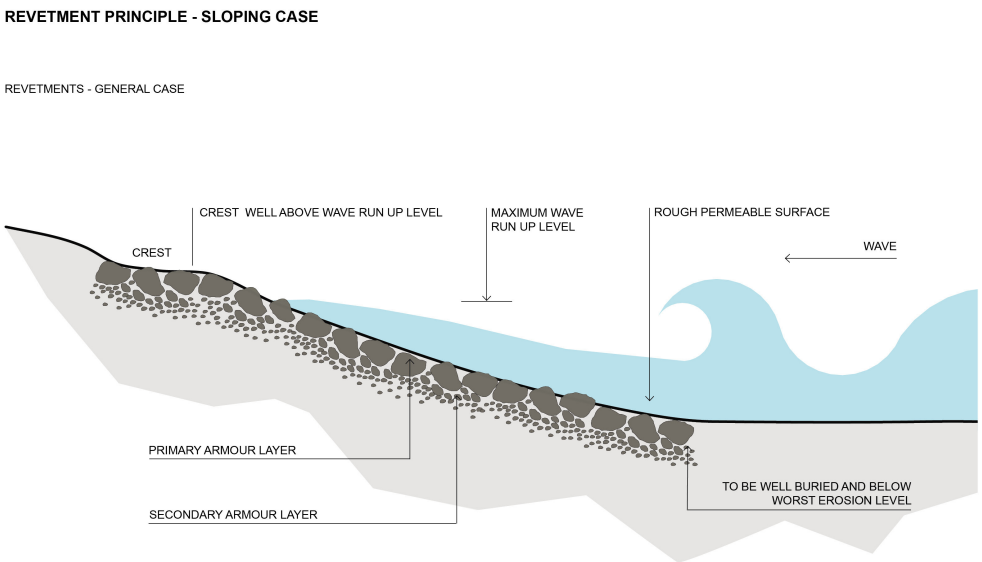

Figure 8 Revetment Principles

9. KNOWLEDGE GAPS AND RECOMMENDATIONS

This plan is based on best information at the time of writing. In some cases this information is scarce or outdated. Further investigation and information collection will continue and the results of this further work will continue to build a better picture of the site and add rigor to future planning. Some areas where further knowledge would be beneficial are outlined in Table 16. A cultural heritage management plan would be essential before any on ground works could be undertaken.

Table 16 Knowledge gaps and recommendations for the target area

Knowledge and data gaps	Action recommended	Responsibility
Conceptual and detail designs for the management works	Engage consultants to carry out investigations and designs	Implementation of any of these recommendations would be dependent on investment from Victorian and Australian Government funding sources as projects managed through the Mallee CMA
Full extent of cultural Heritage values	As per requirements of the Cultural heritage Act 2006	
Unexplained water losses from the weir pool	Holding capacity assessment of the weir pool	
Fish population in the weir pool	Data collection and monitoring	
Water quality monitoring	Data collection and monitoring	
Flora and fauna surveys	Data collection and monitoring	
Accurate depth and volumes for the wetland	Install depth gauges, flow meters and bathymetric survey	
Nesting habits of birds at the site	Data collection and monitoring	
Impacts of climate variability	Data collection and monitoring	

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WEBSITES

Department of Sustainability and Environment Bioregions:
http://www.dse.vic.gov.au/conservation-and-environment/victorias-bioregions#bioregion

Department of Planning and Community Development:
http://www.dpcd.vic.gov.au/indigenous/heritage-tools/areas-of-cultural-sensitivity/41rostr-mallee-region-maps

Grampians Wimmera Mallee Water
http://www.gwmwater.org.au/information/bulk-entitlement

Appendix 1: WATER SOURCES

Sources of water potentially available for this site under current arrangements and in the future.

Bulk Entitlements

A bulk entitlement is a right to use and supply water which may be granted to water corporations, the Victorian Environmental Water Holder and other specified bodies. Bulk entitlements are issued along with a range of conditions and obligations set out under Part 4 of the Water Act 1989. Bulk entitlements can be held in relation to water in a waterway, water in storage works of a water corporation and groundwater.

The Wimmera Mallee Pipeline Project (WMPP) replaced 18,000 km of inefficient earthen channel with 9,159 km of pressurized pipeline and associated structures. The pipeline saves on average 103 billion litres of water a year and provides continuous water supply to farms and towns across the Wimmera and Mallee. The 103 gigalitres (GL) is now a bulk water entitlement to water authorities with 83 GL of water a year going to the region's river systems and 20 GL for regional growth water for towns.

