ROUND LAKE

ENVIRONMENTAL WATERING PLAN

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

PREPARED FOR THE
GOULBURN-MURRAY WATER CONNECTIONS PROJECT

GOULBURN-MURRAY WATER

Version 9, Final, June 2015

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Front cover photo: Round Lake 2009, North Central CMA

The Round Lake Environmental Watering Plan is a working document, compiled from the best available information. It will be subject to revision in the future as new information becomes available.

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Management agreement

Where consistent with the obligations and responsibilities of the respective agencies, I agree to the management actions and responsibilities as described in this EWP.

NCCMA representative signature:

Print name: EMER CAMPBELL

Date: 24/10/2015

GMW representative signature:

Print name: Ross Plunkett

Date: 22.12.2015

EXECUTIVE SUMMARY

The Round Lake Environmental Watering Plan (EWP) documents the approach to mitigating the potential impacts of the Goulburn-Murray Water Connections Project (GMW Connections Project) due to significant reductions in channel outfalls to the lake.

The following components are the primary means by which the commitment of no net environmental loss for Round Lake will be achieved for the GMW Connections Project. The main conclusions are summarised below.

Defining the environmental values of Round Lake
Round Lake is a bioregionally important wetland occupying 40 ha of the Long Lake and Round Lake Water Reserve, which occupies approximately 186 ha. It is an important refuge for Murray Hardyhead (*Craterocephalus fluviatilis*), a species listed as endangered under the International Union for the Conservation of Nature (IUCN) Red List, vulnerable under the Federal *Environment Protection Biodiversity Conservation (EPBC) Act 1999* and listed under Victorian *Flora and Fauna Guarantee (FFG) Act 1988*. Murray Hardyhead is endemic to Australia and currently Round Lake supports one of six remaining populations (consisting of three in Victoria and three in South Australia).

Part of the Murray Flora and Fauna Bulk Entitlement has frequently been used for Round Lake to maintain salinity levels, based on previously recorded levels within the lake and research into the status and requirements of Murray Hardyhead, in order to provide suitable habitat for species. Since 2004, environmental water has regularly been supplied to Round Lake to compensate for declining outfalls resulting from increased irrigation efficiencies and falling regional rainfall volumes.

A water management goal has been developed in light of the current condition of Round Lake, the values the lake supports and potential risk factors that need to be managed.

Round Lake water management goal:
Maintain Round Lake as a permanent, saline lake that provides suitable habitat for the threatened Murray Hardyhead and Saline Aquatic Meadow (EVC 842) vegetation, particularly Large-fruit Tassel (*Ruppia megacarpa*) and Charophytes (macroscopic algae), while also providing suitable waterbird habitat.

Defining the water required to protect the environmental values
A number of ecological objectives have been identified and are based on historic and current wetland condition, and water dependent environmental values (habitat, species/communities and processes). The hydrological requirements for each of these objectives were identified, and a desired water regime required to achieve the water management goal is described.

Wetland water regime:
Provide fresh inflows annually to maintain depth and to regulate salinity levels. Fresh flows should be delivered in late winter/early spring (September) to coincide with the peak breeding season of Murray Hardyhead and counter high evaporation rates.

Note: Fresh flows should be delivered throughout the irrigation supply season allowing the water levels to fluctuate slightly with the highest inputs occurring in late winter/spring.

The volumes of water required to provide the desired water regime for Round Lake have been assessed using a simplified version of the Savings at Wetlands from Evapotranspiration daily Time-Series (SWET) model and by Macumber (2009).

The desired water regime for Round Lake maintains it as a saline lake with fluctuating water levels between 66.8 m AHD (2.58 m) and below 67.2 m (2.98 m) to maintain suitable habitat for Murray Hardyhead and Saline Aquatic Meadow vegetation (EVC 842).

The results of the SWET modelling indicate that the total volume required annually to maintain levels in the lake to provide this permanent regime is 475 ML. The maximum volume ever likely to be required in any one year (i.e. the 95% percentile mean annual volume) is 550 ML.

