Environmental Water Management Plan

Photo: Lake Hawthorn, Cabarita

Lake Hawthorn

mallee catchment management authority

Document control

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1-2	Ongoing working draft		2014
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5	Final Plan	Mallee CMA	
6	Updated fauna list and recreational values with bird survey results from citizen scientists. Reviewed and updated	S.Saris J. Munro	13/2/2020 6/3/20
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8	Whole EWMP review and updated according to latest Guidelines (Alluvium Consulting)	Mallee CMA	28/07/2023
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Cover image: Lake Hawthorn

Acknowledgement of Country

Mallee Catchment Management Authority (CMA) acknowledges and respects Traditional Owners, Aboriginal communities and organisations. We recognise the diversity of their cultures and the deep connections they have with Victoria's lands and waters. We value partnerships with them for the health of people and Country.

Mallee CMA Board, management and staff pay their respects to Elders past, present and emerging and recognise the primacy of Traditional Owners' obligations, rights and responsibilities to use and care for their traditional lands and waters.

Abbreviations and acronyms

ANCA	Australian Nature Conservation Agency
AVIRA	Aquatic Value Identification and Risk Assessment
CAMBA	China-Australia Migratory Bird Agreement
Bonn	The Bonn Convention (Convention on the Conservation of Migratory Species of Wild Animals Appendices I and II)
CAMBA	China-Australia Migratory Bird Agreement
CEWH	Commonwealth Environmental Water Holder
CMAs	Catchment Management Authorities
DEECA	Department of Energy, Environment and Climate Action
DEPI	Department of Environment and Primary Industries (formerly Department of Sustainability and Environment (DSE)
DNRE	Department of Natural Resources and Environment
DSE	Department of Sustainability and Environment
EA	Ecological Associates
EPBC	Environment Protection and Biodiversity Conservation Act
EVC	Ecological Vegetation Class
EWR	Environmental Water Reserve
FFG	Flora Fauna Guarantee Act
FSL	Full Supply Level
G-MW	Goulburn-Murray Water
JAMBA	Japan-Australia Migratory Bird Agreement

MCMA	Mallee Catchment Management Authority
MDBA	Murray-Darling Basin Authority (formerly 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
RGC	Riverside Golf Club
RMUF	River Murray Unregulated Flows
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
TLM	The Living Murray Initiative
TSL	Targeted Supply Level
VAHR	Victorian Aboriginal Heritage Register
VEAC	Victorian Environmental Assessment Council
VEWH	Victorian Environmental Water Holder
WMU	Waterway Management Unit

Executive summary

Environmental Water Management Plans (EWMP) are being prepared for key sites in the Mallee region by the Mallee Catchment Management Authority (CMA) in partnership with the Victorian Department of Energy, Environment, and Climate Action (DEECA). These plans are based on waterway management units (WMUs) of the Murray River floodplain and have been developed to guide future environmental water events at these sites. This EWMP has been developed for Lake Hawthorn and Lake Ranfurly, with part of Lake Hawthorn comprising the target area. The EWMP will help to guide future environmental watering activities for this area.

Lake Hawthorn and Lake Ranfurly are located in the Murray River Floodplain Bioregion within the Mallee Catchment Management Authority (CMA) region on the north-western edge of Mildura and covers 1034 ha.

Lake Hawthorn is primarily used as an irrigation drainage and urban storm water runoff disposal site. It is also part of the Lake Hawthorn Drainage Diversion Scheme, with excess water above 34.85 mAHD pumped to Wargan Basins under defined operating rules. These schemes are determined by Lower Murray Water, Goulburn-Murray Water and Mildura Rural City Council. The Mallee Catchment Management Authority acknowledges this will be the primary use for the site going forward and understands that any ecological and hydrological objectives recommended herein are secondary to the sites primary purpose. However, opportunities to protect the environmental values and improve conditions may be provided through delivery of environmental water at this site. Lake Ranfurly is not within the target area of this EWMP as it is primarily used as an evaporation basin for the Mildura-Merbein Groundwater Interception Scheme.

The Lake Hawthorn target area represents a valuable and productive saline wetland environment that is capable of supporting large numbers of waterbirds. Its position on the Murray River floodplain offers important feeding, foraging and loafing habitat. This offers an extension of Murray River habitat as it is connected with the Murray River by healthy stands of Black box and Lignum communities that allow movement of waterbirds between fresh and saline wetland environments. Lake Hawthorn is also highly valued by the local community.

Furthermore, the area is recognised for its potential to support a large number of migratory shorebird species of international importance. The Red-necked stint (*Calidris ruficollis*) has been recently recorded at Lake Hawthorn, a shorebird known for its annual northward migration to breeding grounds in Siberia and Alaska. More than 80% of the global population of this species migrates to Australia for the non-breeding season. Similarly, the migratory Curlew sandpiper (*Calidris ferruginea*), which was listed as Critically Endangered in 2015 under the EPBC Act, has been recorded at Lake Ranfurly, and may find opportunistic foraging habitat at Lake Hawthorn.

The whole 1034 ha has a water requirement as a floodplain complex (Mallee CMA, 2014), but the focus for this plan is restricted to a target area of approximately 148 ha. The target area for this plan is part of the bed of Lake Hawthorn (Lake Ranfurly and a smaller floodplain wetland, #11448, have been excluded from the target area).

This EWMP was developed in collaboration with key stakeholders, including Lower Murray Water, Goulburn-Murray Water, Mildura Rural City Council, DEECA and local interest groups. This plan also outlines consultation with Traditional Owners to review and provide input into the plan.

The long-term management goal for the Lake Hawthorn EWMP is:

> *To provide a flow regime to the target area that provides permanent shallow wading habitat for internationally important migratory shorebirds and a diverse population of resident native waterbirds.*

To achieve this, ecological and hydrological objectives, were developed to sustain two key ecological components of Lake Hawthorn:

LH1: By 2030, maintain populations and extent of saline aquatic vegetation at the Lake Hawthorn asset including benthic herblands with *Ruppia* beds containing both *R. polycarpa* and *R. megacarpa*.

LH2: By 2030, maintain representative populations of the shallow-water feeding guild of waterbirds including shorebirds (F2, after Jaensch 2002) at the Lake Hawthorn asset, by maintaining shallow-water habitats.

The following watering regimes have been developed to sustain and improve the ecological components of the target area. Each is aimed at maintaining the water level in Lake Hawthorn between 33.0 mAHD and 33.3 mAHD through delivery of environmental water when inflows from other sources are insufficient.

Table 1. Lake Hawthorn short-term regime

Annual Rainfall Value	Water Regime – Lake Hawthorn
Dry Year (e.g. <225 mm)	Provide environmental water via irrigation infrastructure to permanently inundate the target area and achieve a water level of 33.3 mAHD to encourage germination of *Ruppia* spp. and visitation by shorebirds. Allow natural recession of a maximum of 0.3 m (to 33.0 mAHD) before delivering a top-up volume as necessary to return the lake to 33.3 mAHD.
Average Year (e.g. ~290 mm)	Provide environmental water via irrigation infrastructure to permanently inundate the target area and to maintain a water level of 33.3 mAHD to encourage germination of *Ruppia* spp. and visitation by shorebirds. Allow natural recession of a maximum of 0.3 m (to 33.0 mAHD) to expose mudflats for foraging shorebirds and to promote *Ruppia* spp. germination, before delivering a top-up volume as necessary to return the lake to 33.3 mAHD.
Wet Year (e.g. >350 mm)	Monitor water level. Deliver environmental water, if necessary, to sustain a water level of 33.3 mAHD to maintain *Ruppia* spp. beds. Allow natural recession of a maximum of 0.3 m (to 33.0 mAHD) before delivering a top-up volume as necessary to return the lake to 33.3 mAHD.

A number of risks associated with environmental water delivery have been identified and management measures have been put in place in an attempt to decrease and/or mitigate these risks. CDM Smith (2015) completed a preliminary salinity impact assessment on the proposed environmental watering regimes for Lake Hawthorn. The study identified no significant impact at Morgan is expected to arise from delivery under the above regime. Ongoing review of available data is recommended to identify any potential trends.

Table of Contents

1. Introduction

An EWMP is a management plan for a wetland, wetland complex or river system that sets out the environmental watering goals and objectives, and the water regime required to meet the set objectives. An EWMP describes the:

- consultation undertaken for EWMP preparation and implementation
- asset overview and characteristics
- water-dependent environmental values present
- water-related threats to the environmental values
- management goals for the asset
- environmental objectives, targets and values that environmental watering of the asset will support or improve
- watering requirements needed to meet environmental objectives
- environmental water delivery infrastructure, management and constraints
- risks associated with environmental water delivery
- outcomes intended to be demonstrated through monitoring and assessment, and
- knowledge gaps to address.

This Environmental Water Management Plan (EWMP) has been prepared by the Mallee Catchment Management Authority (CMA) to establish the long-term management goals of Lake Hawthorn.

This EWMP was developed in 2016 and updated in 2020 to incorporate new information and revised ecological objectives. The latest version of the EWMP (2023) has been updated to incorporate new information and align with the Department of Energy, Environment, and Climate Action (DEECA) Draft EWMP Guidelines (Version 6 – April 2022).

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.

Management of environmental water in Victoria is a statewide partnership between the Victorian Environmental Water Holder (VEWH), catchment management authorities (including Melbourne Water), the Department of Energy, Environment and Climate Action (DEECA), land managers including Parks Victoria and local councils, water corporations, Traditional Owner groups, and interstate agencies including the Commonwealth Environmental Water Office (CEWO) and the Murray–Darling Basin Authority (MDBA).

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 the region.

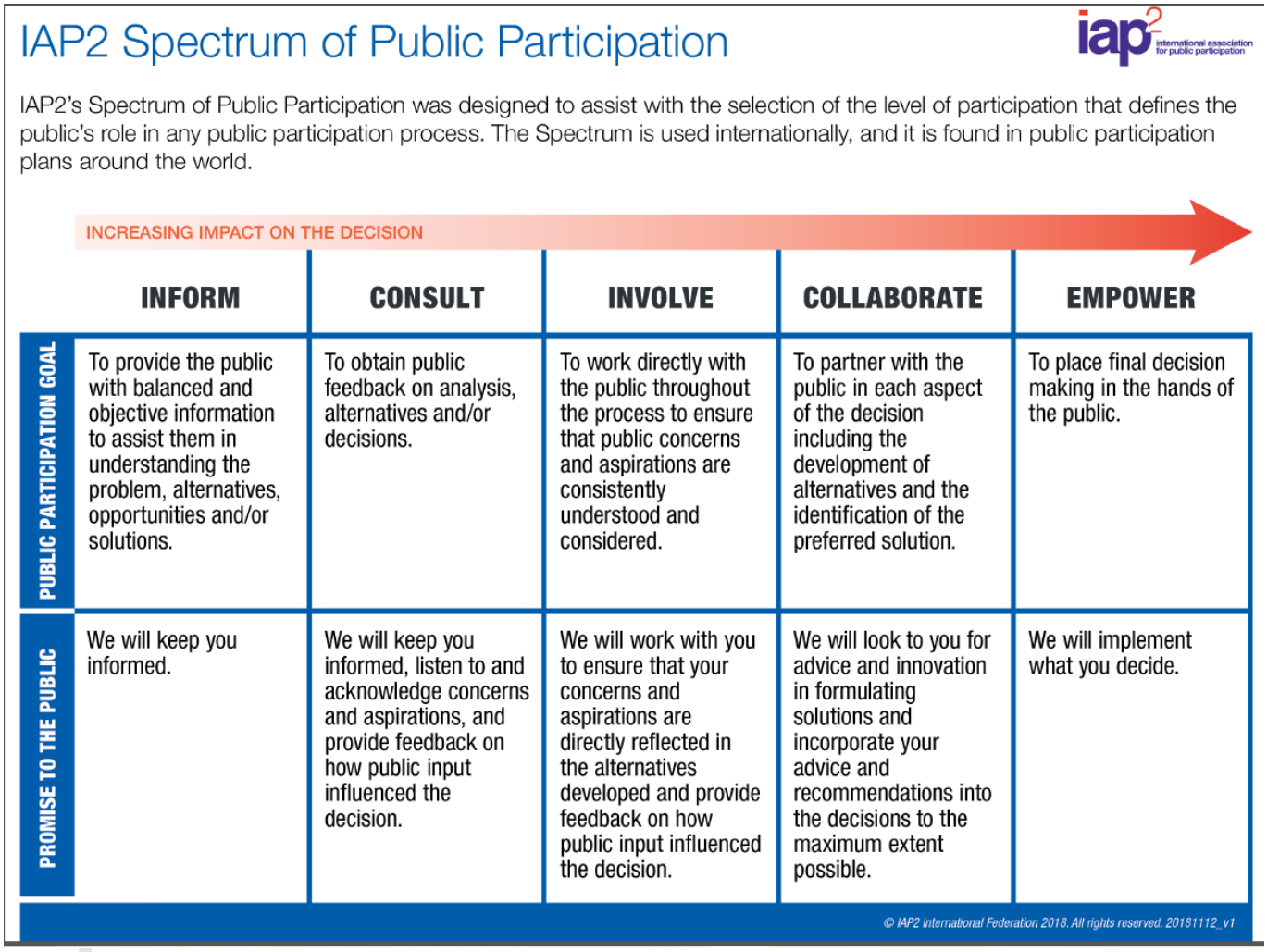
Information on how this EWMP relates to other environmental water documents and policies is included in Appendix 1.

2. Partnership and consultation

2.1 Target Audience

This section identifies the target audience and modes of consultation necessary to manage environmental water delivery, report against stated objectives and targets, and promote adaptive management over the life of the EWMP.

Engagement with different stakeholder groups is based on the International Association of Public Participation (IAP2) spectrum (Figure 1). The spectrum allows for a tailored approach based on stakeholder groups and their needs.



IAP2 Spectrum of Public Participation

IAP2's Spectrum of Public Participation was designed to assist with the selection of the level of participation that defines the public's role in any public participation process. The Spectrum is used internationally, and it is found in public participation plans around the world.

INCREASING IMPACT ON THE DECISION

	INFORM	CONSULT	INVOLVE	COLLABORATE	EMPOWER
PUBLIC PARTICIPATION GOAL	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions.	To obtain public feedback on analysis, alternatives and/or decisions.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and the identification of the preferred solution.	To place final decision making in the hands of the public.
PROMISE TO THE PUBLIC	We will keep you informed.	We will keep you informed, listen to and acknowledge concerns and aspirations, and provide feedback on how public input influenced the decision.	We will work with you to ensure that your concerns and aspirations are directly reflected in the alternatives developed and provide feedback on how public input influenced the decision.	We will look to you for advice and innovation in formulating solutions and incorporate your advice and recommendations into the decisions to the maximum extent possible.	We will implement what you decide.

Figure 1. IAP2 Spectrum
Source: (c) International Association for Public Participation www.iap2.org

Table 2 lists the main stakeholder groups with an interest in environmental water based on their needs and interests and level of engagement required. To read more about the role of specific stakeholders in overseeing environmental water at Lake Hawthorn, refer to Section 3.2.

Mallee CMA develops a communication and engagement plan each year that covers environmental watering events for the entire Mallee CMA region, including Lake Hawthorn. This ensures that all stakeholders and community members are aware of the Lake Hawthorn environmental watering operations.

Table 2. Recent Stakeholder Consultation for Lake Hawthorn EWMP

Stakeholder groups	Stakeholders	Needs and interest	IAP2 level	Consultation modes
Traditional Owners and Interested Parties	See Section 2.4: Traditional Owners	Ongoing connection to Country and protection of cultural heritage and values. Environmental impacts and benefits. environmental watering regimes and how these may be timed to support/promote cultural values.	Collaborate	Via Mallee CMA's Traditional Owner engagement team. Consultation is largely undertaken in-person and, where possible, on Country.
Victorian water holders	VEWH	Make decisions about annual environmental water usage.	Collaborate	Via formal meetings.
River operators	Lower Murray Water	Manage water storage, land management responsibilities.	Collaborate	Via formal meetings.
Scientists	Arthur Rylah Institute, consultancies	Floodplain health, biodiversity and use of environmental water.	Involve	Workshops, meetings, phone calls.
Public land managers	Parks Victoria, DEECA Forest Fire and Regions Group	Managing impacts from watering such as access.	Collaborate	Via monthly meetings.
Local government	Mildura Rural City Council	Access during watering events.	Involve	Meetings, phone calls, correspondence.
Basin-wide river management	MDBA	River Murray operations.	Involve	Via formal meetings.
Private landowners and managers	Adjacent landholders and managers	Possible access to properties during operation as defined in landholder agreements.	Collaborate	Directly affected landholders will be informed of watering proposals and asked to provide feedback if relevant.
Community (interest groups)	Irrigators Community Advisory Groups Environmental, recreational and social groups	Consumptive water use/access. Watering benefits and impacts on local communities such as access to parks and river during watering events.	Inform	Via existing groups such as the Mallee CMA Land and Water Committee. Via Mallee CMA social media and news.
Media	Local, state and national media outlets	Across issues that interest the local community.	Inform	Media packs and media releases.

2.2 Developing/updating the EWMP

Mallee CMA carried out community consultation through the following channels:

- Mallee CMA Land and Water Advisory Committee
- surveys at community events such as farmers' markets
- workshops and on-country visits with Traditional Owners (see Section 2.4)
- campaign emails
- meeting with landholders
- social media channels.

Relevant government agencies were invited to participate in the consultation process via a formal letter. They have also been engaged through existing channels, with discussions and presentations. The key outcomes from this engagement were:

- ensuring that Traditional Owner values were represented in the ecological outcomes
- building more frequent initial watering into the proposed watering regime to help the landscape recover and monitoring outcomes to determine future water needs, in response to Traditional Owner feedback.

2.2.1. Verifying asset values

Asset values at Lake Hawthorn have been established through environmental assessments and the development of previous versions of this EWMP. Consultation has been a key part of these processes with Traditional Owners, community members and technical specialists. Mallee CMA has continued to engage on asset values throughout the development of the EWMP, particularly with Traditional Owners and private and public landholders.