As a result of the pipeline, Grampians Wimmera Mallee Water has been allocated 3 GL of water to supply recreational lakes formerly supplied by the channel. The Beulah weir pool is a recreational lake supplied water under this scheme.

APPENDIX 2 LEGISLATIVE FRAMEWORK

International agreements and conventions

Ramsar Convention on Wetlands (Ramsar)

The Australian Government is a Contracting Party to the convention, which is an inter-governmental treaty whose mission is "the conservation and wise use of all wetlands through local, regional and national actions and international cooperation, as a contribution towards achieving sustainable development throughout the world".

Bilateral migratory bird agreements

Australia is a signatory to the following international bilateral migratory bird agreements:

- Japan-Australia Migratory Bird Agreement (JAMBA);
- China-Australia Migratory Bird Agreement (CAMBA); and
- Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA).

These agreements require that the parties protect migratory birds by:

- limiting the circumstances under which migratory birds are taken or traded;
- protecting and conserving important habitats;
- exchanging information; and
- building cooperative relationships.

Convention on the Conservation of Migratory Species of Wild Animals (Bonn)

This convention (known as the Bonn Convention or CMS) aims to conserve terrestrial, marine and avian migratory species throughout their range. It is an intergovernmental treaty, concluded under the aegis of the United Nations Environment Programme, concerned with the conservation of wildlife and habitats on a global scale. The Convention was signed in 1979 in Bonn, Germany, and entered into force in 1983.

Commonwealth legislation

Environment Protection and Biodiversity Conservation Act 1999 (EPBC)

This is the key piece of legislation pertaining to biodiversity conservation within Australia. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places – defined in the EPBC Act as matters of national environmental significance.

Water Act 2007 (Commonwealth Water Act)

This establishes the Murray-Darling Basin Authority (MDBA) with the functions and powers, including enforcement powers, needed to ensure that Basin water resources are managed in an integrated and sustainable way.

Aboriginal and Torres Straight Islander Heritage Protection Act 1984

This aims to preserve and protect areas and objects in Australia and Australian waters that are of particular significance to indigenous people from injury or desecration.

State legislation and listings

Flora and Fauna Guarantee Act 1988 (FFG)

This is the key piece of Victorian legislation for the conservation of threatened species and communities and for the management of potentially threatening processes.

Advisory lists of rare or threatened species in Victoria (DSE)

Three advisory lists are maintained by DSE for use in a range of planning process and in setting priorities for actions to conserve biodiversity. Unlike other threatened species lists, there are no legal requirements or consequences that flow from inclusion of a species on an advisory list. The advisory lists comprise:

- Advisory List of Rare or Threatened Plants In Victoria – 2005
- Advisory List of Threatened Vertebrate Fauna in Victoria – 2007
- Advisory List of Threatened Invertebrate Fauna in Victoria – 2009

Environmental Effects Act 1978

Potential environmental impacts of a proposed development are subject to assessment and approval under this Act. A structural works program and any associated environmental impacts would be subject to assessment and approval under the Act.

Planning and Environment Act 1987

This controls the removal or disturbance to native vegetation within Victoria by implementation of a three-step process of avoidance, minimisation and offsetting.

Water Act 1989 (Victorian Water Act)

This 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 under 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 this Act.

Other relevant legislation

The preceding legislation operates in conjunction with the following other Victorian legislation to influence the management and conservation of Victoria's natural resources as well as outline obligations with respect to obtaining approvals for structural works:

- Environment Protection Act 1970
- Catchment and Land Protection Act 1994
- Heritage Act 1995
- Conservation, Forests and Lands Act 1987
- Land Act 1958
- Heritage Rivers Act 1992
- Wildlife Act 1975
- Murray Darling Basin Act 1993
- National Parks Act 1975
- Parks Victoria Act 1998
- Forests Act 1958