Macumber (2009) reported that between 420 ML and 460 ML would be required to maintain Round Lake water levels between 66.8 m AHD and 67.2 m AHD.

Assessment of mitigation water requirement

Mitigation water is defined as the volume of water required to ensure no net impacts on high environmental values in waterways and wetlands resulting from GMW Connections Project. Mitigation water may be required where both:

- the waterway or wetland has received incidental irrigation water beneficial and material to high environmental values before the modernisation associated with the Connections Project, and
- where a similar contribution is assessed as being a beneficial part of a water regime which is proposed to continue to support high environmental values following the modernisation.

The assessment of the requirement for mitigation water for Round Lake demonstrates that the **outfall water provides significant benefits to the wetland and mitigation water is warranted.** In particular, it provides freshwater inflows to assist in maintaining water and salinity levels to provide suitable habitat for Murray Hardyhead. If the volume of outfall water was to be reduced or removed, additional water would need to be secured to maintain the lake's environmental values.

The incidental water at the origin was 262 ML in the baseline year and the annualised baseline mitigation water volume was calculated as 262 ML. Therefore, the Mitigation Water Commitment for Round Lake is 100%. This will be used to calculate the interim mitigation water share of any annually calculated water savings. The annualised baseline mitigation water volume represents approximately 55% of the long term annual volume of water required in order to provide the desired water regime (475 ML). GMW Connections Project are only accountable for mitigating any potential impact from the project. As such, it is important that the environmental water holder secures additional sources of water to maintain Round Lake.

Potential risks, limiting factors and adverse impacts associated with the desired water regime

A number of potential risks, limiting factors and adverse impacts have been identified that may result from the provision of mitigation water as a portion of the desired water regime. In particular, the salinity tolerances of eggs and larvae of the Murray Hardyhead is still not known. It is recommended that the EWP is updated regularly (as outlined in Section 8) incorporating additional information on species requirements as it becomes available. It is imperative that the desired water regime is managed adaptively.

Infrastructure requirements

The infrastructure servicing Round Lake must be retained to ensure environmental water delivery is possible in order to maintain suitable habitat for the *EPBC Act* and *FFG Act* listed Murray Hardyhead. Therefore, the immediate infrastructure and channel system servicing should not be rationalised as part of the GMW Connections Project works.

At present, Round Lake is maintained as a permanent saline lake, with top-ups provided via the irrigation system at a rate of 10 ML/day, a rate considered appropriate for maintaining suitable habitat for Murray Hardyhead. The current delivery infrastructure is considered adequate to deliver these smaller flows and no infrastructure upgrades are recommended as part of GMW Connections Project.

Adaptive management framework

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

The Round Lake EWP has been developed using the best available information. However, a number of information and knowledge gaps are identified in the document which may impact recommendations and/or information presented. These knowledge gaps will be addressed as part of the adaptive management approach outlined within the EWP as additional information becomes available.

Governance arrangements

A summary of the roles and responsibilities (e.g. land manager, environmental water manager, and system operator) relating to the development and implementation of EWPs are defined. A framework for operational management has also been developed to describe the annual decision-making process required to coordinate the implementation of the desired water regime for Round Lake.

CONTENTS PAGE

ACKNOWLEDGEMENTS

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The North Central Catchment Management Authority (CMA) acknowledges the assistance of the following people in preparing this EWP.

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- Cherie Campbell, Caitlin Johns, Christine Reid, and Dr Todd Wallace (Murray-Darling Freshwater Research Centre)
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- Pat Feehan (Feehan Consulting)
- Ross Plunkett, Chris Solum and Mark Paganini (NVIRP)
- NVIRP Technical Advisory Committee (listed in Appendix A, Table A1)
- Wetland workshop attendees (listed in Appendix A, Table A2)
- Tom Lowe, John Jobson, Barry Free, Peter Koestveld (Landholders and community members)
- Bridie Velik-Lord, Rebecca Horsburgh, Peter McRostie, Lyndall Rowley (North Central CMA).