2.2.2. Informing proposed management objectives, targets and approaches

Mallee CMA has long worked with those who have an extensive knowledge of Lake Hawthorn and floodplain ecosystems. This work has been central to providing a basis for local knowledge and expertise.

Combined with the Seasonal Watering Proposal, the data and knowledge from the will guide future watering events, as part of the adaptive management approach (see Section 11: Adaptive Management).

2.3.2 Promoting adaptive management

Mallee CMA and other partners will take an adaptive management approach taking into account both varying seasonal conditions and lessons learned from previous events (see Section 11: Adaptive Management).

After the annual adaptive management checkpoint, Mallee CMA will adapt the EWMP if needed, which would then go through consultation, giving stakeholders the opportunity to see any updates.

2.3 Community Engagement

Community stakeholders were engaged via an online survey, which was hosted on the Mallee CMA website in January-February 2023. The survey was designed to enable community, landholders, recreational users, Landcare groups, environmental groups and other interested parties to provide input to the plans. The survey supplements earlier community engagement about the Lake Hawthorn EWMPs, and annual community engagement that informs the Seasonal Watering Proposal (SWP). 4 completed surveys were received through this exercise; two surveys were completed by visitors to the region, 1 survey was completed by a resident and 1 survey was completed by a recreational user. The Engagement survey asked the community to rank values at the site, Table 3 shows the rankings. For further detail about the outcomes of the 2023 community engagement, refer to appendix 6.

Table 3. Community Values ranking

Community Value	Use and Value ranking
Exercise, especially walking/running and bike riding	75% of survey participants use Lake Hawthorn for walking/running. 50% of survey participants use Lake Hawthorn for bike riding. Exercise was ranked important (score of 4.25/5) for survey participants.
Recreational opportunities (e.g. birdwatching, fishing)	Respondents for the Lake Hawthorn survey ranked this value as important (a score of 3.75/5)
Unique landscape features and natural beauty	Respondents for the Lake Hawthorn survey ranked this value as very important (a score of 4/5)
Education purposes	A respondent to the survey identified they used Lake Hawthorn for education purposes. The value of ‘work or education opportunities’ was ranked highly by survey participants (3.5/5).
Nature appreciation	A respondent to the survey identified they used Lake Hawthorn for 'nature appreciation’.
Traditional Owner Values	Respondents for the Lake Hawthorn survey ranked this value as important (a score of 3.25/5).

2.4 Traditional Owners

Lake Hawthorn is located within the formally recognised Country of the First People of the Millewa-Mallee Aboriginal Corporation (FPMMAC). FPMMAC have indicated in DEECA's EWMP guidelines how they would like to be consulted about environmental watering. Consultation with FPMMAC, in-line with the EWMP guidelines, is ongoing. Engagement with Traditional Owners is conducted on a one-on-one basis at the COLLABORATE level of the IAP2 framework, with the level of interest and involvement self-determined by each group. Annual consultation is also undertaken with Traditional Owner groups during the development of the SWP for Lake Hawthorn.

FPMMAC were engaged in March 2023 to collaborate on the EWMP update process. This involved a presentation to a group of Traditional Owner's from FPMMAC about the sites included in the update.

An on Country visit to Lake Hawthorn was also undertaken, to assist in site-based values discussions. Discussions included ecological, social and cultural outcomes and watering regimes to support these. Engagement and discussions about these topics will be on going and essential to future watering programs.

3. Asset overview

The Mallee CMA region is located in the north-west of Victoria. Its area of responsibility covers approximately 39,000km², and 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.

In 2007 the Mallee CMA engaged consultants Ecological Associates to investigate water management options for the Murray River floodplain from Robinvale to Wallpolla Island. One of the major outcomes of these investigations was the development of a system of Floodplain Management Units (FMUs). These divide the floodplain into management units in which water regimes can be managed independently of another FMU. FMUs are relatively consistent in their ecological values and land uses. The Mallee CMA has used FMUs to inform planning and development of environmental water management plans to achieve more effective management of hydrologically connected systems. In addition to this the Mallee CMA has also used individual FMUs or groupings of FMUs to form Waterway Management Units (WMU) for planning within its Mallee Waterway Strategy (MCMA 2014) (Figure 2).

This plan has been prepared for Lake Hawthorn (Figure 2). Lake Hawthorn is located within the Merbein WMU, approximately 3 km north-west of the Mildura CBD. Lake Hawthorn is referred to by name in this document where the lake itself is described.

A regional context document (North, 2014) has been prepared to compliment the Mallee CMA EWMPs and should be read in conjunction with this document.

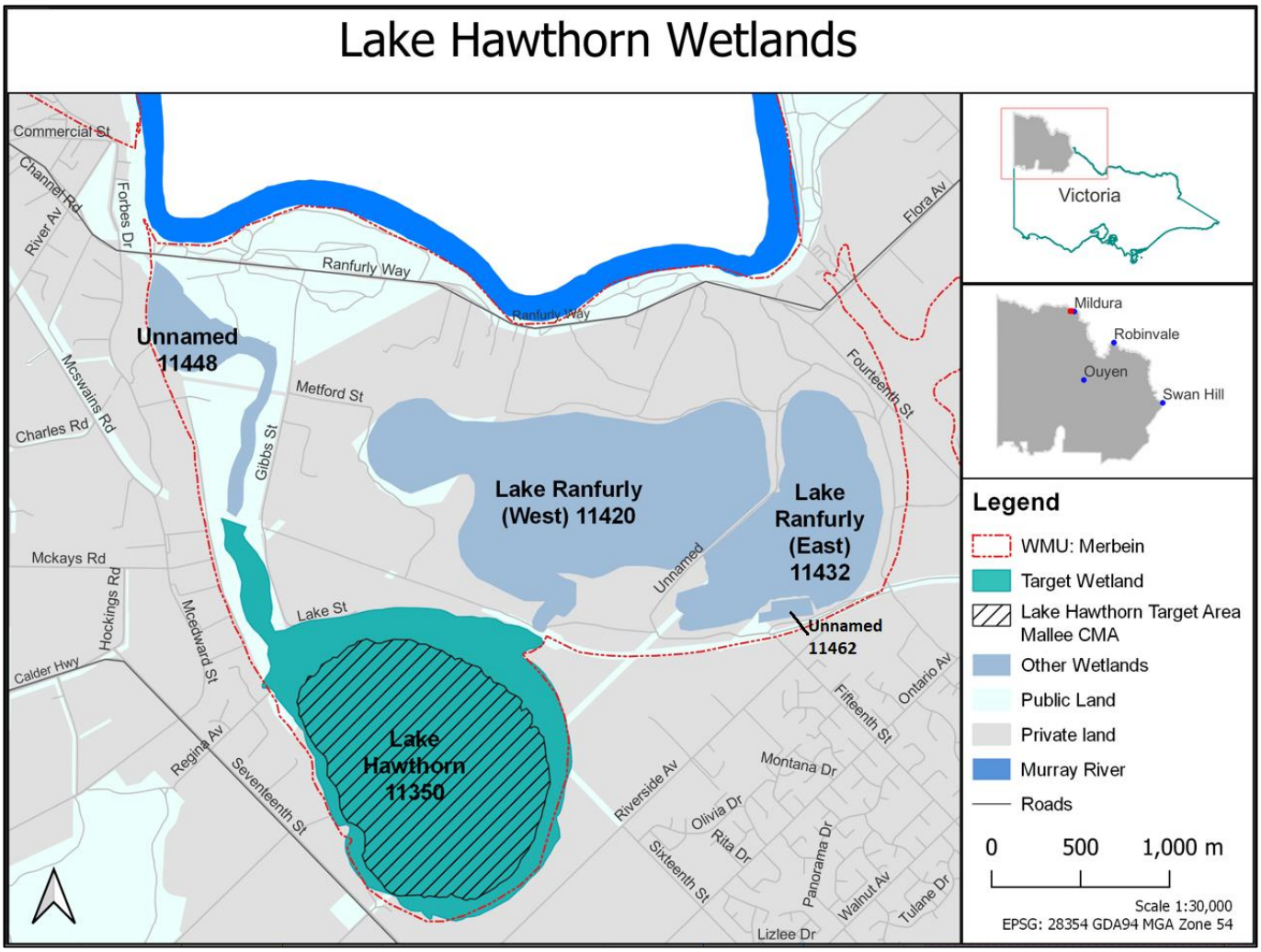


Figure 2. Map of the Lake Hawthorn target area

3.1 Catchment setting

Lake Hawthorn is located in the Murray Scroll Belt Bioregion. The Murray Scroll Belt Bioregion is characterised by an entrenched river valley and associated floodplain and lake complexes of numerous oxbow lakes, billabongs, ephemeral lakes, swamps and active meander belts. Alluvium deposits from the Cainozoic period gave rise to the red brown earths, cracking clays and texture contrast soils (Dermosols, Vertosols, Chromosols and Sodosols) supporting Alluvial-Plain Shrubland, Riverine Grassy Chenopod Woodland and Riverine Grassy Forest ecosystems (DELWP 2015).

In order of increasing depth, the major stratigraphic units encountered within the Lake Hawthorn area include the Woorinen Formation, Coonambidgal Clay, Monoman Formation, Blanchetown Clay, Parilla Sands and Lower Parilla Clay.

3.2 Land Status and Management

Multiple land managers are responsible for different areas of Lake Hawthorn (Table 4). The WMU sub-unit consists largely of agency managed land with areas of crown land and public recreation reserve.

Table 4. Stakeholders for the Lake Hawthorn EWMP

Group	Role
Mallee CMA	Regional waterway and environmental water management
Mildura Rural City Council	Land Manager
Department of Environment, Energy and Climate Action (DEECA)	State level environmental management planning, land manager, threatened species manager
Goulburn-Murray Water	Lake Hawthorn Drainage Diversion Scheme and Mildura-Merbein Salt Interception Scheme Manager
Lower Murray Water	Responsible for disposal of irrigation drainage from the former First Mildura Irrigation Trust area and the Merbein Irrigation District. Responsible for managing recreational access and has land management responsibilities.
Department of Education	Land owner of the College Lease areas (blocks of private land in the south of Lake Hawthorn and Lake Ranfurly.
VicRoads	Roads under VicRoads management pass through the area.
Vic Rail	A railway line passes through the area
Victorian Environmental Water Holder	Manager of Victoria's environmental water entitlements
First People of the Millewa-Mallee Aboriginal Corporation	Indigenous representation
Friends of Merbein Common	Assistance in planning and implementation of programs
Cabarita Inc	Landcare Group, provides assistance in planning and implementation of programs
Local Landholders & Residents	Land users, provide assistance in planning and implementation of programs
Birdlife Mildura	Bird observer group, land user

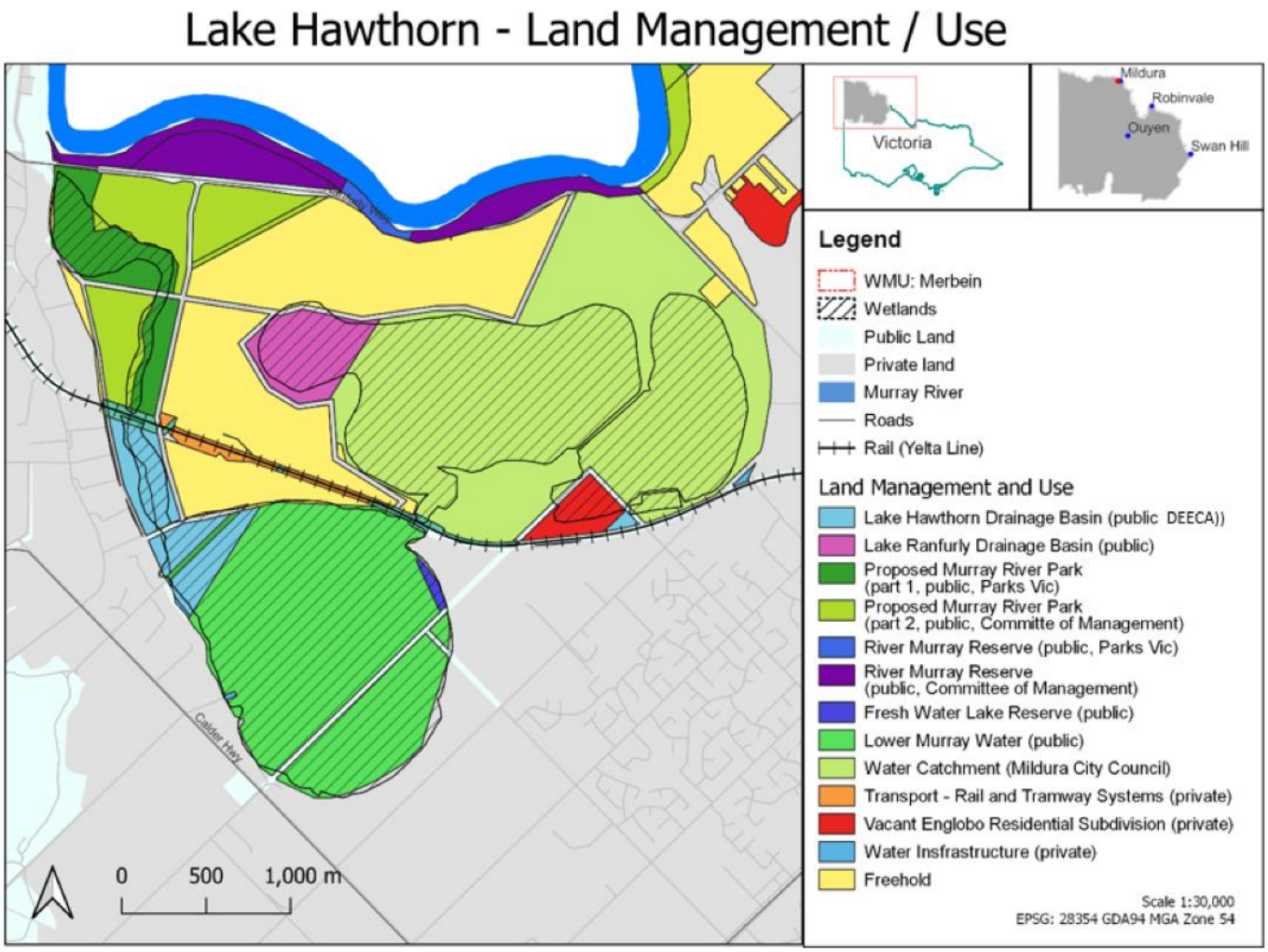


Figure 3. Lake Hawthorn land management boundaries

3.3 Asset characteristics

Lake Hawthorn is situated on the Murray River floodplain, 3km northwest of Mildura at Merbein. The whole 1034 ha has a water requirement as a floodplain complex (Mallee CMA, 2014), but the focus for this plan is restricted to a target area of approximately 148 ha.

Lake Ranfurly (East and West), and wetland #11448 have been excluded from the target area. The primary use of Lake Ranfurly is as an evaporation basin for the Mildura-Merbein Salt Interception Scheme and delivery of environmental water to this site may impact on this use. Wetland #11448 has been excluded from the target area as the health of this wetland and surrounds appears to be sound and does not require management intervention.

A brief overview of the main characteristics of the five wetlands at Lake Hawthorn is provided in table 5.

Table 5. Wetland characteristics for the Lake Hawthorn EWMP

Characteristics	Description
Name	Lake Hawthorn
Mapping ID **(Wetland Current layer)**	Lake Ranfurly (East): 11432 Lake Ranfurly (West): 11420 Lake Hawthorn: 11350 Unnamed: 11448 Unnamed: 11462
Area of wetlands in target area	148 ha
Bioregion	Murray Scroll Belt
Conservation status	Bioregion conservation status: areas of EVCs listed as Vulnerable and Depleted.
Land status	Public Land (variety of tenures and purposes) Regional Park
Land manager	Lower Murray Water, Mildura Rural City Council, Goulburn-Murray Water
Surrounding land use	Urban, irrigated and non-irrigated cropping
Water supply	Irrigation drainage water from Merbein, Mildura and Irymple districts, urban stormwater, Murray River high flows, groundwater inflows from regional and perched water tables.
Wetland category **(Wetland Current layer)**	Lake Hawthorn (11350) - Permanent saline swamp Lake Ranfurly (west) (11420), Lake Ranfurly (east) (11432): Permanent saline lakes 11448: Temporary freshwater marshes and meadows
Wetland depth at capacity	Lake Hawthorn 1.92 m Lake Ranfurly <1.5 m