APPENDIX 3 FLORA AND FAUNA SPECIES LIST

Flora – Native

Common Name	***Scientific Name***	**Records**
Gold-dust Wattle	*Acacia acinacea s.l.*	1
Grey Mulga	*Acacia brachybotrya*	1
Hakea Wattle	*Acacia hakeoides*	1
Umbrella Wattle	*Acacia oswaldii*	8
Buloke	*Allocasuarina luehmannii*	15
Lesser Joyweed	*Alternanthera denticulata s.l.*	1
Box Mistletoe	*Amyema miquelii*	2
Common Woodruff	*Asperula conferta*	1
Berry Saltbush	*Atriplex semibaccata*	9
Saltbush	*Atriplex spp.*	1
Sprawling Saltbush	*Atriplex suberecta*	2
Feather Spear-grass	*Austrostipa elegantissima*	2
Knotty Spear-grass	*Austrostipa nodosa*	1
Rough Spear-grass	*Austrostipa scabra subsp. falcata*	1
Spear Grass	*Austrostipa spp.*	2
Lobe-seed Daisy	*Brachyscome dentata*	1
Silver Moss	*Bryum argenteum*	1
Sweet Bursaria	*Bursaria spinosa*	1
Lemon Beauty-heads	*Calocephalus citreus*	1
Rough Burr-daisy	*Calotis scabiosifolia*	1
Knob Sedge	*Carex inversa*	1
Common Sneezeweed	*Centipeda cunninghamii*	1
Frosted Goosefoot	*Chenopodium desertorum*	2
Frosted Goosefoot	*Chenopodium desertorum subsp. desertorum*	1
Windmill Grass	*Chloris truncata*	3
Common Everlasting	*Chrysocephalum apiculatum s.l.*	1
Spreading Crassula	*Crassula decumbens var. decumbens*	1
Swamp Crassula	*Crassula helmsii*	1
Gypsum Moss	*Crossidium geheebii*	1
Black-anther Flax-lily	*Dianella revoluta s.l.*	1
Stiff Flax-lily	*Dianella sp. aff. revoluta (North-west Victoria)*	1
Beard Moss	*Didymodon torquatus*	1
Nodding Saltbush	*Einadia nutans subsp. nutans*	9
Common Spike-sedge	*Eleocharis acuta*	1
Ruby Saltbush	*Enchylaena tomentosa var. tomentosa*	13
Spider Grass	*Enteropogon acicularis*	3
Cane Grass	*Eragrostis australasica*	4
Turkey Bush	*Eremophila deserti*	1
Berrigan	*Eremophila longifolia*	1

Blue Devil	*Eryngium ovinum*	1
Bull Mallee	*Eucalyptus behriana*	5
Red Mallee	*Eucalyptus calycogona*	2
Red Mallee	*Eucalyptus calycogona subsp. trachybasis*	1
Dumosa Mallee	*Eucalyptus dumosa*	8
Black Box	*Eucalyptus largiflorens*	8
Oil Mallee	*Eucalyptus oleosa subsp. oleosa*	3
Yarriambiack Mallee-box	*Eucalyptus sp. aff. wimmerensis (Yarriambiack)*	2
Common Eutaxia	*Eutaxia microphylla*	1
Pineapple Moss	*Gigaspermum repens*	1
Cut-leaf Goodenia	*Goodenia pinnatifida*	1
Small-flower Goodenia	*Goodenia pusilliflora*	1
Common Blown-grass	*Lachnagrostis filiformis s.l.*	1
Small Loosestrife	*Lythrum hyssopifolia*	1
Short-leaf Bluebush	*Maireana brevifolia*	5
Black Cotton-bush	*Maireana decalvans*	1
Wingless Bluebush	*Maireana enchylaenoides*	3
Hairy Bluebush	*Maireana pentagona*	1
Common Nardoo	*Marsilea drummondii*	2
Yam Daisy	*Microseris scapigera s.l.*	1
Tangled Lignum	*Muehlenbeckia florulenta*	7
Sugarwood	*Myoporum platycarpum*	3
Wood Sorrel	*Oxalis spp.*	2
Panic	*Panicum spp.*	1
Weeping Pittosporum	*Pittosporum angustifolium*	4
Narrow Plantain	*Plantago gaudichaudii*	1
Earth Moss	*Pterygoneurum ovatum*	1
Feather Heads	*Ptilotus macrocephalus*	1
Drumsticks	*Pycnosorus globosus*	1
Hedge Saltbush	*Rhagodia spinescens*	6
Paper Sunray	*Rhodanthe corymbiflora*	4
Sand Thread-moss	*Rosulabryum campylothecium*	1
Slender Dock	*Rumex brownii*	2
Brown-back Wallaby-grass	*Rytidosperma duttonianum*	1
Bristly Wallaby-grass	*Rytidosperma setaceum*	2
Bristly Wallaby-grass	*Rytidosperma setaceum var. setaceum*	1
Wallaby Grass	*Rytidosperma spp.*	2
Prickly Saltwort	*Salsola tragus*	2
Prickly Saltwort	*Salsola tragus subsp. tragus*	1
Grey Copperburr	*Sclerolaena diacantha*	2
Black Roly-poly	*Sclerolaena muricata*	1
Two-spined Copperburr	*Sclerolaena uniflora*	1
Narrow-leaf Desert Cassia	*Senna form taxon 'zygophylla'*	3
Sida	*Sida spp.*	1
Quena	*Solanum esuriale*	1
Broughton Pea	*Swainsona procumbens*	2