The EWP was updated in February 2015 (Version 9), in consultation and agreement with:

- Emer Campbell and Bree Bisset (North Central CMA)
- Andrea Keleher and Bruce Mathers (Department of Environment, Land, Water and Planning)
- Goulburn-Murray Water Connections Project Environmental Technical Advisory Committee
- Chris Solum, Ross Plunkett and Ed Thomas (Goulburn-Murray Water).

ABBREVIATIONS

AAV	Aboriginal Affairs Victoria
AVW	Atlas of Victorian Wildlife
ANCA	Australian Nature Conservation Agency
AUSRIVAS	Australian River Assessment System
BE	Bulk Entitlement
BONN	Convention on the Conservation of Migratory Species of Wild Animals
CAMBA	China–Australia Migratory Bird Agreement
CMA	Catchment Management Authority
DCFL	Department of Conservation Forests and Lands
DEDJTR	Department of Economic Development, Jobs, Transport and Resources
DELWP	Department of Environment, Land, Water and Planning
DEWHA	Department of the Environment, Water, Heritage and the Arts
DPCD	Department of Planning and Community Development
DPI	Department of Primary Industries
DSE	Department of Sustainability and Environment
EES	Environmental Effects Statement
EPBC	*Environment Protection and Biodiversity Conservation Act 1999*
ERP	Expert Review Panel
EVC	Ecological Vegetation Class
EWH	Environmental Water Holder
EWP	Environmental Watering Plan
FFG	*Flora and Fauna Guarantee Act 1988*
FIS	Flora Information System
FSL	Full Supply Level
GIS	Geographic Information Systems
GL	Gigalitre (one billion litres)
GMID	Goulburn Murray Irrigation District
GMW	Goulburn–Murray Water
JAMBA	Japan–Australia Migratory Bird Agreement
LTCE	Long-term Cap Equivalent
MDFRC	Murray-Darling Freshwater Research Centre
MNES	Matters of National Environmental Significance
North Central CMA	North Central Catchment Management Authority
NVIRP	Northern Victoria Irrigation Renewal Project
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
SEMP	Site Environmental Management Plan
TAC	Technical Advisory Committee
TIS	Torrumbarry Irrigation System

VEAC	Victorian Environmental Assessment Council
VROTS	Victorian Rare or Threatened Species
WCMF	Water Change Management Framework

1. Goulburn-Murray Water Connections Project

The Goulburn-Murray Water Connections Project (GMW Connections Project), formerly Northern Victoria Irrigation Renewal Project (NVIRP) is a $2 billion works program to upgrade ageing irrigation infrastructure across the Goulburn Murray Irrigation District (GMID) and to save water lost through leakage, seepage, evaporation and system inefficiencies. Works will include lining and automating channels, building pipelines and installing new, modern metering technology. These combined works will improve the irrigation system's delivery efficiency and recover a long term average (LTCE) of 429 GL of water per year.

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

1.1. Decision under the Environmental Effects Act 1978

On the 14 April 2009, the Minister for Planning made a decision that an Environment Effects Statement (EES) was not required for the NVIRP, now GMW Connections Project, although this decision was subject to several conditions (DPCD 2009). The conditions that apply to the protection of wetlands and waterways include:

Condition 3: *development of a framework for protection of aquatic and riparian ecological values through management of water allocations and flows within the modified GMID system to the satisfaction of the Minister of Water*

GMW Connections Project has developed a Water Change Management Framework (GMW 2013) in response to this condition. The framework outlines the processes and methods for preparing Environmental Watering Plans (EWPs) to mitigate potential impacts on wetlands and waterways at risk from the implementation of the GMW Connections Project through adaptive water management (GMW 2013).