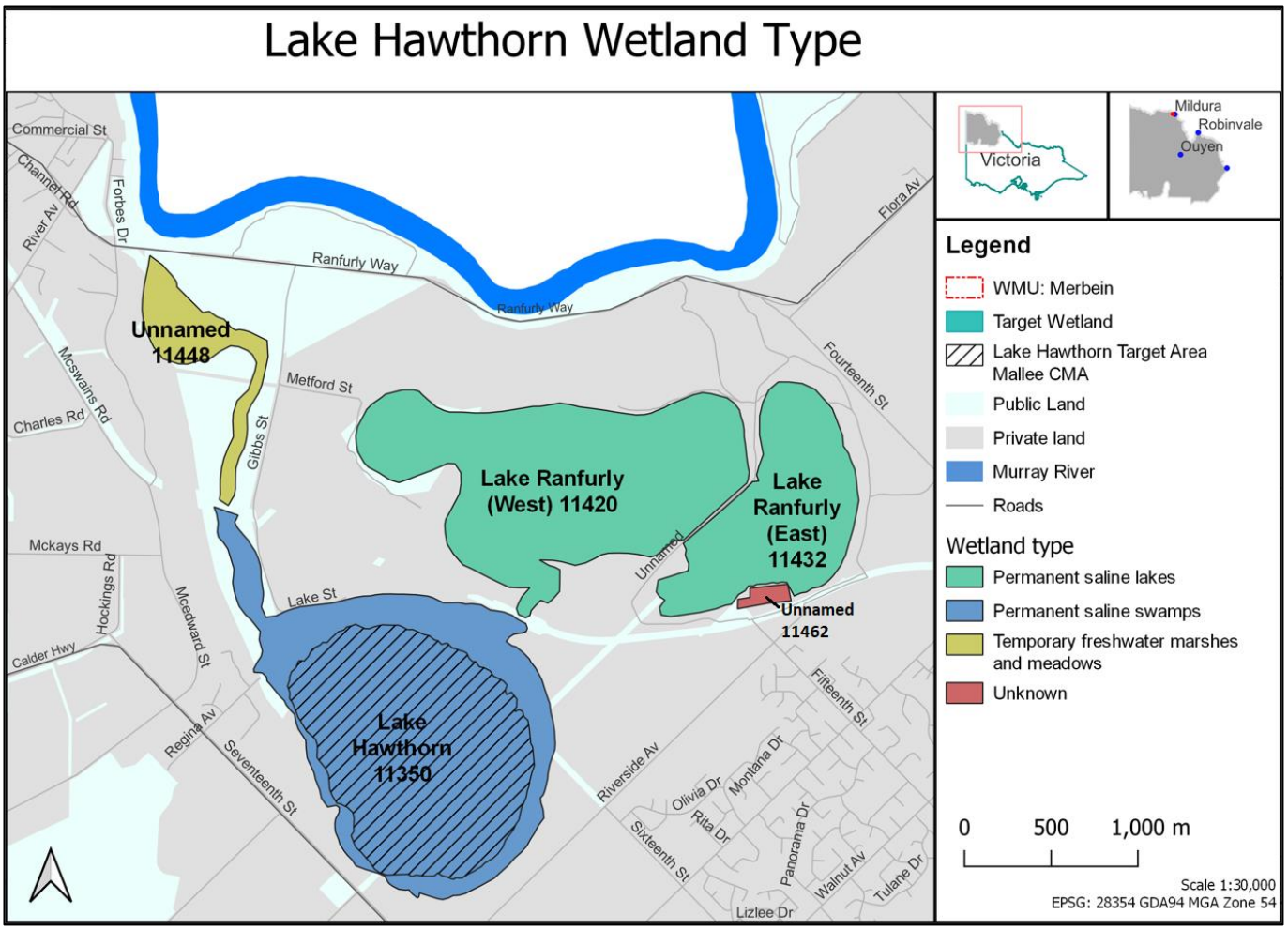


Figure 4. Wetland locations and classification at Lake Hawthorn

3.4 Environmental water sources

Water delivered to Lake Hawthorn will be made available by the VEWH under the *Bulk Entitlement (River Murray – Flora and Fauna) Conversion Order 1999* held by the VEWH. This may include water held by the CEWO and donated water. Other sources of water may become available through water trading or changes in water entitlements.

4. Current/historical hydrological regime 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 2005a). 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 2005a). Duration, frequency and seasonality (timing) are the main components of the hydrological regime for wetlands and rivers.

Prior to river regulation in this reach of the Murray River, the floodplain experienced inundation more frequently and for longer periods. The regulation and diversion of the Murray River has reduced the frequency and duration of peaks in river flow which activate anabranches, fill wetlands and inundate floodplain areas. In this part of the Murray River, the frequency, duration and magnitude of all but the largest floods have been reduced due to effects of major storages in the Murray and its tributaries (Thoms et al., 2000).

Prior to river regulation and levee bank construction, Lake Hawthorn and Lake Ranfurly were inundated under Murray River flows above approximately 50,000 ML/day (Ecological Associates 2015, p.3), and would have retained water for a period of time after river levels fell, and potentially also experienced drying phases. Natural flows were strongly seasonal with daily discharges highest in spring and lowest in autumn (Ecological Associates 2007b).

The construction of levees at Hawthorn/Ranfurly has increased the commence to flow (CTF) rate at Lake Hawthorn to an estimated 86,000 (ML/day) (Gippel, cited in Ecological Associates 2015, p.3). Lake Hawthorn now primarily receives inflows from stormwater and irrigation drainage however all sources of inflow are impacted by extended dry conditions.

Under post-regulation conditions, the percentage of years with the threshold event 50,000 ML/d pre-regulation to 90,000 ML/day post-regulation (baseline) have significantly reduced (from 75 per cent to 12 per cent of years) (Gippel 2014). The interval between events has also increased (Gippel 2014). The seasonal distribution of flows in this section of the Murray River show that, despite a reduction in discharge, the river retains the same annual pattern of higher flows in Winter and Spring with lower flows in Summer and Autumn.).

Wetland #11448

Wetland #11448 is a natural floodplain wetland in a section of Black Box floodplain that has suffered reduced connectivity to the Murray River by construction of levees, although a limited connection exists via an old regulator structure. This wetland would have connected with the river during high flows, and flow through to Lake Hawthorn would be achieved. Reports have suggested the presence of a freshwater lens (CDM Smith 2015) below this wetland, which may explain its apparently healthy condition, regardless of altered hydrology.

Lake Hawthorn

Lake Hawthorn is a natural floodplain wetland that filled under high Murray River flows prior to river regulation in 1915 (Ecological Associates 2007b). In high flow conditions the lake would fill from the Murray River, via wetland #11448. Levee banks now limit connectivity to the wetland and, subsequently, Lake Hawthorn from the Murray River (Ecological Associates 2007b).

Lake Ranfurly

Lake Ranfurly is a natural floodplain deflation basin which filled under high Murray River flows, although levee banks now restrict flooding of the lake (Ecological Associates 2007b). The lake is divided into two sections, east and west, by a causeway when water levels are low (SKM 2001). Lake Ranfurly is used for irrigation drainage disposal and groundwater inputs from the Mildura-Merbein Salt Interception Scheme, which has resulted in the water in Lake Ranfurly being hypersaline (levels frequently exceed 100,000 EC) (Bluml, 1991). Lake Ranfurly East receives less corrosive groundwater and urban stormwater run-off which maintains salinity levels lower than that of the western section, but still in excess of 60,000 EC (SKM 2001).

4.1 Groundwater Interactions

Groundwater salinity levels vary throughout the WMU, with low salinity recorded beneath Wetland #11448, which suggests the presence of a freshwater lens at this location. It is possible that this lens may provide a buffer against instream salinity impacts (AWE 2014, p.29). High groundwater salinity has been recorded beneath Lake Ranfurly, and elevated salinity beneath Lake Hawthorn.

It is expected that Lake Hawthorn receives groundwater when water levels are low (although the contribution to water balance is negligible), and it may recharge the aquifer when water levels are high (Ecological Associates 2015). There is potentially a flow-through effect on the floodplain, with the highest groundwater levels at 35.5 m AHD to the southwest,

falling to around 32.5 m AHD to the north of Lake Ranfurly. Salinity impact is dependent upon the level of connectivity between Lake Hawthorn, the floodplain aquifer (Monoman formation), and the Murray River.

The Mildura-Merbein Salt Interception Scheme was established in 1979 to intercept highly saline groundwater which would otherwise enter the Murray River. This scheme is managed by Goulburn-Murray Water (Sunraysia Drainage Coordination Group 2005) and is operated intermittently. Groundwater is discharged to Lake Ranfurly as part of the scheme, with excess going to Wargan Basins.

Figure 5. Pelican at Lake Hawthorn

4.2 Irrigation and drainage impact on hydrology within the target area

Lake Hawthorn is used as a disposal basin for urban stormwater by Mildura Rural City Council, and irrigation drainage by Lower Murray Water. Stormwater from several newly developed areas in the Mildura township is diverted to the Mildura South stormwater drainage wetlands, which in turn outfalls to Lake Hawthorn.

Since the 1940's, water levels in Lake Hawthorn have been managed, and fluctuations of over 1 m annually are known to occur (Lloyd 2007). However, water levels have tended to be more stable since 2000, in part due to reduced irrigation drainage to the lake as irrigation techniques have improved. It is estimated that irrigation drainage volumes received by Lake Hawthorn have reduced from approximately 10,140 ML/year in 1988 to approximately 2,640 ML/year or less (Lumb 2015, p.10).

Levee banks now restrict flooding from the Murray River to Lake Hawthorn; however, Lake Hawthorn can receive inflows from other sources (described below) and can connect with Lake Ranfurly at high water levels (Ecological Associates 2007b). There are regulators in place under the railway line between Lake Hawthorn and Lake Ranfurly and on the channel that connects Lake Hawthorn and wetland #11448 to the Murray River.

The Lake Hawthorn Drainage Diversion Scheme was set up in 1968 to allow disposal of saline drainage water to Wargan Basins and reduce the likelihood of the lake becoming overfull and water being released to the Murray River. This scheme is also operated by Goulburn-Murray Water and is run in accordance with the Lake Hawthorn Operating Rules (Appendix 5).[1]

Lloyd Environmental (2007) states that Lake Hawthorn receives water (and salt) from:

[1] As this environmental watering proposal is not inundating Lake Hawthorn to a level above 34.85 m AHD subsequently triggering Goulburn-Murray Water to pump excess water to the Wargan Basins, this proposal is not accountable under the operating rules.

- Irrigation subsurface drainage water from the Merbein, Mildura and Irymple districts as part of Lower Murray Water's sub-surface drainage scheme;
- Irrigation drainage water directly from individual irrigated properties;
- Runoff from surrounding urban areas;
- Inflows from the Murray River under high flows;
- Rainfall; and
- Groundwater inflows from regional and perched watertables.

Historically, Lake Hawthorn received inflows from Lake Ranfurly through a regulator, however Lake Ranfurly is hypersaline, and this option is no longer used. Water has been allowed to flow from Lake Hawthorn into Lake Ranfurly to provide temporary storage of drainage water during periods of elevated water levels (Lloyd Environmental 2007).

Water outflows from Lake Hawthorn include:

- Pumping to Wargan Evaporation Basin;
- Evaporation;
- Controlled release to the Murray River under high river flows (>15,000 ML/d);
- Seepage to groundwater.

4.3 Environmental watering

Lake Hawthorn received an initial delivery of 350 ML of environmental water in 2005 covering an approximate surface area of 200 ha. This environmental allocation was focused on sustaining the Murray Hardyhead population in the lake. Since that time water delivery has recommenced in 2016 and continued almost annually to support habitat for a wide range of migratory shorebirds, waders and other waterbird species that are frequently observed at the lake.

Table 6 - A summary of environmental watering events at Lake Hawthorn

Water year	Time of inflow	Environmental Water Source	Total volume (ML)	Area (ha) inundated
2005	Summer-Autumn	Unknown	350	200
2010-11	Spring	Natural flows	n/a	n/a
2016	Autumn-Winter	VEWH	460	148
2016-17	Spring	Natural flows	n/a	n/a
2018	Autumn-Winter	VEWH	447	n/a
2018-19	Spring-Autumn	VEWH	1498	148
2019-20	Spring-Autumn	VEWH	1460.179	148
2020-21	Spring-Autumn	VEWH	859.77	148
2021-22	Summer	VEWH	177.176	148
2023-24	Autumn	VEWH	381.595	148

5. Water-dependant values

Wetlands and waterways on the floodplain are a vital component of the landscape and support flora and fauna which vary 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.

Lake Hawthorn and Lake Ranfurly provide a range of shelter and food resources for indigenous fauna, flora and vegetation communities. The types of habitat provided, and consequently the species that utilise the site, change as water fills the wetlands, creek and floodplain and recedes again.

Data from the Victorian Biodiversity Atlas (DELWP, 2016b) and recent monitoring (Ecology Australia, 2023) have been referenced. It is recommended that flora and fauna surveys are repeated at the site to improve knowledge of the site's ecological values.

5.1 Environmental Values

5.1.1 Ecosystem Type and Function

The wetlands in this area are a mixture of temporary freshwater marshes and meadows, permanent saline lakes and permanent saline swamps. Present vegetation communities include Lake Bed Herbland, Lignum Swampy Woodland, Semi-Arid Woodland and Riverine Chenopod Woodland.

Wetland ecosystems support distinctive communities of plants and animals and support numerous ecosystem functions. Floodplain wetlands perform important functions necessary to maintain the hydrological, physical and ecological health of river systems.

Four key broad ecosystem functions have been identified for the Lake Hawthorn EWMP. Each function is interlinked and must be supported in order for the ecosystem to flourish. The functions are briefly described below.

Creation and maintenance of vital habitat for threatened/endangered species

Wetlands act as refugia for frogs, native fish and waterbirds during periods of extended drought in an arid landscape. Inundation of areas of the wetland woodland mosaic provides a diversity of feeding, breeding and nursery sites for native water-dependent biota including waterbirds.

Diversity of habitat for feeding, breeding and nursery

Seasonal fluctuations in water levels in the wetlands increase the availability of specific habitat niches for feeding, breeding and nursery areas. Permanent and semi-permanent water bodies provide a source of food, refuge from predators and nesting sites and materials (Kingsford and Norman, 2002).

Wetland filling and water recession increases the extent of the band of sedges, rushes and semiaquatic forbs surrounding wetlands. Areas of deeper, permanent water support submerged aquatic macrophytes, and promote high levels of aquatic productivity and high habitat value for frogs, fish, and waterbirds.

The presence of aquatic vegetation such as Ruppia sp. at Lake Hawthorn would support habitat for shallow-water feeding guilds of waterbirds, including shorebirds. Seasonal variation in water levels is recommended by EA (2023), to promote germination of ruppia.

Transportation and dilution of nutrients and organic matter and increase in macroinvertebrate productivity and biofilm diversity

Drying of wetlands, particularly during summer and autumn, exposes sediments and facilitates decomposition and processing of organic matter. The microbial decay of plant material is an important route for energy and nutrients to enter the riverine food chain (Young, 2001).

Wetland inundation transports nutrients and carbon into the water column, which then becomes available for consumption by bacteria, algae and macroinvertebrates. On re-wetting, decomposition accelerates and becomes more efficient. Carbon and nutrients are released from the soil and enter the water and are available for aquatic plants and animals. The release of energy and nutrients results in increased productivity, with an increase in bacteria and invertebrates (Ecological Associates, 2013). This results in abundant food for fish, birds and other animals.

Fluctuations in water levels allows exposure of substrates such as large wood and plant stems through a drying cycle, which increases the diversity of the biofilms grazed by macroinvertebrates and fish.

5.1.2 Flora and Fauna

There are five water-dependant EVCs modelling in the Lake Hawthorn target area, described in Table 6. However, surveys conducted by Ecology Australia (2023) noted that the vegetation present at Lake Hawthorn was markedly different from the mapped EVC type. Where Ecology Australia noted that EVCs such as Lake Bed Herbland (EVC 107) and Riverine Chenopod Woodland (EVC 103) were modelled EVCs present at Lake Hawthorn, only Samphire Shrubland (EVC 101) was observed in 2022.

Table 7 – List of EVCs modelled and observed at Lake Hawthorn WMU.

EVC Number	EVC Name	Bioregional conservation status	Modelled as present	Observed in 2022
107	Lake Bed Herbland	Vulnerable	Yes	No
823	Lignum Swampy Woodland	Depleted	Yes	No
97	Semi-Arid Woodland	Depleted	Yes	No
103	Riverine Chenopod Woodland	Depleted	Yes	No
98	Semi-Arid Chenopod Woodland	Depleted	Yes	No
101	Samphire Shrubland	Least Concern	No	Yes

Samphire Shrubland (EVC 101) is described as a low open shrub layer to 0.5m of succulent chenopods on saline clay pans.

Figure 6. Samphire Shrubland EVC at Lake Hawthorn

Water-Dependent Flora

One hundred and sixty-four species have been recorded at Lake Hawthorn, ten of which are introduced (see appendices 2 and 3). Of special interest and management responsibility are the twenty-four water dependent fauna species listed in legislation, agreements or conventions.

Lake Hawthorn supports species listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)*, and *Victoria's Flora and Fauna Guarantee Act 1988 (FFG Act)* (Table 7).

These records are drawn from Naturekit (incidental and targeted surveys); however, it is fair to assume that more listed species are likely to occur due to the availability of habitat and nearby sightings.

Table 8. Listed water-dependant fauna at Lake Hawthorn

Scientific Name	Common Name	Type	FFG Act	EPBC Act Status
Calidris ferruginea	Curlew Sandpiper	B	CE	CE
Calidris tenuirostris	Great Knot	B	CE	CE
Galaxias rostratus	Flat-headed Galaxias	F	VU	CE
Craterocephalus fluviatilis	Murray Hardyhead	F	CE	EN
Calidris canutus	Red Knot	B	EN	EN
Limosa lapponica	Bar-tailed Godwit	B	VU	VU
Neophema chrysostoma	Blue-winged Parrot	B		VU
Limosa limosa	Black-tailed Godwit	B	CE	
Falco subniger	Black Falcon	B	CE	
Ardea intermedia plumifera	Plumed Egret	B	CE	
Tringa nebularia	Common Greenshank	B	EN	
Stictonetta naevosa	Freckled Duck	B	EN	
Haliaeetus leucogaster	White-bellied Sea-Eagle	B	EN	
Egretta garzetta	Little Egret	B	EN	
Tringa stagnatilis	Marsh Sandpiper	B	EN	
Gelochelidon macrotarsa	Australian Gull-billed Tern	B	EN	
Arenaria interpres	Ruddy Turnstone	B	EN	
Aythya australis	Hardhead	B	VU	
Spatula rhynchotis	Australasian Shoveler	B	VU	
Hydroprogne caspia	Caspian Tern	B	VU	
Hieraaetus morphnoides	Little Eagle	B	VU	
Oxyura australis	Blue-billed Duck	B	VU	
Lophoictinia isura	Square-tailed Kite	B	VU	
Struthidea cinerea	Apostlebird	B	VU	

Lifeform type: Amphibian (A), Bird (B), Fish (F), Reptile (R)
EPBC threatened status/Victorian Status - FFG: VU = Vulnerable, EN = Endangered, CE = Critically Endangered, NL = Not Listed

The above listed species are directly dependent on water due to food, shelter or breeding requirements.