Flat Templetonia	*Templetonia rossii*	3
Germander	*Teucrium spp.*	1
Flamingo Moss	*Tortula atrovirens*	1
Annual New Holland Daisy	*Vittadinia cervicularis*	2
Fuzzy New Holland Daisy	*Vittadinia cuneata*	1
New Holland Daisy	*Vittadinia spp.*	1
River Bluebell	*Wahlenbergia fluminalis*	1
Rigid Panic	*Walwhalleya proluta*	1
Green-tufted Stubble-moss	*Weissia controversa*	1
Pointed Twin-leaf	*Zygophyllum apiculatum*	1
Pale Twin-leaf	*Zygophyllum glaucum*	3

Flora – Exotic

Common Name	***Scientific Name***	**Records**
Sheep Sorrel	*Acetosella vulgaris*	1
Cape Weed	*Arctotheca calendula*	1
Bridal Creeper	*Asparagus asparagoides*	5
Onion Weed	*Asphodelus fistulosus*	4
Wild Oat	*Avena fatua*	5
Oat	*Avena spp.*	3
Mediterranean Turnip	*Brassica tournefortii*	3
Great Brome	*Bromus diandrus*	10
Soft Brome	*Bromus hordeaceus subsp. hordeaceus*	1
Red Brome	*Bromus rubens*	7
Boneseed	*Chrysanthemoides monilifera*	2
Spear Thistle	*Cirsium vulgare*	1
Drain Flat-sedge	*Cyperus eragrostis*	1
Perennial Veldt-grass	*Ehrharta calycina*	1
Dense-flower Fumitory	*Fumaria densiflora*	1
Common Heliotrope	*Heliotropium europaeum*	1
Ox-tongue	*Helminthotheca echioides*	1
Mediterranean Barley-grass	*Hordeum hystrix*	1
Barley-grass	*Hordeum leporinum*	1
Sea Barley-grass	*Hordeum marinum*	2
Barley-grass	*Hordeum murinum s.l.*	1
Barley Grass	*Hordeum spp.*	2
Barley	*Hordeum vulgare s.l.*	1
Smooth Cat's-ear	*Hypochaeris glabra*	1
Flatweed	*Hypochaeris radicata*	2
Prickly Lettuce	*Lactuca serriola*	4
Common Peppercress	*Lepidium africanum*	3
Stiff Rye-grass	*Lolium loliaceum*	1
Wimmera Rye-grass	*Lolium rigidum*	4
Rye Grass	*Lolium spp.*	1
African Box-thorn	*Lycium ferocissimum*	27
Horehound	*Marrubium vulgare*	6

Little Medic	*Medicago minima*	1
Burr Medic	*Medicago polymorpha*	1
Lucerne	*Medicago sativa subsp. sativa*	1
Prickly Pear	*Opuntia spp.*	4
False Hair-grass	*Pentameris airoides subsp. airoides*	4
Paradoxical Canary-grass	*Phalaris paradoxa*	2
Fog-fruit	*Phyla canescens*	1
Prostrate Knotweed	*Polygonum aviculare s.l.*	1
Annual Beard-grass	*Polypogon monspeliensis*	1
Onion Grass	*Romulea rosea*	1
Curled Dock	*Rumex crispus*	2
Wild Sage	*Salvia verbenaca*	2
Pepper Tree	*Schinus molle*	2
Arabian Grass	*Schismus barbatus*	1
Scorzonera	*Scorzonera laciniata*	1
Indian Hedge-mustard	*Sisymbrium orientale*	2
Silver-leaf Nightshade	*Solanum elaeagnifolium*	8
Rough Sow-thistle	*Sonchus asper s.l.*	1
Common Sow-thistle	*Sonchus oleraceus*	3
Lesser Sand-spurrey	*Spergularia diandra*	1
Red Sand-spurrey	*Spergularia rubra s.l.*	1
Narrow-leaf Clover	*Trifolium angustifolium var. angustifolium*	1
Wall Fescue	*Vulpia muralis*	5
Rat's-tail Fescue	*Vulpia myuros*	1
Bathurst Burr	*Xanthium spinosum*	1