Condition 5: *Environmental Watering Plans are required for 'at risk' waterways and wetlands before operation of the relevant NVIRP work commences*

1.2. Decision under the Environment Protection and Biodiversity Conservation Act 1999

On the 10 May 2010, the Minister for Environment Protection, Heritage and the Arts approved the NVIRP, now GMW Connections Project, under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), subject to several conditions. The conditions that apply to the protection of wetlands and waterways include:

Condition 3: *This condition applies equally to sites identified through the Water Change Management Frameworks…as requiring the preparation of an environmental watering plan (plan). This includes Johnson Swamp. All plans must be prepared in accordance with the Water Change Management Framework and provided to the Minister for approval. No modified operations potentially impacting on a site to which a plan relates may occur until the plan has been approved by the Minister. All approved plans must be implemented.*

GMW Connections Project has developed this Environmental Watering Plan in accordance with the EPBC Act decision and the Water Change Management Framework (GMW 2013).

1.3. Water Change Management Framework

The Water Change Management Framework (GMW 2013) sets out the overarching key principles with respect to environmental management for the operation of the modified GMID. These principles include:

- GMW Connections Project will strive for efficiency in both water supply and farm watering systems.
- GMW Connections Project will design and construct the modernised GMID system to comply with environmental requirements as specified in the no-EES conditions.

- GMW Connections Project will develop management and mitigation measures consistent with established environmental policies and programs in place in the GMID.
- Renewal or refurbishment of water infrastructure will be undertaken to the current best environmental practice, including any requirements to better provide environmental water. Best environmental practice will require irrigation infrastructure required to deliver environmental water to be retained (no rationalisation at these sites) or upgraded to allow for future use.
- Management and mitigation measures will be maintained into the future through establishment of or modification to operating protocols and operational arrangements.

In October 2008, the Food Bowl Modernisation Project Environmental Referrals Report (SKM 2008) assessed Stage 1 (upgrade of the backbone and connections) of the GMW Connections Project in relation to operational impacts on waterways, wetlands and regional groundwater from increased system efficiencies such as changes in channel outfalls, delivery patterns and reductions in leakage and seepage.

SKM (2008) identified 23 wetlands and 17 waterways with significant environmental values which were potentially at risk from the GMW Connections Project, particularly by significant reductions in channel outfalls across the GMID. A wetland shortlisting report undertaken by Hydro Environmental (2009) reduced this number to nine wetlands, which required EWPs to be prepared. Feehan Consulting (2009) shortlisted the waterways, resulting in three waterways requiring EWPs.

EWPs have been required for an additional two waterways and one wetland as a result of further information and scope changes.

While GMW Connections Project has been established to implement the modernised works, it will have no ongoing role in the operation of the modified GMID or environmental management in the region. Therefore GMW Connections Project will need to establish effective management arrangements to ensure that any management or mitigation measures are implemented on an ongoing basis, particularly in the EWPs (GMW 2013).

1.4. Purpose and scope of Environmental Watering Plans

The EWPs are the primary means by which the commitment of no net environmental loss will be achieved for water savings projects (GMW 2013). Each EWP will:

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

This EWP is not a wetland management plan, therefore it is not intended to provide management guidance for wetlands; rather it is aimed at providing a water supply protocol that can be agreed upon by land, water and catchment managers.

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

- reduced outfalls due to Government policy initiatives
- water trade

- drought and climate change
- management and modernisation programs carried out by others (GMW 2013).

The EWPs are to be reviewed in 2015 and every five years after this time.

1.5. Development process

The Round Lake EWP was initially developed in 2010 in collaboration with key stakeholders including Goulburn–Murray Water (GMW), NVIRP (now GMW Connections Project), the Department of Sustainability and Environment (DSE; now Department of Environment, Land, Water and Planning [DELWP]), Parks Victoria and the Department of Primary Industries (DPI; now Department of Economic Development, Jobs, Transport and Resources [DELWP]) according to the process outlined in Figure 1. A number of tasks were undertaken to develop the EWP, as follows:

- scoping and collating information
- defining ecological objectives and associated water requirements
- identifying risks and threats
- assessing infrastructure requirements
- identifying need to provide mitigation water and, if needed, determine the quantification of mitigation water
- developing recommendations on governance arrangements and adaptive management
- consulting and engaging stakeholders and adjacent landholders.