Waterbirds

Lake Hawthorn and Lake Ranfurly are well known for their ability to support a large range of waterbirds. Of particular significance are EPBC listed migratory species recorded; Curlew Sandpiper (*Calidris ferruginea*), Great Knot (*Calidris tenuirostris*), Red Knot (*Calidris canutus*) and Bar-tailed Godwit (*Limosa lapponica*).

Waterbird diversity and abundance are influenced by wetland habitat diversity, with different species and feeding guilds using different habitats for breeding and foraging (Haig, Mehlman and Oring, 1998). Water depth in particular influences waterbird diversity due to the specific feeding behaviours of different species (Bancroft, Gawlick and Rutchey, 2002). Managing wetlands to provide diverse habitats such as variable water depth, mud flats, inundated vegetation and areas of deep water increases the likelihood of increased waterbird diversity (Taft, Colwell, Isola and Safran, 2002).

Table 9. Waterbird functional feeding groups (Roshier, Robertson and Kingsford, 2002) and their resource use.

Waterbird Group	Food Resource	Habitat Use	Waterbird Group
Dabbling and Diving ducks (e.g. Chestnut teal, Pink-eared duck, Freckled duck)	Generalists; plankton, small invertebrates, plant material	Shallow Water (Dabblers)	Solitary
Grazing Waterfowl (e.g. Shellduck, Wood Duck)	Plant material, seeds, invertebrates	Shallow Water, littoral zone	Colonial or solitary
Fish Eaters (e.g. Pelican, Cormorants, Grebes, Darter, Egret, Heron, Tern)	Fish	Open and deep water	Colonial
Small Waders (e.g. Stilt, Plovers, Dotterels)	Small invertebrates, seeds	Littoral zone, mudflats	Solitary
Large Waders (e.g. Ibis)	Macroinvertebrates, fish, amphibians	Littoral zone	Colonial or solitary
Shoreline Foragers (e.g. Lapwings, Hens)	Plant material, seeds, invertebrates,	Littoral zone, mudflats	Solitary or small groups

Figure 7. Red-capped Plovers at Lake Hawthorn

Reptiles

The Stumpy-tailed lizard (*Tiliqua rugosa*) is the only reptile recorded as present at Lake Hawthorn, though it is likely that more reptiles inhabit the target area, due to the availability of reptile habitat of, and the sightings of reptiles nearby to Lake Hawthorn and Lake Ranfurly.

The Hooded Scaly-foot (*Pygopus nigriceps*) is a legless lizard that is critically endangered in Victoria (DSE 2013), and has historically been recorded at Lake Ranfurly. The population of this species found at Lake Ranfurly is one of only six known populations in Victoria. Little is known about the ecology, habitat requirements or home range of this species although it appears to depend upon the burrows of large invertebrates for shelter and feeds on spiders and scorpions (Robertson & Canessa 2012). The number of Hooded Scaly-foot individuals recorded at Lake Ranfurly during monitoring efforts has declined significantly from 15 in 2002/2003, to five individuals recorded between 2006 and 2008 (Robertson & Sluiter 2010), and only one in surveys of 2012-2013 (Robertson 2013). Although this species is not directly dependent on water, it does require vegetation cover and woody debris (MCMA 2011A), making it indirectly dependent on water. As it is a species of high conservation significance and the Lake Ranfurly population appears to be in decline, it should be considered as part of any works, including environmental watering, at Hawthorn/Ranfurly.

Flora

Seventy-eight flora species have been recorded at Lake Hawthorn, twenty-four of which are introduced. Nine flora species that have been recorded at Lake Hawthorn are listed under the FFG Act (Table10).

Table 10. Listed flora at Lake Hawthorn

Scientific Name	Common Name	FFG Act
Acacia loderi	Nealie	CE
Eragrostis australasica	Cane Grass	CE
Duma horrida subsp. horrida	Spiny Lignum	CE
Swainsona reticulata	Kneed Swainson-pea	EN
Sida ammophila	Sand Sida	EN
Sarcozona praecox	Sarcozona	EN
Sida fibulifera	Pin Sida	EN
Calandrinia volubilis	Twining Purslane	VU
Malacocera tricornis	Goat Head	VU

Victorian Status - FFG: VU = Vulnerable, EN = Endangered, CE = Critically Endangered, NL = Not Listed

A key wetland species known to re-establish at Lake Hawthorn if water persists (Ellis 2013) is Ruppia spp. This submerged macrophyte offers important wading, feeding and foraging habitat for waterbirds. The Ruppia spp. present at Lake Hawthorn exist in the saline water and require constant inundation. A fluctuating shoreline, however, may open up vegetated forage habitat for shorebirds that feed on Ruppia seeds and forage on macroinvertebrates located in Ruppia beds.

Spiny Lignum, Muehlenbeckia horrida subsp. horrida, is considered rare in Victoria (DEPI 2014) and is found in the target area. This species occurs in the Lignum Swampy Woodland EVC close to the river, along with Tangled Lignum. It is also considered to be a species typical of the vulnerable Lake Bed Herbland EVC (DSE 2004) which dominates the wetland beds within Lake Hawthorn. The water regime for these EVCs and for Tangled Lignum may also be appropriate for Spiny Lignum given that they are found in the same habitats.

The vulnerable Kneed Swainson-pea (Swainsona reticulata) has been recorded at Lake Hawthorn. This floodplain species is only known to occur at only eight sites in the Mallee (Mallee CMA 2011B).

Figure 8. Lake Hawthorn

5.1.3 Current Condition

Lake Hawthorn has not been assessed using the Index of Wetland Condition criteria.

Ecology Australia surveyed Lake Hawthorn in 2022 (Ecology Australia, 2023) They noted that Lake Hawthorn was a heavily modified wetland due to the changed water regime – Lake Hawthorn would have originally been connected to the Murray River (via Wetland #7329 998173) during periods of high flow but has since been restricted in its connectivity due to river regulation and levee bank creation (Ecological Associates 2007a, Ecology Australia 2023). Ecology Australia found that spiny rush (CaLP-listed weed) cover was particularly high within surveyed quadrats at Lake Hawthorn (Ecology Australia 2023). Lake Hawthorn is also likely impacted by weed invasion due to edge effects and exposure to agricultural land (Ecology Australia 2023). During the Ecology Australia surveys, Lake Hawthorn was found to be hypersaline (conductivity above that of sea water), with a reading of 74.4ms/cm upon sampling in Autumn 2022. Consequently, no fish or turtles were recorded, however large numbers of halophilic ostracods (seed shrimp) were observed during sampling (Ecology Australia, 2023). As Lake Hawthorn was observed to be hypersaline, no aquatic vegetation was present during the time of the Ecology Australia Survey in 2022. However, in subsequent site visits undertaken by Mallee CMA, aquatic vegetation including Ruppia was observed to be present. It is possible that the sequence of three wet years has reduced salinity levels and allowed aquatic vegetation to establish in the lake to the benefit of waterbirds including swans.

Due to a persistent La Nina and the associated high rainfall and flooding across the Murray-Darling Basin, Lake Hawthorn and Lake Ranfurly are experiencing a very wet period (late 2020-early 2023). It is likely that Lake Hawthorn and Lake Ranfurly will

be subject to more extreme wetting and drying cycles under a changing climate. It is important to ensure that climate change adaptation is considered in environmental watering management decisions for Lake Hawthorn and Lake Ranfurly, in order to preserve and enhance their significant environmental values.

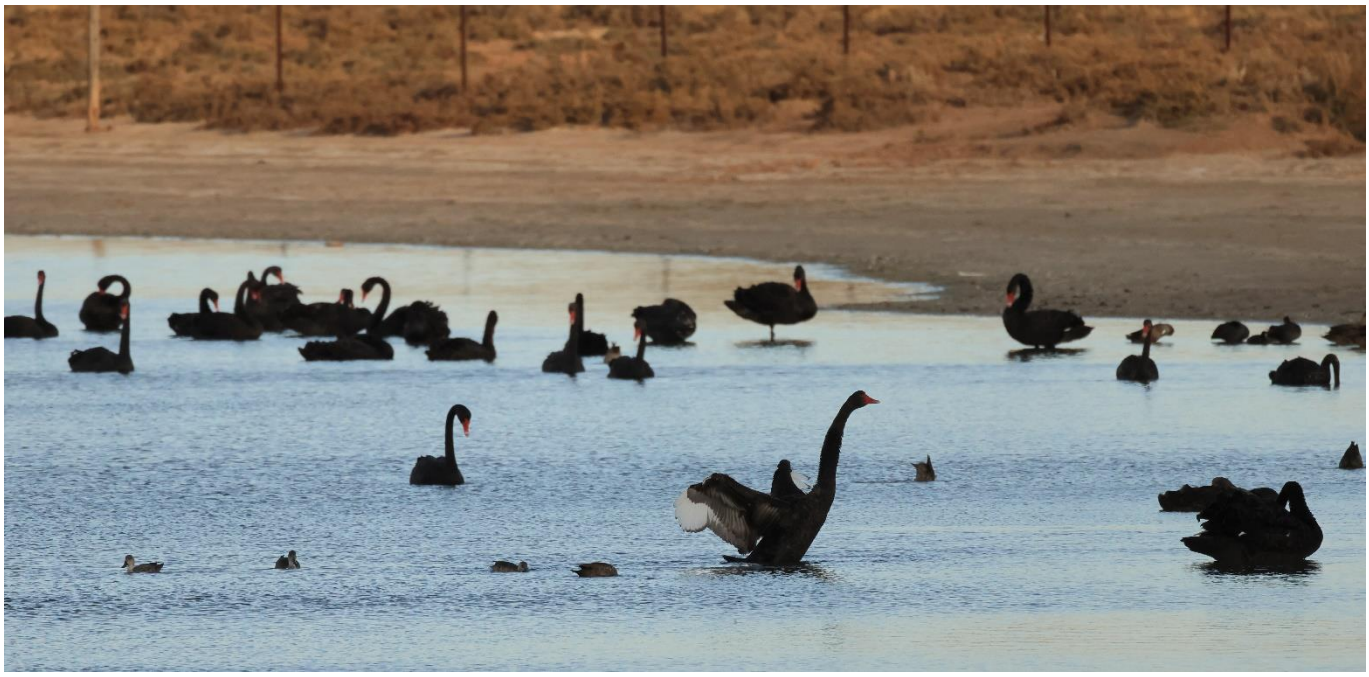


Figure 9. Swans on the southern shore of Lake Hawthorn

5.2 Shared benefits

While the primary requirement of environmental watering is to achieve environmental objectives and outcomes, environmental water can provide benefits beyond environmental objectives. Shared benefits will arise from improving the condition of an asset by using environmental watering, which in turn may contribute to benefits or outcomes for other water users and values, including for cultural outcomes and increased recreation and amenity value (DEECA EWMP Guidelines 2022, pg 16).

In addition to its significant environmental values. Lake Hawthorn has significant social and economic values. Water-dependant values that were identified for Lake Hawthorn is detailed in Table 11.

Table 11. Water-dependant values at Lake Hawthorn

Type of value	Water-dependant value
Recreational	Exercise, especially walking/running and bike riding
Recreational	Birdwatching
Recreational	Fishing
Recreational	Nature appreciation (unique landscape features and natural beauty)
Economic	Education opportunities
Environmental	Eco-system function – supporting the health of the river and wetlands
Environmental	Creation and maintenance of vital habitat for threatened/endangered species
Environmental	Diversity of habitat for feeding, breeding and nursery
Recreational/environmental?	Citizen Science
Environmental	Transportation and dilution of nutrients and organic matter and increase in macroinvertebrate productivity and biofilm diversity
Cultural	European cultural heritage

The above water-dependant values are reflected in or are closely tied to the ecological values of the site. Environmental watering decisions at Cardross and Koorlong Lakes will have direct impacts on the social, cultural and environmental values identified. Improved environmental watering will therefore have broader positive impacts for a wider range of community values at Cardross and Koorlong Lakes.

5.2.1 Aboriginal cultural values

The Mallee region has been occupied by hundreds of generations of Indigenous people with human activity dated as far back as 23,400 years ago. The region's rich and diverse Indigenous heritage has been formed through the historical and spiritual significance of sites associated with this habitation; together with the strong and enduring connection Traditional Owners have with the Mallee's natural landscapes.

In Indigenous culture, water is inseparable from the land, air, plants and animals. Caring for, and healing, Country is an inherited cultural obligation that is reliant upon having water in the landscape in the right place, at the right time of year. Water creates and sustains life and is a living and cultural entity that connects Traditional Owners to Ancestors, Country, cultural practice and identity.

Within the Mallee CMA region, the Murray River and its associated waterways continue to be culturally significant habitation areas for many Aboriginal groups. The high number of Indigenous cultural heritage sites throughout the Murray floodplain is unique in Victoria because of their concentration and diversity. It is typical to find high densities of identified Indigenous cultural heritage sites located around, or close to, freshwater sources. The Aboriginal Heritage Regulations 2018 define "areas of cultural heritage sensitivity" which include land within 200 m of named waterways and land within 50 m of registered Aboriginal cultural heritage places. A review of the Aboriginal Cultural Heritage Register and Information System (ACHRIS) confirms that all of the target area at Lake Hawthorn is defined as an area of cultural heritage sensitivity.

The Registered Aboriginal Party (RAP) for the area is the First People of the Millewa-Mallee Aboriginal Corporation (FPMMAC). Their Action Plan and Country and Water Plan "seek to repair the natural environment and our people's place in the environment" (Mallee CMA, 2022). The Mallee CMA have engaged with the FPMMAC about this EWMP and are committed to working with Traditional Owners to ensure that tangible and intangible Aboriginal culture and heritage is protected, and that Traditional Owner led practices are imbedded in the management and healing of Country (Mallee CMA, 2022).

Cultural heritage

Some cultural sites have been documented through various archaeological investigations, but the true extent of the number and types of sites present is still unknown.

Surveyed sites at Lake Hawthorn include middens, earth features, scarred trees, Aboriginal mounds and surface scatters. Surface scatters in this area may consist of chipped stone artefacts, animal bones, shell, charcoal, hearth stones, clay balls and ochre.

Aboriginal people continue to have a connection to this country. The recorded cultural heritage sites show the area was an important meeting place for Aboriginal people, with water and food sources making it possible to survive in this landscape. Mallee CMA has a contingency plan in place which details the actions necessary if Aboriginal cultural heritage values are unearthed during environmental water delivery activities.

European heritage reflects the pioneering history of the area. Significant European footprints include those of Americans George and William Chaffey, who came to develop irrigation infrastructure on an old sheep station arising in the settlement of Mildura in 1887. William Chaffey constructed the Mildura Winery just downstream of this sub-unit, in Merbein, in 1909 (Merbein n.d.).

Figure 10. Lake Hawthorn

5.2.2 Recreational values

Lake Hawthorn is popular for bike riding, bird watching, nature photography and walking. There are existing bike trails around Lake Hawthorn (Sunraysia Drainage Coordination Group 2005) and walking trails were reinstated in 2016 (Cabarita Inc 2016) that link with the Murray River and offer walkers the capacity to link Council's planned Murray River Walking Trail. The former Lake Hawthorn Sailing Club building is also located at the site, and community events are held at Lake Hawthorn including the 'Make the Lake' Art Exhibition, which draws visitors from the wider community.

Lake Hawthorn facilitates the Lake Hawthorn Drainage Diversion Scheme, the Mildura-Merbein Salt Interception Scheme, and irrigation and stormwater drainage usage. Lake Hawthorn also provides recreation and tourism opportunities.

The community utilises Lake Hawthorn for citizen science activities. As the Lake Hawthorn area has historically maintained a high recreational value for birdwatchers, three citizen scientists have been collecting bird data at Lake Hawthorn. Local citizen scientist Pauline Bartel has been collecting and maintaining bird survey data for over 16 years. Eight new species of birds have been surveyed by the scientists that were not previously listed in this plan.

5.2.3 Trajectory of change

Without management intervention in the form of environmental water delivery, condition within the target area is expected to further decline. The lack of inflows to Lake Hawthorn resulted in the eradication of all resident fish, including one of only five known populations of the nationally endangered Murray hardyhead (Craterocephalus fluviatilis), as the lake dried out from late 2008 to mid-2010 (Ellis 2013), and dried out again in 2016. A translocation of Murray hardyhead was trialled at Lake Hawthorn in 2018, however subsequent fish surveys have failed to detect any individuals of the species. It is suspected that the high salinity level in the lake is a barrier to successful recruitment and that the translocated population is likely to become extinct. No fish or turtle species were recorded in a survey conducted by Ecology Australia in 2022.

Dry conditions will continue to impact. If the modified Lake Bed Herbland vegetation community and the extensive beds of *Ruppia* spp. continue to be lost, the potentially significant communities of migratory shorebirds will not be able to be sustained. This may lead to reduced ecosystem services provided by both the wetland and waterbirds as the abundance and diversity of waterbirds that visit the lake will decline. Maintenance of the water level at Lake Hawthorn suitable for shorebirds and waders that has been in place since 2016 however, is likely to continue to render the site as favourable habitat for these and other waterbird guilds.

It is likely that Lake Hawthorn will be subject to more extreme wetting and drying cycles under a changing climate, and without proper consideration of climate change adaptation, it is likely that the environmental values at Lake Hawthorn will deteriorate.

6. Managing water-related threats

The current altered water regime and complete drying of the lakebed is considered the biggest threat for the target area and is the primary factor behind the development of this environmental water management plan.

Some of the threats which impact on the values at Lake Hawthorn include:

- Altered water regime;
- Loss or reduction of wetland connectivity;
- Water quality;
- Introduction/increase of exotic flora and fauna;
- Increased salinity;
- Degraded habitats;
- Altered physical form of wetland

Altered water regime

The regulation of the Murray River has seen the water regime through Hawthorn/Ranfurly altered. Flow events of the magnitude required to allow flows into the lake are less frequent and of shorter duration. Levees have increased the flow threshold to further reduce the frequency of natural inundation at Lake Hawthorn. This, combined with dry conditions over the last decade resulting in reduced runoff, and reduced drainage and urban stormwater inflows affects the capacity of the wetland to provide habitat and vegetation that is part of a functioning floodplain ecosystem.