Fauna – Native

Common Name	***Scientific Name***	**Type**	**Records**
Plains-wanderer	*Pedionomus torquatus*	B	1
Crested Pigeon	*Ocyphaps lophotes*	B	5
Black-tailed Native-hen	*Gallinula ventralis*	B	1
Masked Lapwing	*Vanellus miles*	B	1
Black-fronted Dotterel	*Elseyornis melanops*	B	1
Eastern Great Egret	*Ardea modesta*	B	1
White-faced Heron	*Egretta novaehollandiae*	B	1
Brown Falcon	*Falco berigora*	B	1
Musk Lorikeet	*Glossopsitta concinna*	B	1
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*	B	1
Galah	*Eolophus roseicapilla*	B	5
Red-rumped Parrot	*Psephotus haematonotus*	B	4
Blue Bonnet	*Northiella haematogaster*	B	1
Laughing Kookaburra	*Dacelo novaeguineae*	B	1
Welcome Swallow	*Hirundo neoxena*	B	1
Grey Fantail	*Rhipidura albiscarpa*	B	1

Willie Wagtail	*Rhipidura leucophrys*	B	6
Red-capped Robin	*Petroica goodenovii*	B	1
Flame Robin	*Petroica phoenicea*	B	1
Rufous Whistler	*Pachycephala rufiventris*	B	1
Grey Shrike-thrush	*Colluricincla harmonica*	B	1
Magpie-lark	*Grallina cyanoleuca*	B	3
Weebill	*Smicrornis brevirostris*	B	2
Yellow Thornbill	*Acanthiza nana*	B	1
Chestnut-rumped Thornbill	*Acanthiza uropygialis*	B	1
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*	B	2
Rufous Songlark	*Cincloramphus mathewsi*	B	1
Variegated Fairy-wren	*Malurus lamberti*	B	1
White-breasted Woodswallow	*Artamus leucorynchus*	B	1
White-browed Woodswallow	*Artamus superciliosus*	B	1
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*	B	3
White-plumed Honeyeater	*Lichenostomus penicillatus*	B	4
Noisy Miner	*Manorina melanocephala*	B	1
Yellow-throated Miner	*Manorina flavigula*	B	2
Australasian Pipit	*Anthus novaeseelandiae*	B	1
Australian Magpie	*Gymnorhina tibicen*	B	4
Unknown Raven	*Corvus sp.*	B	1
Australian Raven	*Corvus coronoides*	B	4
Little Raven	*Corvus mellori*	B	2
Striated Pardalote	*Pardalotus striatus*	B	2
Water Rat	*Hydromys chrysogaster*	M	1
West Australian Blind Snake	*Ramphotyphlops australis*	R	1
Peters's Blind Snake	*Ramphotyphlops bituberculatus*	R	2

Legend
Type: Invertebrate, Fish, Amphibian, Reptile, Bird, Mammal

Fauna – Exotic

Common Name	***Scientific Name***	**Type**	**Records**
House Sparrow	*Passer domesticus*	B	5
Common Starling	*Sturnus vulgaris*	B	5
European Hare	*Lepus europeaus*	B	1

Legend
Type: Invertebrate, Fish, Amphibian, Reptile, Bird, Mammal

APPENDIX 4 ECOLOGICAL VEGETATION CLASSES

Description of each EVC on the Yarriambiack Creek at Beulah

EVC no.	EVC name	Bioregional Conservation Status	Description
		Murray Mallee	
823	Lignum Swampy Woodland	Vulnerable	Understorey dominated by Lignum, typically of robust character and relatively dense (at least in patches), in association with a Eucalypt and/or Acacia woodland to 15 m tall. The ground layer includes a component of obligate wetland flora that is able to persist even if dormant over dry periods.
103	Riverine Chenopod Woodland	Depleted	Eucalypt woodland to 15 m tall with a diverse shrubby and grassy understorey occurring on most elevated riverine terraces. Confined to heavy clay soils on higher level terraces within or on the margins of riverine floodplains (or former floodplains), naturally subject to only extremely infrequent incidental shallow flooding from major events if at all flooded.