Following development, EWPs were reviewed by the DSE Approvals Working Group (membership comprised of departmental representatives) and the Expert Review Panel (ERP) prior to consideration by the Victorian Minister for Water and Commonwealth Minister for the Environment.

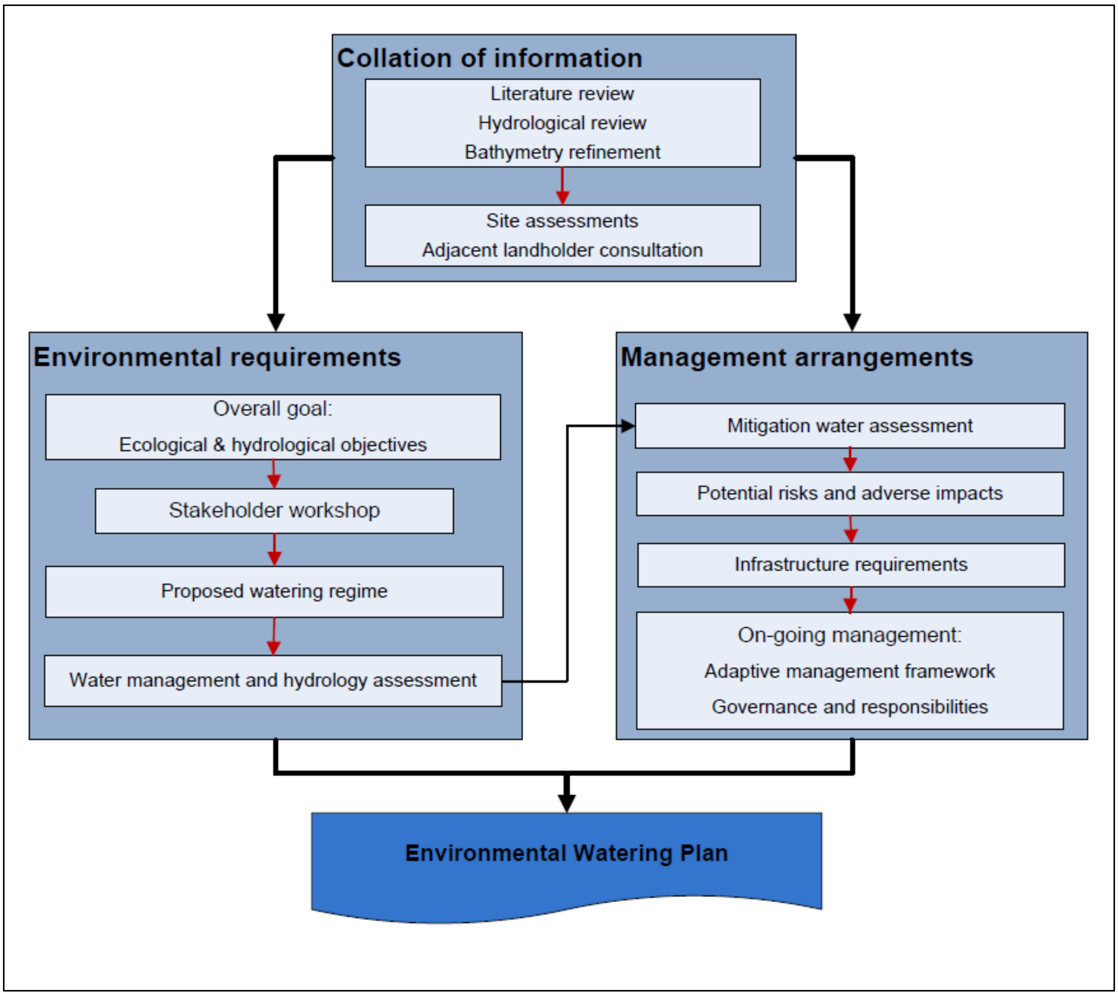

Figure 1: EWP development process

1.5.1. Consultation and engagement

To assist in collating information for the Round Lake EWP, a targeted community and agency engagement process was undertaken. Key groups consulted were the NVIRP Technical Advisory Committee (TAC), agency stakeholders, interest groups and adjoining landholders. An outline of the various groups' involvement is provided below.