Loss of wetland connectivity

Reduced connectivity to the Murray River and reduced frequency of natural flooding events has led to less frequent freshwater inflows and restricted movement of aquatic fauna.

Acid sulfate soils

Sulfidic sediments (potential acid sulfate soils) can be an issue in freshwater wetlands impacted by secondary salinization (Baldwin 2008). Wetlands used as drainage or disposal basins, such as Lake Hawthorn and Ranfurly, can be exposed to sulfates through saline irrigation discharge and groundwater salinity. Evaporation and lack of flushing in these basins can result in further elevations in salinity (CSIRO 2004). Waterlogged and anaerobic conditions can encourage sulfidic sediment formation. When exposed to oxygen during a drying phase sulfuric acid can form and be released into surrounding waters when subsequently flooded, with dire environmental consequences (MCMA 2012). Baldwin (2008) found that although Lake Hawthorn had a large store of reduced sulfur in its sediments, there was little likelihood of the wetland turning acidic during a drying event due to the large neutralizing, or buffering, capacity of the lake sediments.

Increased salinity

Salinity affects the growth of aquatic vegetation and the provision of habitat for native fauna such as the Murray Hardyhead. During a survey in 2022, Ecology Australia found Lake Hawthorn to be hypersaline (74.461 mS/cm; a conductivity above that of sea water), and consequently, no fish or turtles were recorded – though large numbers of halophilic ostracods (seed shrimp) were observed during sampling). Persistent, increased salinity risks reducing the capacity of Lake Hawthorn to provide habitat for key flora and fauna identified in ecological objectives for this site.

Other threats: Introduced Flora and Fauna

Introduced fish species Common Carp (Cyprinus carpio), and Mosquito fish (Gambusia holbrooki), pose a serious threat to the ecology of Lake Hawthorn. Ho et al (2004) found both these species to be present during aquatic vertebrate surveys, although complete dry down has resulted in extirpation of all fish species in the lake. Carp have been found to contribute to the loss of aquatic vegetation and increased turbidity, resulting in loss of habitat for waterfowl (Purdey & Loyn 2008). This species also competes with native fish for habitat and food as well as having a detrimental effect on water quality (MCMA 2003).

Agricultural and other weeds are an ongoing threat and management issue along the Murray River floodplain. These may pose a threat when water is applied. Spiny rush (Juncus acutus subsp. Acutus) is present at Lake Hawthorn (Ecology Australia, 2023) and African Boxthorn (Lycium ferocissimum) is found around both lakes (Bluml 1992).

Assessing risks

Consideration of risk provides a link between recognition of system threats and key management processes, including decade and seasonal planning. Risk assessments are composed of both likelihood and consequence components. In this instance likelihood is influenced by the probability that there will be sufficient environmental water to maintain lake water and salinity levels.

From a seasonal watering perspective, prioritisation of watering actions will be based on consequence. While consequence for an individual wetland can be determined, environmental water allocations require consideration of the consequences at larger scales. For the Mallee CMA it is their region, for the VEWH it is Victoria and the CEWH it is the MDB. Lake Hawthorn represents an important habitat for waterbirds. The Lake has previously dried, and the aquatic vegetation recovered demonstrating resilience. Waterbirds are critically dependent on the availability of foraging habitat and Lake Hawthorn is clearly regionally important. The consequence of a change in flow regime or water quality is therefore a regional reduction in foraging habitat for species with the capacity to disperse.

Not all consequences can be identified as readily and so we have provided a process that can be followed in Appendix 5.

7. Management goals, objectives and targets

7.1 Management goal

The overall goal proposed for Lake Hawthorn target area has been developed through consultation with various experts and stakeholders including DEECA 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.

To provide a flow regime to the target area that provides permanent shallow wading habitat for internationally important migratory shorebirds and a diverse population of resident native waterbirds.

It is strongly linked to the goals of the Mallee Waterway Strategy 2014-22 (Mallee CMA 2014) :

- To maintain or improve habitat within waterways and on surrounding riparian land;
- To manage all land tenures for water quality benefits and respond appropriately to threatening events (both natural and pollution based);
- To restore appropriate water regimes and improve connectivity;
- To protect the extent and condition of Cultural Heritage (Indigenous and non-Indigenous) sites associated with waterways; and
- To increase community capacity for, awareness of and participation in waterway management.

7.2 Environmental objectives and targets

Environmental objectives represent the desired environmental outcomes of the site based on the management goal, above, as well as the key values outlined in the Water Dependent Values section. It is intended that EWMP objectives will be described in terms of the primary environmental outcomes, in most cases ecological attributes.

During 2020, the environmental objectives (formally ecological objectives) were refined with the intent of improving the specificity and measurability of the objectives through the development of targets, and to improve line of sight to the Basin Plan. While the process attempted to maintain the intent and integrity of the original objectives, it provided an opportunity to reassess the suitability of these objectives for the asset. The rationalisation, assessment of SMARTness, mapping to Basin Plan and update of each objective for Lake Hawthorn can be found in Section 5.7.1 of Butcher et al. (2020). The numbering of the environmental objectives in this EWMP have been adopted directly from the Butcher et al (2020) assessment.

Table 12. Environmental objectives and targets for Lake Hawthorn

Environmental objective	Target
LH1: **By 2030, maintain populations and extent of saline aquatic vegetation at the Lake Hawthorn asset including benthic herblands with Ruppia beds containing both R. polycarpa and R. megacarpa.**	By 2030, vigorous populations of saline aquatic vegetation at the Lake Hawthorn asset: • improve cover of Ruppia to ≥30% and at least 10 live (green) shoots per core at 40% of sites assessed • measured by taking sediment 5 core samples (75mmx4cm deep) at transects of dry zone above waterline, waterline, 30cm and 60cm depths • up to five random transects per site minimum of 200m apart To achieve this specific water regime and salinity levels will need to be established – i.e. once a baseline is established these targets may be modified. Sampling method modified from Paton et al. (2018). Suggested salinity threshold of 30ppt should support growth/germination and condition of both species (see Sim et al. 2006). Flowering is likely to require 3 months at <15ppt salinity (Sim et al. 2006). These thresholds need to be confirmed for this wetland system and others where Ruppia outcomes are the objective.
LH2: **By 2030, maintain representative populations of the shallow-water feeding guild of waterbirds including shorebirds (F2, after Jaensch 2002) at the Lake Hawthorn asset, by maintaining shallow-water habitats.**	By 2030, 80% of representative F2 species of ducks and allies and large waders recorded at the Lake Hawthorn asset in 8 years out of any 10-year period where conditions are suitable. • Representative F2 species of ducks and allies include: Australasian Grebe (Tachybaptus novaehollandiae), Pacific Black Duck (Anas superciliosa), Grey Teal (Anas gracilis), White-necked Heron (Ardea pacifica), Australian White Ibis (Threskiornis molucca), Masked Lapwing (Vanellus miles), White-faced Heron (Egretta novaehollandiae), Yellow-billed Spoonbill (Platalea flavipes), Royal Spoonbill (Platalea regia) • By 2030, 50% of representative F2 species of shorebirds recorded at the Lake Hawthorn asset in 8 years out of any 10-year period where conditions are suitable. • Representative F2 species of shorebirds include: Sharp-tailed Sandpiper (Calidris acuminata), Red-necked Stint (Calidris ruficollis), Redcapped Plover (Charadrius ruficapillus), Black-winged Stilt (Himantopus himantopus), Black-tailed Godwit (Limosa limosa), Red-necked Avocet (Recurvirostra novaehollandiae), Common Greenshank (Tringa nebularia), Marsh Sandpiper (Tringa stagnatilis) • Feeding habitat defined as shallow feeding areas (<0.5m depth and or drying mud) with intermittent inundation of densely vegetated

7.3 Regional Significance

Lake Hawthorn supports a range of environmental values of local, regional and Basin significance as described in section 5. While these values do not constitute Lake Hawthorn and Lake Ranfurly being rare or pristine sites, the riparian and floodplain communities of the Murray River are important to the functioning of the river system and its sustainability. Water birds rely

on a range of different wetland habitats. Saline wetlands are known to support significantly larger numbers of waterbirds than freshwater wetlands, although freshwater wetlands are needed for some species for breeding (Young, 2001).

Lake Hawthorn and Lake Ranfurly offer valuable shallow feeding, foraging and loafing habitat for waterbirds that is not often found on the floodplain. The target area at Lake Hawthorn represents a rare opportunity to provide habitat for internationally recognised, EPBC listed, migratory shorebird species. Additionally, resident waterbird populations are also a likely to benefit from permanent inundation of the lake and its close proximity to Lignum communities for breeding.

Lake Hawthorn dried out between 2008 and 2010, before refilling due to localised flooding and elevated Murray River flows in 2010-11. The refilling event resulted in the re-establishment of Ruppia beds throughout the lake, indicating the viability of seed banks within the wetland bed and its capacity to perform important ecosystem services. There is great potential for re-establishing a shallow wading environment for shorebirds at Lake Hawthorn.

The historic waterbird records for this area are abundant and diverse, with extensive areas of Lignum Shrublands providing roosting, nesting and feeding habitats. Particularly, the large number of EPBC listed migratory species among the wader guild emphasise the target area's potential to support, and perhaps encourage, a diversity of species.

The values contained within Hawthorn/Ranfurly, and specifically the target area for this plan, makes this area a priority for protection and enhancement through environmental water management.

The environmental values listed in Section 5 are linked to the management goals and environmental objectives and targets described in Section 7. Details of the links between the environmental objectives and environmental outcomes at a regional/Basin scale are provided in Appendix 4. The management goals and environmental objectives and targets are aligned with the goals of the Mallee Waterway Strategy as described in Section 7.1.

Figure 11. Red-necked Avocets on Lake Hawthorn

7.4 Alignment to Basin Plan

Key elements of the Basin Plan have been integrated into the Lake Hawthorn EWMP objectives, including adopting the same conceptual framework. The EWMP objectives were also developed based on the same ecological knowledge about how Murray River floodplains work.

Under the Basin Plan, the overall environmental objectives for the water-dependent ecosystems of the Murray–Darling Basin are:

- to protect and restore water-dependent ecosystems of the Murray–Darling Basin (8.05)
- to protect and restore the ecosystem functions of water-dependent ecosystems (8.06)
- to ensure that water-dependent ecosystems are resilient to climate change and other risks and threats (8.07).

The Lake Hawthorn EWMP objectives were developed to align with these overall objectives and to integrate and encode the intent of Basin Plan. Table 12 shows the alignment between the EWMP objectives and the Basin Plan's overall environmental objectives and subobjectives under 8.05, 8.06 and 8.07.

Table 13. Mapping Lake Hawthorn EWMP objectives to Basin Plan EWP objectives

EWMP objective	Alignment with Basin Plan		
	8.05 Ecosystem and biodiversity	8.06 Ecosystem function	8.07 Ecosystem resilience
LH1: **By 2030, maintain populations and extent of saline aquatic vegetation at the Lake Hawthorn asset including benthic herblands with Ruppia beds containing both R. polycarpa and R. megacarpa.**		2, 6(b)	
LH2: **By 2030, maintain representative populations of the shallow-water feeding guild of waterbirds including shorebirds (F2, after Jaensch 2002) at the Lake Hawthorn asset, by maintaining shallow-water habitats.**	3b	6(b)	

8. Environmental water requirements and intended water regime

8.1 Watering requirements and intended watering regimes

The wetland watering regime has been derived from the ecological and hydrological objectives and is limited by these specific 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, however flexibility is encouraged in accordance with the minimum, maximum and optimal hydrological objectives in Table 13, below.

The optimal watering regime for Lake Hawthorn is described in the following pages. Due to the inter-annual variability of these estimates (particularly the climatic conditions and inflows), determination of the predicted volume requirements in any given year will need to be undertaken by the environmental water manager when watering is planned. Environmental watering of Lake Hawthorn may not be required during median or wet years.

Water level monitoring will be required to maintain a minimum water level of 33.0 mAHD, and a target of 33.3 mAHD at Lake Hawthorn. Delivery of environmental water may be required at various times during the year to maintain a minimum level, however the frequency, extent and timing of delivery will be dependent on:

- Availability of environmental water;
- Urban stormwater and irrigation drainage inflows; and
- Irrigation demand in the delivery system.

Water levels could be allowed to decrease marginally through summer to expose wetland sediments and fringing vegetation whilst also maintaining aquatic macrophyte beds within the wetland (Ellis 2013). Subsequent increases in water level should be high enough to inundate exposed sediments to promote a rise in primary production.

The proposed water regime is provided below. A 'dry' year and a 'wet' year for the purposes of this regime are defined as 20% below and 20% above average annual rainfall respectively. These definitions are likely to require refinement in the future. For the purposes of planning delivery, a rolling 12-month total may be suitable to apply in conjunction with water level trends.

Table 14. Water regime for Lake Hawthorn

Predicted Annual Rainfall Value*	Water Regime – Lake Hawthorn
Dry Year	Provide environmental water via irrigation infrastructure to permanently inundate the target area and achieve a water level of 33.3 m AHD to encourage germination of Ruppia spp. and visitation by shorebirds. Allow natural recession of a maximum of 0.3 m (to 33.0 m AHD) before delivering a top-up volume as necessary to return the lake to 33.3 m AHD.
Average Year	Provide environmental water via irrigation infrastructure to permanently inundate the target area and to maintain a water level of 33.3 m AHD to encourage germination of Ruppia spp. and visitation by shorebirds. Allow natural recession of a maximum of 0.3 m (to 33.0 m AHD) to expose mudflats for foraging shorebirds and to promote Ruppia spp. germination, before delivering a top-up volume as necessary to return the lake to 33.3 m AHD.
Wet Year	Monitor water level. Deliver environmental water, if necessary, to sustain a water level of 33.3 m AHD to maintain Ruppia spp. beds. Allow natural recession of a maximum of 0.3 m (to 33.0 m AHD) before delivering a top-up volume as necessary to return the lake to 33.3 m AHD.

8.2 Expected watering effects

This section aims to explicitly outline the potential watering actions and expected watering effects needed to achieve the stated environmental objective.

Table 15. Environmental objectives for Lake Hawthorn and the watering actions required to achieve them

Objective Code	Environmental objective	Potential watering actions	Expected watering effects
LH1	**By 2030, maintain populations and extent of saline aquatic vegetation at the Lake Hawthorn asset including benthic herblands with Ruppia beds containing both R. polycarpa and R. megacarpa.**	Facilitate seasonally variable watering to support natural wetting and drying cycles of the wetlands. Facilitate variable and brief inundation (for <1 month) to support EVC 101 Samphire Shrubland. Maintain a salinity threshold of 30ppt to support growth/germination and condition of both Ruppia species.	Maintain and improve environmental conditions to support saline aquatic vegetation (including Ruppia species) at Lake Hawthorn.
LH2	**By 2030, maintain representative populations of the shallow-water feeding guild of waterbirds including shorebirds (F2, after Jaensch 2002) at the Lake Hawthorn asset, by maintaining shallow-water habitats.**	Facilitate seasonally variable watering to support natural wetting and drying cycles of the wetlands. Maintain permanent ponding with variations in water levels. Time inflows preferably in late Winter/early Spring, allow water levels to recede over summer/autumn. Lake Hawthorn must experience an inundation phase between spring and autumn to provide wading habitat for migratory shorebirds.	Maintain adequate sallow- and deep-water habitats at Lake Hawthorn to support waterbird populations: - Provide suitable habitat (food, refuge, nesting sits) in flooded wetland and floodplain vegetation in spring and summer. - Provide foraging habitat in shallow open water (<0.5m depth) and mudflats as water recedes over summer and autumn.

8.3 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 Waterway Management Strategy.

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 Figure 6.

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.

During droughts and dry periods, waterbirds will disperse away from the region and aquatic plants will tolerate dry periods through seeds and vegetative structures. There are, however, populations of small fish and crustaceans in the lake that would be vulnerable to drying or high salinity. Within this context it is worth maintaining a refuge pool in Lake Hawthorn, noting that the lake has experienced both drying and high salinity levels in the past and has then recovered.

As the volumes of environmental water increase, there are increasing opportunities to initiate cycles of inundation and drying to promote productive aquatic vegetation that provides habitat and food resources for a range of animals including waterbirds.

As the volumes of available water increase the focus should be on the capacity to engage higher regions of the riparian zone and to promote habitat heterogeneity which would be expected to be associated with increases in vegetation species richness.

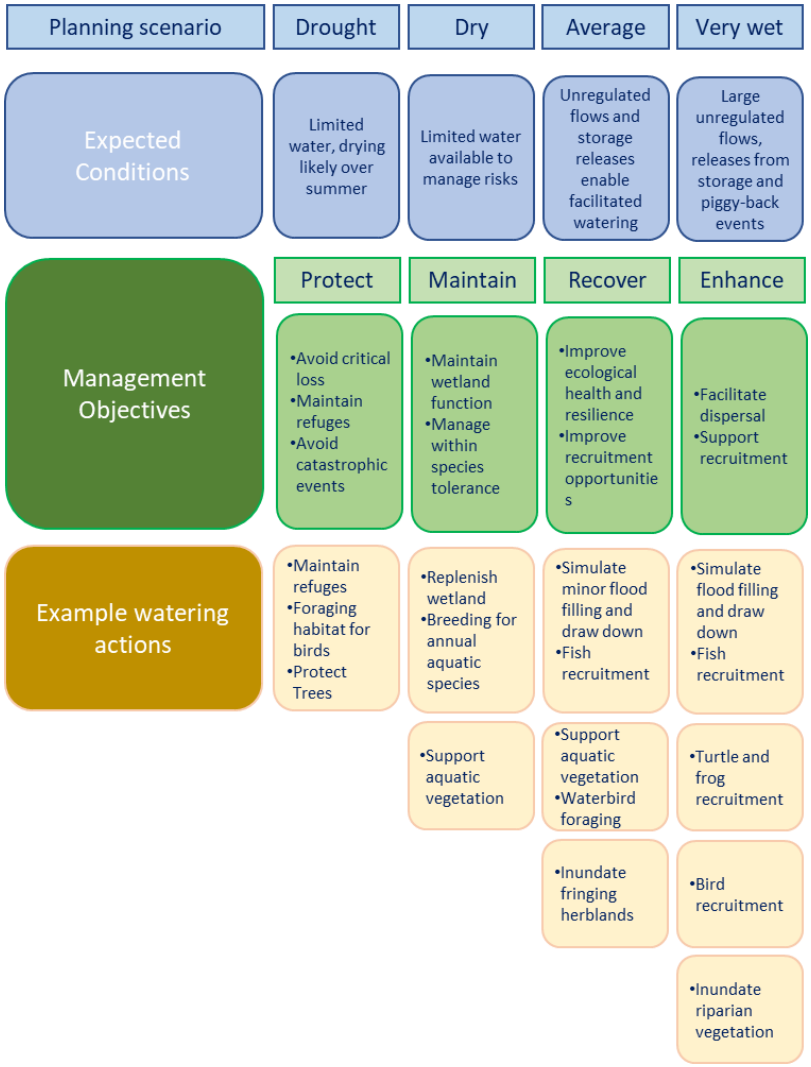


Figure 12. Seasonally adaptive approach for Lake Hawthorn

9. Environmental water delivery infrastructure

9.1 Water delivery infrastructure

Environmental water will be delivered to Lake Hawthorn via existing irrigation supply infrastructure which outfalls to the south eastern shoreline of the lake. A key constraint to the delivery of environmental water to Lake Hawthorn is the time and rate at which water can be delivered. Increased horticultural demand is placed on the irrigation supply system during the spring and summer each year, which corresponds with the peak growing season and lower seasonal rainfall.

To achieve the ecological objectives, specifically, to provide wading habitat for migratory shorebirds, the lake must experience an inundation phase between spring and autumn. Supply pressure in peak irrigation season may limit the delivery of environmental water to the lake. It is strongly recommended that investigations are undertaken to determine a means of

delivering suitable volumes of environmental water to Lake Hawthorn during spring and summer to maintain the shallow wading habitat.

Connectivity of Lake Hawthorn to the Murray River via wetland #7329 998173 occurs through a regulator along Ranfurly Way and a regulator between wetland #7329 998173 and Lake Hawthorn at the railway line. This infrastructure would facilitate freshwater inflows during natural flood events; however this is not currently a feasible delivery method.

9.2 Constraints and complementary works recommendations

Downstream salinity risk management

Mallee CMA commissioned a Preliminary Salinity Impact Assessment (CDM Smith 2015) to investigate the likely downstream impacts of environmental watering events at Hawthorn/Ranfurly in accordance with the Murray Darling Basin Authority's Basin Salinity Management Strategy. This study tested potential watering regimes for Lake Hawthorn and wetland #7329 98173, focussing on surface water salinity processes and groundwater salinity processes, and estimated the salinity impact of these regimes in terms of their EC impact at Morgan.

The salinity impact assessment included three target areas and stage levels, with minimum, optimal and maximum regimes:

- an initial inundation of wetland #7329 998173 to a height of 35.7 mAHD and draw down to 34.9 mAHD;
- inundation of Lake Hawthorn to between 34.3 and 34.8 mAHD; and
- permanent inundation of Lake Hawthorn to 33.3 mAHD (the option proposed in this EWMP).

The preliminary assessment estimates that by maintaining a shallow level in Lake Hawthorn between 33.0 and 33.3 mAHD the total impact at Morgan could be 0.02 EC for the proposed inundation of Lake Hawthorn (Table 16). The other target areas are not proposed in this EWMP.

Table 16. Estimated EC impacts at Morgan for watering options at Lake Hawthorn

Option					Estimated EC impact at Morgan		
	Target Area (ha)	Stage level (m AHD)	Target watering frequency		Groundwater pathway	Surface Water pathway	Total
Wetland #7329998173	44	35.7, drawn down to 34.9	Min	1 year in every 10	0.01	negligible	0.02
			Opt & Max	2 years in every 10	0.03	negligible	0.03
Lake Hawthorn	225	34.3 - 34.8	Min	1 year in every 10	0.01	n.a.	0.01
			Opt & Max	2 years in every 10	0.03	n.a.	0.03
Proposed Regime: Lake Hawthorn	148	33.3	Optimal	10 years in every 10	0.02	n.a.	0.02

(CDM Smith 2015)

As the salinity impacts of the proposed watering actions at Lake Hawthorn do not exceed 0.1 EC at Morgan, they are not considered an accountable action under the BSMS. Furthermore, it is not proposed to return environmental water to the Murray River from Lake Hawthorn, thus no surface water pathway for salinity will occur as a result of the proposed regime.

10. Demonstrating outcomes

10.1 Environmental Monitoring

The watering program at Lake Hawthorn has been designed to optimise ecological outcomes based on environmental water requirements.

Table 17. Links between environmental objectives, monitoring questions and survey methods

Objective	Monitoring focus	Monitoring question	Method	When
LH1	Improving condition and maintaining extent of saline aquatic vegetation (Ruppia)	Is the condition of saline aquatic vegetation improving? What is the change in extent?	Surveying, transects	Annual
LH2	Improving condition and maintaining extent of habitat for shallow- and deep-water feeding birds.	Is the condition of What is the change in areas of deep and shallow water?	This could be achieved through installation of a depth recorder or use areas as a surrogate using GA Wetland Information Tool. Appropriately timed field surveys to coincide with migrations of shorebirds and habitat availability within the lake.	Annual

10.2 Monitoring priorities at the asset

Ecological monitoring is required to demonstrate the effectiveness of environmental watering in achieving ecological objectives, to help manage environmental risks and to identify opportunities to improve the efficiency and effectiveness of the program. The broad program logic for the lake is:

- Objectives (Section 7.2)
- Environmental flows to provide:
    - Appropriate water quality
    - Shallow wading habitat
- Outcomes
    - Saline aquatic vegetation
    - Migratory shorebirds
    - Native waterbirds

The highest priorities for monitoring at Lake Hawthorn are the monitoring questions that most strongly influence watering decisions and the evaluation of watering effectiveness.

All these priorities align with the following long-term outcomes of the Mallee Regional Catchment Strategy Waterway theme:

- 3.2.1 The condition of high value aquatic and riparian habitat is improved.
- 3.2.2 Appropriate water regimes are restored to priority waterways and connectivity is improved.

Table 18. Monitoring priorities at Lake Hawthorn

Monitoring priority	Reason for priority
Wetland Depth	Habitat characteristic that influences vegetation and waterbirds.
Monitoring of water quality condition on a regular basis, including monitoring of salinity levels through the water column to identify seasonal stratification.	Water quality monitoring would inform environmental watering actions and support risk management.
Index of Wetland Condition assessments should be undertaken every 5 years	To monitor the health of the vegetation communities in response to the implementation of the EWMP.
Photo point monitoring be conducted before and after watering events.	To measure the success of environmental water in improving wetland and riparian vegetation communities.
Waterbird presence	To improve understanding of impact of environmental water in improving habitat for waterbirds.

11. Knowledge gaps and recommendations

This plan is based on best information at the time of writing. Further investigation and information collection will continue and the results of this work will continue to build a better understanding of the site and add rigor to future planning. Some areas where further knowledge could enhance planning and delivery capacity are outlined in Table 19.

Table 19. Knowledge gaps and recommendations for the target area

Knowledge and data gaps	Action recommended	Priority level	Responsibility
Conceptual and detailed designs for the proposed water delivery infrastructure	Engage consultant(s) to carry out investigations and designs	1	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
Determine significance of floodplain and wetland #7329 998173 for resident waterbird breeding habitat	Data collection and monitoring	2	
IWC for Lake Hawthorn	Index of Wetland Condition assessment undertaken to establish baseline condition and as the basis for ongoing monitoring of improvement over time	3	
Habitat availability for waterbirds at Lake Hawthorn	Monitor depth, vegetation and food availability (focusing on target species preferences)	4	

The following monitoring is recommended:

<u>Water</u>

- Monitoring of wetland depth. This could be achieved through installation of a depth recorder or use areas as a surrogate using GA Wetland Information Tool
- Monitoring of water quality condition on a regular basis, including monitoring of salinity levels through the water column to identify seasonal stratification. Water quality monitoring would inform environmental watering actions and support risk management.
- Detailed monitoring of environmental water delivery would be dependent on funding from the State or Commonwealth governments.

- The Index of Wetland Condition assessments if undertaken for this site, could review and report on changes in hydrology and water quality.

Vegetation

- Photo point monitoring before and after watering events to measure the success of environmental water in improving wetland and riparian vegetation communities;
- Index of Wetland Condition assessments are undertaken every 5 years to assess the health of vegetation communities.

Waterbirds

- Appropriately timed field surveys to coincide with migrations of shorebirds and habitat availability within the lake.

12. Adaptive Management

Mallee CMA uses an adaptive management approach in planning, delivering and managing environmental watering actions.

Adaptive management is the process of incorporating new scientific and operational information into the implementation of a project or plan to ensure that the goals of the activity are being reached efficiently. It is a standard and well-established practice for environmental water management, recognising the inherent uncertainties and risks associated with the complex relationships between changes to hydrology and ecological responses, and the potential for a watering event to provide both positive and adverse outcomes. Figure 13 shows an illustration of the adaptive management cycle for environmental water delivery.

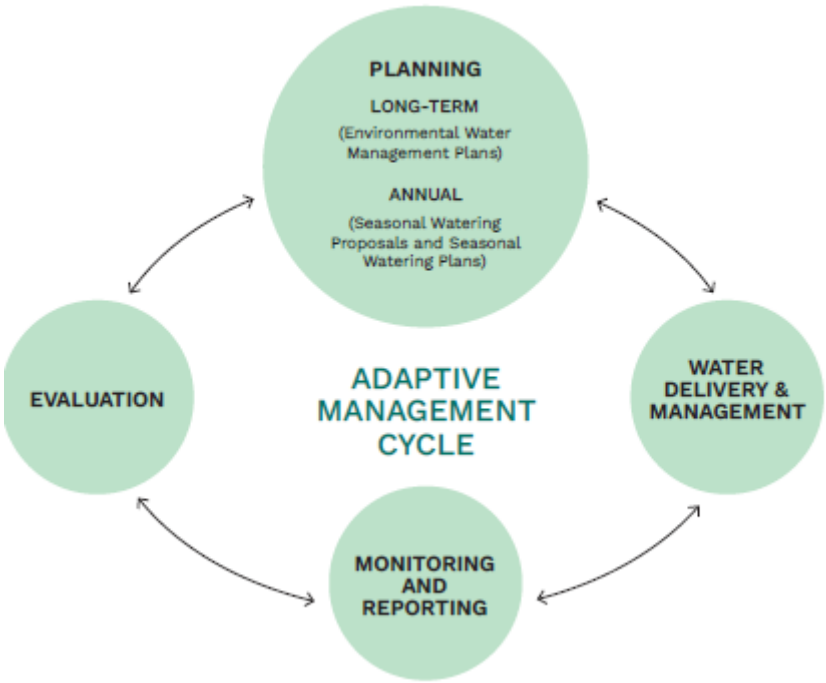


Figure 13. The adaptive management cycle for environmental water delivery and management.

Mallee CMA uses three main pathways to identify inputs to the adaptive management process (also referred to as lessons):

- monitoring to detect differences between what was planned and the outcomes at the environmental watering site
- incidental observations by managers, operators or other observers that identify opportunities to reduce risk or improve outcomes
- research or investigations into hydraulic or ecological management practices that could improve the conceptual models on which operations are based.

In 2022, Mallee CMA further refined its adaptive management approach, implementing the Environmental Watering Adaptive Management Framework (MCMA, 2022).

Mallee CMA formally documents lessons to strengthen organisational memory and provide transparency in continual improvement measures. Recording of lessons is crucial for both annual environmental watering actions and long-term planning. Demonstrating continual improvement provides the justification for monitoring programs and confirms that assets are being managed responsibly.

Mallee CMA's adaptive management framework has several components that work together to build lessons learned from environmental watering actions and program partners into the environmental water program. In this way, we iteratively improve the way environmental watering is undertaken using the best available evidence.

The EWMP will be constantly refined to incorporate learnings from ecological monitoring as well as feedback from community consultation.

Land managers and river operators are included in the operational planning cycle which include adaptive management processes to incorporate learnings and risk management.

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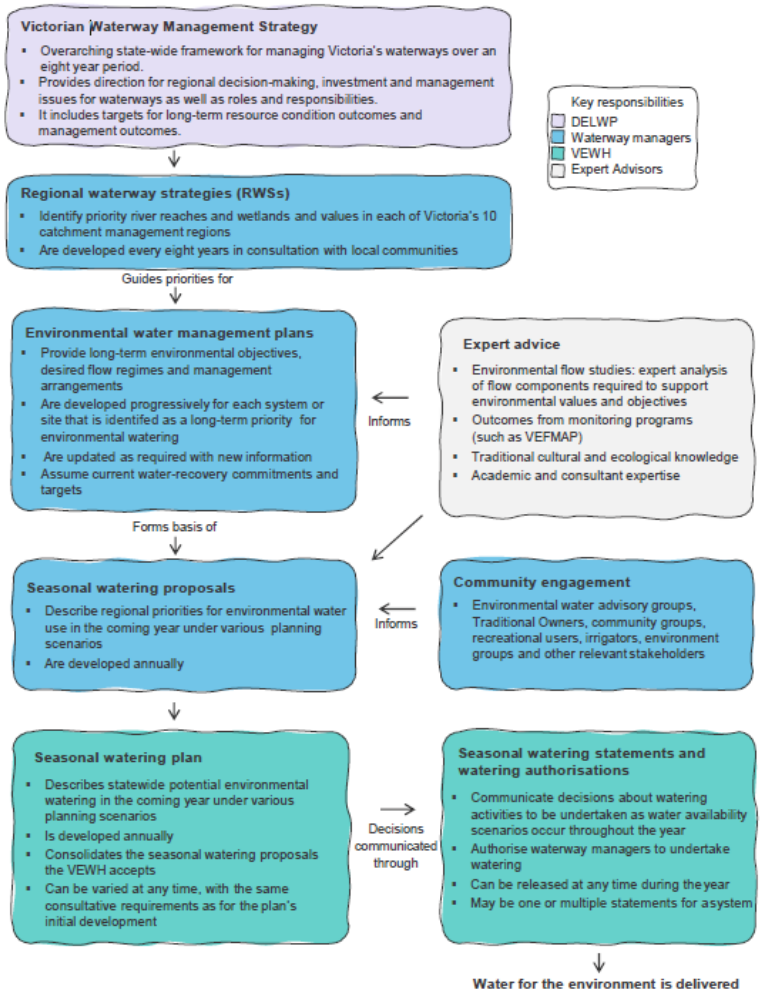
14. Appendix 1 – Framework for Environmental Water Management

Environmental water in Victoria is managed as an integral part of the Victorian Waterway Management Program. The state-level Victorian Waterway Management Strategy (VWMS) provides the overarching framework for environmental water management (see accompanying figure). The Mallee Waterway Strategy (2014-22) drives implementation of the VWMS at the regional level. Information from the Mallee Waterway Strategy is a key input to environmental water planning arrangements, including the selection of eligible assets to receive environmental water. Environmental water management plans are site-specific plans developed for a wetland or wetland complex deemed a priority to receive environmental water through the Mallee Waterway Strategy development process. This document is the Environmental Water Management Plan (EWMP) for Lake Hawthorn in the Mallee Catchment Management region.



Environmental watering in the Mallee Region has historically been supported by management plans such as this one, that document key information including the watering requirements of an asset, predicted ecological responses and water delivery arrangements. These plans support annual decisions about which sites should receive water and assist managers to evaluate how well those assets respond to the water they receive or what could be done better. Environmental water management at Lake Hawthorn is further underpinned by the Murray-Darling Basin Plan 2012 (Commonwealth) and the associated Basin-wide environmental watering strategy. In accordance with Basin Plan requirements, Victoria has also developed the Victorian Murray Water Resource Plan and Victorian Murray Long-Term Watering Plan, which apply at Lake Hawthorn.

Mallee Catchment Management Authority (MCMA), the Department of Energy, Environment and Climate Action, the Victorian Environmental Water Holder (VEWH) and Traditional Owner groups have worked together to develop several EWMPs for watered assets throughout the Mallee region. These plans are continually updated through an adaptive management process. A primary purpose of EWMPs is to provide a consistent set of documents that support seasonal watering proposals to be submitted by asset managers to the VEWH annually.

15. Appendix 2 – Flora and fauna species list

Flora and fauna species lists were sourced from Naturekit records, extracted May 2023. Observations within the Ecology Australia 2023 report were added.

Flora

Scientific Name	Common Name	Record Number	Source
Acacia loderi	Nealie	1	Naturekit export May 2023
Acacia stenophylla	Eumong	1	Naturekit export May 2023
Asperula spp.	Woodruff	2	Naturekit export May 2023
Atriplex eardleyae	Small Saltbush	2	Naturekit export May 2023
Atriplex halocarpa	Pop Saltbush	1	Ecology Australia 2023
Atriplex leptocarpa	Slender-fruit Saltbush	2	Naturekit export May 2023
Atriplex lindleyi	Flat-top Saltbush	3	Naturekit export May 2023
Atriplex pseudocampanulata	Mealy Saltbush	1	Naturekit export May 2023
Atriplex semibaccata	Berry Saltbush	2	Naturekit export May 2023
Atriplex stipulata subsp. Stipulata	Kidney saltbush	1	Ecology Australia 2023
Atriplex spp.	Saltbush	1	Naturekit export May 2023
Atriplex suberecta	Sprawling Saltbush	1	Naturekit export May 2023
Austrostipa spp.	Spear Grass	1	Naturekit export May 2023
Brachyscome ciliaris	Variable Daisy	1	Naturekit export May 2023
Bulbine semibarbata	Leek lily	1	Ecology Australia 2023
Calandrinia eremaea	Small Purslane	2	Naturekit export May 2023
Calandrinia volubilis	Twining Purslane	1	Naturekit export May 2023
Crassula colorata	Dense Crassula	3	Naturekit export May 2023
Crassula sieberiana s.l.	Sieber Crassula	3	Naturekit export May 2023
Cressa australis	Rosinweed	4	Naturekit export May 2023
Disphyma crassifolium subsp. clavellatum	Rounded Noon-flower	6	Naturekit export May 2023
Dissocarpus biflorus var. biflorus	twin-flower saltbush	1	Ecology Australia 2023
Dissocarpus paradoxus	Hard-head saltbush	1	Ecology Australia 2023
Duma florulenta	Tangled Lignum	1	Naturekit export May 2023
Duma horrida subsp. horrida	Spiny Lignum	1	Naturekit export May 2023
Einadia nutans	Nodding Saltbush	3	Naturekit export May 2023
Einadia spp.	Einadia	1	Naturekit export May 2023
Enchylaena tomentosa var. tomentosa	Ruby Saltbush	3	Naturekit export May 2023
Enteropogon acicularis	Spider Grass	2	Naturekit export May 2023
Eragrostis australasica	Cane Grass	1	Naturekit export May 2023
Eragrostis dielsii	Mallee love-grass	1	Ecology Australia 2023
Eucalyptus largiflorens	Black Box	4	Naturekit export May 2023
Goodenia pinnatifida	Cut-leaf Goodenia	1	Naturekit export May 2023
Lysiana exocarpi	Harlequin Mistletoe	1	Naturekit export May 2023
Maireana appressa	Grey Bluebush	1	Naturekit export May 2023
Maireana brevifolia	Short-leaf Bluebush	1	Naturekit export May 2023
Maireana pyramidata	Sago Bush	1	Naturekit export May 2023
Malacocera tricornis	Goat Head	1	Naturekit export May 2023
Osteocarpum acropterum var. deminutum	Babbagia	1	Naturekit export May 2023

Scientific Name	Common Name	Record Number	Source
Oxalis perennans	Grassland Wood-sorrel	1	Naturekit export May 2023
Pachymitus cardaminoides	Sand Cress	1	Naturekit export May 2023
Paspalidium spp.	Panic Grass	1	Naturekit export May 2023
Phragmites australis	Common reed	1	Ecology Australia 2023
Rhagodia spinescens	Hedge Saltbush	4	Naturekit export May 2023
Rytidosperma caespitosum	Common Wallaby-grass	1	Naturekit export May 2023
Rytidosperma spp.	Wallaby Grass	1	Naturekit export May 2023
Sarcozona praecox	Sarcozona	3	Naturekit export May 2023
Sclerochlamys brachyptera	Short-wing Saltbush	3	Naturekit export May 2023
Sclerolaena diacantha	Grey Copperburr	2	Naturekit export May 2023
Sclerolaena tricuspis	Streaked Copperburr	1	Naturekit export May 2023
Senecio glossanthus s.l.	Slender Groundsel	1	Naturekit export May 2023
Senecio spanomerus	Mallee Groundsel	1	Naturekit export May 2023
Senna artemisioides s.l.	Desert Cassia	1	Naturekit export May 2023
Sida ammophila	Sand Sida	2	Naturekit export May 2023
Sida fibulifera	Pin Sida	2	Naturekit export May 2023
Tetricornia halocnemoides subsp. Halocnemoides	Grag glasswort	1	Ecology Australia 2023
Swainsona reticulata	Kneed Swainson-pea	14	Naturekit export May 2023
Tecticornia pergranulata	Blackseed Glasswort	5	Naturekit export May 2023
Tecticornia pergranulata subsp. pergranulata	Blackseed Glasswort	1	Naturekit export May 2023
Tecticornia spp.	Glasswort	2	Naturekit export May 2023
Vittadinia spp.	New Holland Daisy	1	Naturekit export May 2023
Walwhalleya proluta	Rigid Panic	1	Naturekit export May 2023

Fauna

Scientific Name	Common Name	Record Number	Source
Acanthagenys rufogularis	Spiny-cheeked Honeyeater	4	Naturekit export May 2023
Acanthiza chrysorrhoa	Yellow-rumped Thornbill	12	Naturekit export May 2023
Acanthiza nana	Yellow Thornbill	4	Naturekit export May 2023
Accipiter cirrocephalus	Collared Sparrowhawk	1	Naturekit export May 2023
Accipiter fasciatus	Brown Goshawk	2	Naturekit export May 2023
Acrocephalus australis	Reed-Warbler	24	Naturekit export May 2023
Anas castanea	Chestnut Teal	15	Naturekit export May 2023
Anas gracilis	Grey Teal	110	Naturekit export May 2023
Anas superciliosa	Pacific Black Duck	56	Naturekit export May 2023
Anhinga novaehollandiae	Australasian Darter	7	Naturekit export May 2023
Anthochaera carunculata	Red Wattlebird	29	Naturekit export May 2023

Scientific Name	Common Name	Record Number	Source
Anthus australis	Australian Pipit	2	Naturekit export May 2023
Ardea alba	Great Egret	13	Naturekit export May 2023
Ardea intermedia plumifera	Plumed Egret	1	Naturekit export May 2023
Ardea pacifica	White-necked Heron	4	Naturekit export May 2023
Arenaria interpres	Ruddy Turnstone	5	Naturekit export May 2023
Artamus leucorynchus	White-breasted Woodswallow	12	Naturekit export May 2023
Aythya australis	Hardhead	19	Naturekit export May 2023
Barnardius zonarius zonarius	Port Lincoln Parrot	1	Naturekit export May 2023
Cacatua sanguinea	Little Corella	14	Naturekit export May 2023
Cacatua tenuirostris	Long-billed Corella	2	Naturekit export May 2023
Cacomantis pallidus	Pallid Cuckoo	2	Naturekit export May 2023
Calidris acuminata	Sharp-tailed Sandpiper	21	Naturekit export May 2023
Calidris canutus	Red Knot	1	Naturekit export May 2023
Calidris ferruginea	Curlew Sandpiper	7	Naturekit export May 2023
Calidris ruficollis	Red-necked Stint	31	Naturekit export May 2023
Calidris tenuirostris	Great Knot	3	Naturekit export May 2023
Chalinolobus gouldi	Gould’s wattled bat	1	Ecology Australia 2023
Chalinolobus morio	Chocolate wattled bat	1	Ecology Australia 2023
Charadriidae spp.	Plovers, Dotterels and Lapwings	1	Naturekit export May 2023
Charadrius bicinctus	Double-banded Plover	3	Naturekit export May 2023
Charadrius ruficapillus	Red-capped Plover	67	Naturekit export May 2023
Chenonetta jubata	Australian Wood Duck	6	Naturekit export May 2023
Cheramoeca leucosterna	White-backed Swallow	3	Naturekit export May 2023
Chlidonias hybrida	Whiskered Tern	17	Naturekit export May 2023
Chroicocephalus novaehollandiae	Silver Gull	102	Naturekit export May 2023
Chrysococcyx basalis	Horsfield's Bronze-Cuckoo	7	Naturekit export May 2023
Cincloramphus cruralis	Brown Songlark	1	Naturekit export May 2023
Cincloramphus mathewsi	Rufous Songlark	3	Naturekit export May 2023
Circus approximans	Swamp Harrier	14	Naturekit export May 2023
Cisticola exilis	Golden-headed Cisticola	1	Naturekit export May 2023
Cladorhynchus leucocephalus	Banded Stilt	35	Naturekit export May 2023

Scientific Name	Common Name	Record Number	Source
Colluricincla harmonica	Grey Shrike-thrush	9	Naturekit export May 2023
Coracina novaehollandiae	Black-faced Cuckoo-shrike	9	Naturekit export May 2023
Corcorax melanorhamphos	White-winged Chough	1	Naturekit export May 2023
Corvus bennetti	Little Crow	2	Naturekit export May 2023
Corvus coronoides	Australian Raven	16	Naturekit export May 2023
Corvus mellori	Little Raven	15	Naturekit export May 2023
Corvus spp.	Ravens and Crows	1	Naturekit export May 2023
Cracticus nigrogularis	Pied Butcherbird	34	Naturekit export May 2023
Cracticus torquatus	Grey Butcherbird	5	Naturekit export May 2023
Craterocephalus fluviatilis	Murray Hardyhead	4	Naturekit export May 2023
Craterocephalus stercusmuscarum fulvus	Unspecked Hardyhead	1	Naturekit export May 2023
Cygnus atratus	Black Swan	122	Naturekit export May 2023
Dacelo novaeguineae	Laughing Kookaburra	7	Naturekit export May 2023
Dicaeum hirundinaceum	Mistletoebird	8	Naturekit export May 2023
Egretta garzetta	Little Egret	3	Naturekit export May 2023
Egretta novaehollandiae	White-faced Heron	29	Naturekit export May 2023
Elanus axillaris	Black-shouldered Kite	1	Naturekit export May 2023
Elseyornis melanops	Black-fronted Dotterel	30	Naturekit export May 2023
Entomyzon cyanotis	Blue-faced Honeyeater	12	Naturekit export May 2023
Eolophus roseicapilla	Galah	21	Naturekit export May 2023
Epthianura albifrons	White-fronted Chat	27	Naturekit export May 2023
Epthianura aurifrons	Orange Chat	7	Naturekit export May 2023
Erythrogonys cinctus	Red-kneed Dotterel	25	Naturekit export May 2023
Falco berigora	Brown Falcon	2	Naturekit export May 2023
Falco cenchroides	Nankeen Kestrel	10	Naturekit export May 2023
Falco longipennis	Australian Hobby	4	Naturekit export May 2023
Falco peregrinus	Peregrine Falcon	2	Naturekit export May 2023
Falco subniger	Black Falcon	3	Naturekit export May 2023
Fulica atra	Eurasian Coot	29	Naturekit export May 2023
Galaxias rostratus	Flat-headed Galaxias	2	Naturekit export May 2023

Scientific Name	Common Name	Record Number	Source
Gallinula tenebrosa	Dusky Moorhen	6	Naturekit export May 2023
Gavicalis virescens	Singing Honeyeater	32	Naturekit export May 2023
Gelochelidon macrotarsa	Australian Gull-billed Tern	3	Naturekit export May 2023
Geopelia placida	Peaceful Dove	2	Naturekit export May 2023
Grallina cyanoleuca	Magpie-lark	48	Naturekit export May 2023
Gymnorhina tibicen	Australian Magpie	39	Naturekit export May 2023
Haliaeetus leucogaster	White-bellied Sea-Eagle	3	Naturekit export May 2023
Haliastur sphenurus	Whistling Kite	33	Naturekit export May 2023
Hieraaetus morphnoides	Little Eagle	4	Naturekit export May 2023
Himantopus leucocephalus	Pied Stilt	72	Naturekit export May 2023
Hirundo neoxena	Welcome Swallow	47	Naturekit export May 2023
Hydroprogne caspia	Caspian Tern	38	Naturekit export May 2023
Hypseleotris klunzingeri	Western Carp Gudgeon (Species Complex)	2	Naturekit export May 2023
Lalage tricolor	White-winged Triller	2	Naturekit export May 2023
Limnodynastes tasmaniensis	Spotted marsh frog	1	Ecology Australia 2023
Limosa lapponica	Bar-tailed Godwit	1	Naturekit export May 2023
Limosa limosa	Black-tailed Godwit	2	Naturekit export May 2023
Lophoictinia isura	Square-tailed Kite	1	Naturekit export May 2023
Macquaria ambigua	Golden Perch	8	Naturekit export May 2023
Malacorhynchus membranaceus	Pink-eared Duck	25	Naturekit export May 2023
Malurus assimilis	Purple-backed Fairywren	17	Naturekit export May 2023
Malurus cyaneus	Superb Fairy-wren	11	Naturekit export May 2023
Malurus leucopterus	White-winged Fairy-wren	34	Naturekit export May 2023
Malurus splendens	Splendid Fairy-Wren	1	Ecology Australia 2023
Malurus spp.	Fairywrens	1	Naturekit export May 2023
Manorina flavigula	Yellow-throated Miner	15	Naturekit export May 2023
Manorina melanocephala	Noisy Miner	29	Naturekit export May 2023
Manorina melanophrys	Bell Miner	1	Naturekit export May 2023
Melopsittacus undulatus	Budgerigar	2	Naturekit export May 2023
Merops ornatus	Rainbow Bee-eater	4	Naturekit export May 2023
Microcarbo melanoleucos	Little Pied Cormorant	25	Naturekit export May 2023

Scientific Name	Common Name	Record Number	Source
Microeca fascinans	Jacky Winter	1	Naturekit export May 2023
Milvus migrans	Black Kite	21	Naturekit export May 2023
Myiagra inquieta	Restless Flycatcher	1	Naturekit export May 2023
Nematalosa erebi	Bony Herring	3	Naturekit export May 2023
Neophema chrysostoma	Blue-winged Parrot	1	Naturekit export May 2023
Northiella haematogaster	Blue Bonnet	5	Naturekit export May 2023
Nyctophilus gouldi	Gould's long-eared bat	1	Ecology Australia 2023
Nyctophilus geoffroyi	Lesser long-eared bat	1	Ecology Australia 2023
Nyctophilus corbeni	South-eastern long-eared bat	1	Ecology Australia 2023
Nycticorax caledonicus	Nankeen Night-Heron	1	Naturekit export May 2023
Ocyphaps lophotes	Crested Pigeon	37	Naturekit export May 2023
Oxyura australis	Blue-billed Duck	3	Naturekit export May 2023
Pachycephala rufiventris	Rufous Whistler	1	Naturekit export May 2023
Pardalotus striatus	Striated Pardalote	6	Naturekit export May 2023
Pelecanus conspicillatus	Australian Pelican	47	Naturekit export May 2023
Petrochelidon ariel	Fairy Martin	4	Naturekit export May 2023
Petrochelidon nigricans	Tree Martin	18	Naturekit export May 2023
Petroica goodenovii	Red-capped Robin	1	Naturekit export May 2023
Phalacrocorax carbo	Great Cormorant	15	Naturekit export May 2023
Phalacrocorax sulcirostris	Little Black Cormorant	21	Naturekit export May 2023
Phalacrocorax varius	Pied Cormorant	5	Naturekit export May 2023
Phaps chalcoptera	Common Bronzewing	9	Naturekit export May 2023
Philypnodon grandiceps	Flatheaded Gudgeon	1	Naturekit export May 2023
Platalea flavipes	Yellow-billed Spoonbill	14	Naturekit export May 2023
Platalea regia	Royal Spoonbill	2	Naturekit export May 2023
Platycercus elegans	Crimson Rosella	13	Naturekit export May 2023
Podiceps cristatus	Great Crested Grebe	4	Naturekit export May 2023
Podicipedidae spp.	Grebes	1	Naturekit export May 2023
Poliocephalus poliocephalus	Hoary-headed Grebe	27	Naturekit export May 2023
Poodytes gramineus	Little Grassbird	28	Naturekit export May 2023
Porphyrio melanotus	Australasian Swamphen	24	Naturekit export May 2023

Scientific Name	Common Name	Record Number	Source
Porzana fluminea	Australian Spotted Crake	10	Naturekit export May 2023
Porzana pusilla	Baillon's Crake	2	Naturekit export May 2023
Porzana tabuensis	Spotless Crake	3	Naturekit export May 2023
Psephotus haematonotus	Red-rumped Parrot	27	Naturekit export May 2023
Ptilotula penicillata	White-plumed Honeyeater	20	Naturekit export May 2023
Recurvirostra novaehollandiae	Red-necked Avocet	71	Naturekit export May 2023
Retropinna semoni	Australian Smelt	1	Naturekit export May 2023
Rhipidura albiscapa	Grey Fantail	7	Naturekit export May 2023
Rhipidura leucophrys	Willie Wagtail	33	Naturekit export May 2023
Scotorepens greyii	Little broad-nosed bat	1	Ecology Australia 2023
Scotorepens balstoni	Inland broad-nosed bat	1	Ecology Australia 2023
Smicrornis brevirostris	Weebill	4	Naturekit export May 2023
Spatula rhynchotis	Australasian Shoveler	33	Naturekit export May 2023
Stictonetta naevosa	Freckled Duck	4	Naturekit export May 2023
Struthidea cinerea	Apostlebird	1	Naturekit export May 2023
Tachybaptus novaehollandiae	Australasian Grebe	12	Naturekit export May 2023
Tadorna tadornoides	Australian Shelduck	117	Naturekit export May 2023
Taeniopygia guttata	Zebra Finch	6	Naturekit export May 2023
Threskiornis molucca	Australian White Ibis	21	Naturekit export May 2023
Threskiornis spinicollis	Straw-necked Ibis	10	Naturekit export May 2023
Tiliqua rugosa	Stumpy-tailed Lizard	1	Naturekit export May 2023
Todiramphus pyrrhopygius	Red-backed Kingfisher	2	Naturekit export May 2023
Todiramphus sanctus	Sacred Kingfisher	1	Naturekit export May 2023
Tribonyx ventralis	Black-tailed Native-hen	7	Naturekit export May 2023
Trichoglossus moluccanus	Rainbow Lorikeet	1	Ecology Australia 2023
Tringa nebularia	Common Greenshank	7	Naturekit export May 2023
Tringa stagnatilis	Marsh Sandpiper	11	Naturekit export May 2023
Vanellus miles	Masked Lapwing	82	Naturekit export May 2023
Vanellus tricolor	Banded Lapwing	1	Naturekit export May 2023
Zosterops lateralis	Silvereye	7	Naturekit export May 2023

16. Appendix 3 – Exotic flora and fauna species list

Flora

Scientific Name	Common Name	Record Number	Source
Asphodelus fistulosus	Onion Weed	1	Naturekit export May 2023
Brassica tournefortii	Mediterranean Turnip	1	Naturekit export May 2023
Bromus rubens	Red Brome	2	Naturekit export May 2023
Carrichtera annua	Ward's weed	1	Ecology Australia 2023
Erigeron sumatrensis	Tall fleabane	1	Ecology Australia 2023
Gazania linearis	Gazania	1	Ecology Australia 2023
Hordeum glaucum	Northern barley-grass	1	Ecology Australia 2023
Hordeum murinum s.l.	Barley-grass	2	Naturekit export May 2023
Hypochaeris glabra	Smooth Cat's-ear	1	Naturekit export May 2023
Juncus acutus subsp. acutus	Spiny Rush	1	Naturekit export May 2023
Lactuca serriola	Prickly Lettuce	1	Naturekit export May 2023
Limonium lobatum	Winged Sea-lavender	1	Naturekit export May 2023
Lolium rigidum	Wimmera Rye-grass	1	Naturekit export May 2023
Lycium ferocissimum	African Box-thorn	7	Naturekit export May 2023
Malva parviflora	Small-flower mallow	1	Ecology Australia 2023
Medicago minima	Little Medic	2	Naturekit export May 2023
Medicago polymorpha	Burr Medic	2	Naturekit export May 2023
Melilotus indicus	Sweet Melilot	3	Naturekit export May 2023
Mesembryanthemum crystallinum s.s.	Common ice-plant	1	Ecology Australia 2023
Mesembryanthemum granulicaule	Wiry noon-flower	1	Ecology Australia 2023
Mesembryanthemum nodiflorum	Small Ice-plant	4	Naturekit export May 2023
Olea europaea	Olive	1	Naturekit export May 2023
Parapholis incurva	Coast Barb-grass	2	Naturekit export May 2023
Poa annua s.l.	Annual meadow-grass	1	Ecology Australia 2023
Polypogon monspeliensis	Annual beard-grass	1	Ecology Australia 2023
Polycarpon tetraphyllum	Four-leaved Allseed	1	Naturekit export May 2023
Reichardia tingitana	False sow-thistle	1	Ecology Australia 2023
Rostraria pumila	Tiny Bristle-grass	2	Naturekit export May 2023

Scientific Name	Common Name	Record Number	Source
Schismus barbatus	Arabian Grass	1	Naturekit export May 2023
Sisymbrium erysimoides	Smooth mustard	1	Ecology Australia 2023
Sisymbrium irio	London Rocket	1	Naturekit export May 2023
Sonchus oleraceus	Common Sow-thistle	1	Naturekit export May 2023
Spergularia diandra	Lesser Sand-spurrey	1	Naturekit export May 2023
Spergularia rubra s.s.	Red Sand-spurrey	1	Naturekit export May 2023
Suaeda maritima subsp. maritima	Annual seablite	1	Ecology Australia 2023
Symphyotrichum subulatum	Aster-weed	1	Ecology Australia 2023
Vulpia myuros	Rat's-tail Fescue	1	Naturekit export May 2023
Asphodelus fistulosus	Onion Weed	1	Naturekit export May 2023

Fauna

Scientific Name	Common Name	Record Number	Source
Passer domesticus	House Sparrow	17	Naturekit export May 2023
Sturnus vulgaris	Common Starling	26	Naturekit export May 2024
Anas superciliosa X Anas platyrhynchos	Pacific Black Duck/Mallard Hybrid	1	Naturekit export May 2025
Turdus merula	Common Blackbird	2	Naturekit export May 2026
Cyprinus carpio	European Carp	4	Naturekit export May 2027
Oryctolagus cuniculus	European Rabbit	3	Naturekit export May 2028
Carduelis carduelis	European Goldfinch	1	Naturekit export May 2029
Columba livia	Domestic Pigeon	4	Naturekit export May 2030
Gambusia holbrooki	Eastern Gambusia	1	Naturekit export May 2031
Perca fluviatilis	Redfin	1	Naturekit export May 2032

17. Appendix 4 – Lake Hawthorn EWMP Updated Environmental Objectives, Further Information (From Butcher et al 2020).

Lake Hawthorn EWMP updated environmental objectives, further information (from Butcher et al. 2020).

SMARTness and rationalisation

Site-specific environmental objectives for the Lake Hawthorn EWMP (DSE 2010b).

EWMP objectives
LH1: Reintroduce saline marsh habitat, particularly benthic herblands including Ruppia beds.
LH2: Provide suitable wading, feeding, foraging and loafing habitat for shorebirds

Assessment of SMARTness of current Lake Hawthorn EWMP objectives. Scoring: 1 is criterion met, 0 is criterion not met, and 0.5 is partially met

	Specific		Measurable			Achievable		Relevant		Timely	
Objective	Magnitude clearly specified	Location and scale detailed	Indicators available or easily developed	Can be analysed using accepted statistical practices	Capacity to collect data exists	Under river operating constraints and current climate variability	Considered feasible by knowledgeable stakeholders	Matters driven by environmental watering and/or works and measures	Linked to BP objectives	Absolute date or time period specified	Considers likely lags in response
LH1	0	0	0.5	0.5	0.5	0.5	1	1	1	0	0
LH2	0	0	0.5	0.5	1	0.5	1	0.5	0.5	0	0

Rationalised environmental objectives for the Lake Hawthorn EWMP (Mallee CMA 2016b).

Objective	Issue	Outcome
LH1	Ruppia species not listed in EWMP – need this information to advise on water regime for target setting.	As R. megacarpa is a perennial species whereas R. polycarpa is an annual – it is possible that megacarpa is the species at this wetland. Also ALA records suggest R. megacarpa is more common in the region, but this is obviously dependent on sampling and reporting to ALA – species present needs to be determined particularly as salinity tolerance will differ among halophytes.
LH2	No issue with objective other than its not fully SMART and no baseline data.	Objective updated to align with Basin Plan language

Mapping to Basin Plan

Basin Plan Schedule 8 and 9 criteria.

Schedule 8 criteria met	Schedule 9 criteria met
From DELWP (2015a)	
1: JAMBA, KAMBA, ROKAMBA **4:** FFG Act, EPBC act, DSE Listed **5:** High level of biodiversity	**1:** Supports the creation and maintenance of vital habitats and populations **2:** water quality - ecosystem processes supports the transportation and dilution of nutrients, organic matter and sediment; supports the dilution of carbon and nutrients from the floodplain to the river system **4:** lateral connectivity - (between floodplains, anabranches and wetlands)
Updated assessment	
3(b): Prevents declines in native biota	**1(e):** Vital habitat - preventing decline of native biota

Mapping updated Lake Hawthorn EWMP objectives to Basin Plan Environmental Watering Plan (EWP) objectives, Basin Plan Schedule 7 targets, Basin wide Environmental Watering strategy (BWS) quantified environmental expected outcomes (QEEO) (MDBA 2019), and Long-term Watering Plan (LTWP) Victorian Murray objective (DEECA 2015).

EWMP objectives	Basin Plan EWP objective	Relevant Schedule 7 target	Relevant BWS QEEO	LTWP objective
LH1	8.06,6(b) 8.06,2	Condition of priority ecosystem functions - creation of vital habitat - habitat for prevention of decline in native species Condition of priority asset - prevention of decline in native biota	B2.11	LTWPVM2 LTWPVM4
LH2	8.06,6(b) 8.05,3(b)	Condition of priority ecosystem functions - creation of vital habitat - habitat for prevention of decline in native species Condition of priority asset - Vital habitat - feeding, breeding, nursery	B3.1	LTWPVM12 LTWPVM13

Updated objectives for Lake Hawthorn

Current objective	LH1: Reintroduce saline marsh habitat, particularly benthic herblands including Ruppia beds.
Comments	Need to establish baseline of species present.
EWP objective(s)	8.06,6(b) 8.06,2 8.05,3(b)
Schedule 7 targets	Condition of priority ecosystem functions - creation of vital habitat - habitat for prevention of decline in native species Condition of priority asset - prevention of decline in native biota
PEA/PEF criteria met	PEF 1(e) Vital habitat - preventing decline of native biota PEA 3(b) Prevents declines in native biota
BEWS QEEO	B2.11
LTWP objective	LTWPVM2 Improve the species richness of aquatic vegetation in wetlands LTWPVM4 Improve the extent of aquatic vegetation
LTWP target	None specified
2020 Objective:	By 2030, maintain populations and extent of saline aquatic vegetation at the Lake Hawthorn asset including benthic herblands with *Ruppia* beds containing both *R. polycarpa* and *R. megacarpa*.
2020 Targets:	By 2030, vigorous populations of saline aquatic vegetation at the Lake Hawthorn asset: - improve cover of *Ruppia* to ≥30% and at least 10 live (green) shoots per core at 40% of sites assessed
	- measured by taking sediment 5 core samples (75mmx4cm deep) at transects of dry zone above waterline, waterline, 30cm and 60cm depths - up to five random transects per site minimum of 200m apart To achieve this specific water regime and salinity levels will need to be established – i.e. once a baseline is established these targets may be modified. Sampling method modified from Paton et al. (2018). Suggested salinity threshold of 30ppt should support growth/germination and condition of both species (see Sim et al. 2006). Flowering is likely to require 3 months at <15ppt salinity (Sim et al. 2006). These thresholds need to be confirmed for this wetland system and others where Ruppia outcomes are the objective.

Current objective	LH2: Provide suitable wading, feeding, foraging and loafing habitat for shorebirds
Comments	
EWP objective(s)	8.05,3(b)
Schedule 7 targets	Condition of priority asset - Vital habitat - feeding, breeding, nursery
PEA/PEF criteria met	PEA 3(a) iii Vital habitat - feeding, breeding, nursery sites PEF 1 (c) Vital habitat - feeding, breeding, nursery sites
BWS QEEO	B3.1 That the number and type of water bird species present in the Basin will not fall below current observations
LTWP objective	LTWPVM12: Improve habitat for waterbirds LTWPVM13: Improve feeding areas for waterbirds
LTWP target	Appropriate water regime to support feeding and habitat areas for guilds of waterbirds delivered at 50% of sites, 8 years in 10
2020 Objective:	By 2030, maintain representative populations of the shallow-water feeding guild of waterbirds including shorebirds (F2, after Jaensch 2002) at the Lake Hawthorn asset, by maintaining shallow-water habitats.
2020 Targets:	By 2030, 80% of representative F2 species of ducks and allies and large waders recorded at the Lake Hawthorn asset in 8 years out of any 10-year period where conditions are suitable. • Representative F2 species of ducks and allies include: Australasian Grebe (*Tachybaptus novaehollandiae*), Pacific Black Duck (*Anas superciliosa*), Grey Teal (*Anas gracilis*), White-necked Heron (*Ardea pacifica*), Australian White Ibis (*Threskiornis molucca*), Masked Lapwing (*Vanellus miles*), White-faced Heron (*Egretta novaehollandiae*), Yellow-billed Spoonbill (*Platalea flavipes*), Royal Spoonbill (*Platalea regia*) By 2030, 50% of representative F2 species of shorebirds recorded at the Lake Hawthorn asset in 8 years out of any 10-year period where conditions are suitable. • Representative F2 species of shorebirds include: Sharp-tailed Sandpiper (*Calidris acuminata*), Red-necked Stint (*Calidris ruficollis*), Red-capped Plover (*Charadrius ruficapillus*), Black-winged Stilt (*Himantopus himantopus*), Black-tailed Godwit (*Limosa limosa*), Red-necked Avocet (*Recurvirostra novaehollandiae*), Common Greenshank (*Tringa nebularia*), Marsh Sandpiper (*Tringa stagnatilis*) • Feeding habitat defined as shallow feeding areas (<0.5 m depth and or drying mud) with intermittent inundation of densely vegetated shrublands.

18. Appendix 5. Assessing Risks

When prioritizing wetland watering, it is often difficult because there is no framework by which you can compare the fate of different species. To support prioritization, this guide seeks to put each wetland and its associated species within a regional context. The process can also be used when communicating the rationale behind decisions or support engagement by providing a framework for discussion.

The process is presented in Figure 14, with a more detailed explanation provided in Tables 21 and 22.

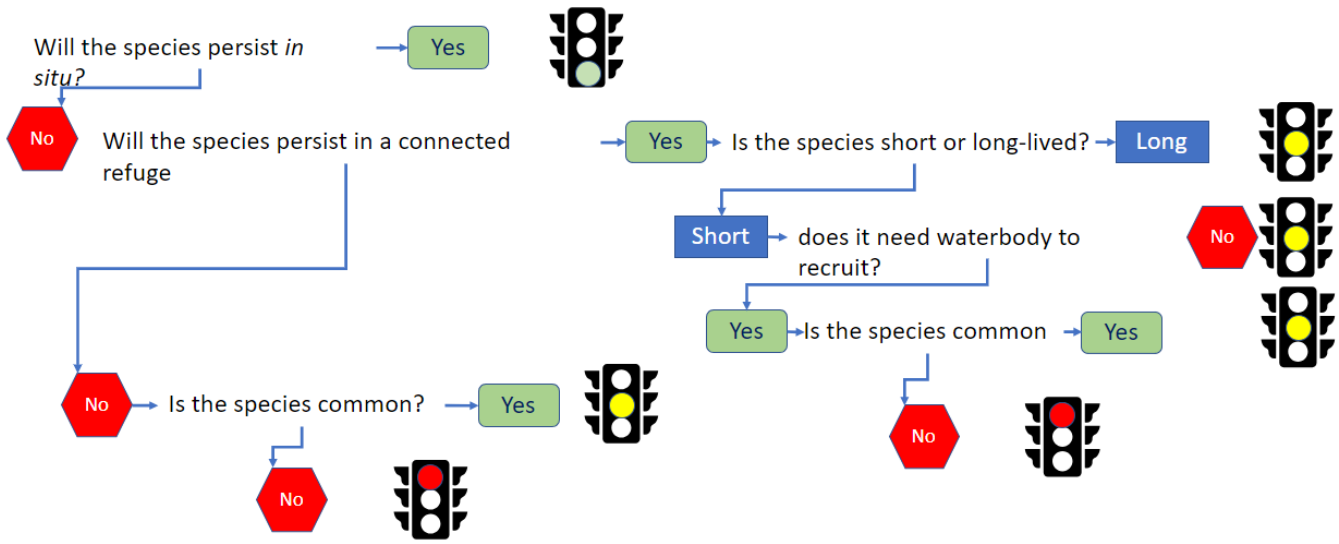


Figure 14. Risk decision tree

Table 16. Risk decision tree

Row	Question	Rationale	Response	Risk	Go To
1	Will the species persist *in situ*?	If the species will survive without intervention, It becomes a lower priority	Yes	Low	
			No		Row 2
2	Will the species persist in a connected refuge?	If the species has the capacity (its own capability and appropriate connectivity) to survive, it becomes a lower priority	Yes		Table 2
			No		Row 3
3	Is the species common?	If a species is common then there may be other populations that are more likely or easier to protect than the ones in the wetland.	Yes	Med	
			No	High	

Table 17. Risk decision tree

Row	Question	Rationale	Response	Risk	Go To
1	Is the species short or long lived?	Long-lived species often have greater capacity to endure periods of hardship, whereas short lived species are programmed to die.	Long	Med	
			Short		Row 2
2	Does the species need the wetland to recruit?	If the species requires the wetland to recruit then sustaining will require protection of wetland condition.	No	Med	
			Yes		Row 3
3	Is the species common?	If a species is common then there may be other populations that are more likely or easier to protect than the ones in the wetland.	Yes	Mod	
			No	High	

19. Appendix 6. Community Engagement 2023 Summary.

To update the community values present at Lake Hawthorn, Mallee CMA engaged with the local community through an online survey. This survey requested information from participants about which wetland area was most important or meaningful, how they used that area, additional water dependent values of the area, a ranking of the importance of values, as well as demographic information from survey participants. This engagement exercise represented the 'Consult' activity in the IAP2 Public Participation Spectrum.

Seven of forty-seven respondents identified Lake Hawthorn as the most important site (of all eight sites), although only 4 completed surveys were received. Two of the respondents are visitors to the region, one is a resident, and one is a recreational user. 50% (2/4 respondents) visit Lake Hawthorn once or twice a year, 25% (1 respondent) visits Lake Hawthorn every few months, and 25% (1 respondent) visits Lake Hawthorn less than once a year. Respondents visit Lake Hawthorn in all seasons, with a slight majority visiting over springtime (2/4 respondents – all other seasons received one response). Over 75% of respondents (3/4) visit Lake Hawthorn for walking/running. Other identified uses of Lake Hawthorn include bike riding, nature appreciation and education purposes (2, 1, and 1 response respectively. No survey respondents identified that Lake Hawthorn is used for birdwatching, socialising, tourism operations and photography.

Table 20 - Community Values rankings

Community Value	Use and Value ranking
Exercise, especially walking/running and bike riding	75% of survey participants use Lake Hawthorn for walking/running. 50% of survey participants use Lake Hawthorn for bike riding. Exercise was ranked important (score of 4.25/5) for survey participants.
Recreational opportunities (e.g. birdwatching, fishing)	Respondents for the Lake Hawthorn survey ranked this value as important (a score of 3.75/5)
Unique landscape features and natural beauty	Respondents for the Lake Hawthorn survey ranked this value as very important (a score of 4/5)
Education purposes	A respondent to the survey identified they used Lake Hawthorn for education purposes. The value of 'work or education opportunities' was ranked highly by survey participants (3.5/5).
Nature appreciation	A respondent to the survey identified they used Lake Hawthorn for 'nature appreciation'.
Traditional Owner Values	Respondents for the Lake Hawthorn survey ranked this value as important (a score of 3.25/5).

The Lake Hawthorn waterway area is comprised of the following wetlands: Lake Hawthorn, Lake Ranfurly (West), Lake Ranfurly (East), and Unnamed Wetlands #11448 & #11462. Lake Hawthorn itself is the area most frequently visited by survey respondents (4/4 respondents visit this area. One respondent indicated that they also frequently visit Lake Ranfurly (West). Lake Hawthorn is the area selected as most important/meaningful to all the survey participants.

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