The TAC was convened by the NVIRP to oversee the development of the EWPs to ensure quality, completeness and practicality. The committee includes representation from CMAs, G-MW, DPI (now DEDJTR), NVIRP (now GMW Connections Project) and DSE (now DELWP) (Appendix A). A content template for the EWPs was developed and approved by the TAC.

The TAC is now replaced by the GMW Connections Project Environmental Technical Advisory Committee (ETAC), and has representation from CMAs, GMW, DELWP, DEDJTR and Parks Victoria.

A workshop was held on 25 February 2010 with key agency stakeholders and technical experts (Appendix A) in order to discuss and refine the water management goal, ecological objectives, and watering requirements for Round Lake.

Consultation was also undertaken with adjoining landholders (2 March 2010) who have had a long association with the lake and proven interest in maintaining its environmental value. Other community and agency people were directly engaged to provide technical and historic information, including G-MW water bailiffs and field naturalists. A summary of the information sourced from this process is provided in Appendix B.

1.5.2. The 2015 Review

This review was completed in consultation with the CMAs, GMW, DEWLP, DEDJTR and Parks Victoria. GMW Connections Project prepared a report (GMW 2015) to review the ecological data for each EWP site against the stated ecological objectives. The DSE Approvals Working Group has been replaced by the ETAC, comprising departmental representatives (see Appendix A for membership). The EWP has been revised and updated, and approved by the GMW Connections Project ETAC and reviewed by the GMW Connections Project ERP.

This document was reviewed in 2015, in accordance with the requirements of the WCMF (GMW 2013). The review considered whether there was any new hydrological and ecological knowledge, changes impacting on the mitigation water assessment and changes to project and departmental names. Specific changes to this document are:

- Updating of site ecological information (Section 3)
- Updating of site hydrological information (Section 4)
- Updating of roles and responsibilities of agencies (Sections 8, 9 and 10)
- Administrative changes such as project and departmental name changes (throughout document).

1.5.3. Cessation of GMW Connections Project

The GMW Connections Project is scheduled for completion in June 2018. At this time, as per Section 9.4.4 of the WCMF, the responsibility for delivery of mitigation water will transfer to the designated environmental water manager, operating under the Victorian Environmental Water Management Framework. The entitlement itself will be held by the Victorian Environmental Water Holder. Calculation and confirmation on the LTCE conversion factor will be required from DELWP to finalise mitigation water arrangements prior to handover. This will be decided at or near the end of the GMW Connections Project.

2. Round Lake

Round Lake, immediately south-west of Lake Boga (Figure 2), is a permanent, saline lake. It occupies approximately 40 ha (Archards Irrigation 2010) and currently forms part of the Long Lake and Round Lake Water Reserve, which occupies approximately 186 ha (DSE 2009a). It also forms a component of the Tresco Lakes, a series of three relatively deep wetlands including (from south to north) Golf Course Lake, Round Lake and Long Lake (Figure 3).

Round Lake is an important refuge for Murray Hardyhead (*Craterocephalus fluviatilis*), a small native fish which lives for a maximum of 18 months in the wild. The species is listed as endangered under the International Union for the Conservation of Nature (IUCN) Red List, vulnerable under the Federal *Environment Protection Biodiversity Conservation (EPBC) Act 1999* and is listed under Victorian *Flora and Fauna Guarantee (FFG) Act 1988*. Murray Hardyhead is endemic to Australia and currently Round Lake supports one of six remaining populations (consisting of three in Victoria and three in South Australia) and is the only viable population in the Kerang area (pers. comm. Andrea Keleher [DELWP] 27 Nov 2014). Round Lake is a bioregionally important wetland (NLWRA, cited in NCCMA 2005).

With a full supply level (FSL) at 67.4 m AHD, Round Lake has a storage capacity of 820 ML (Archards Irrigation 2010). It has a maximum depth of 3.2 m and a flat bed.

Refer to Appendix C for the contour plan prepared for Round Lake by Archards Irrigation (2010).

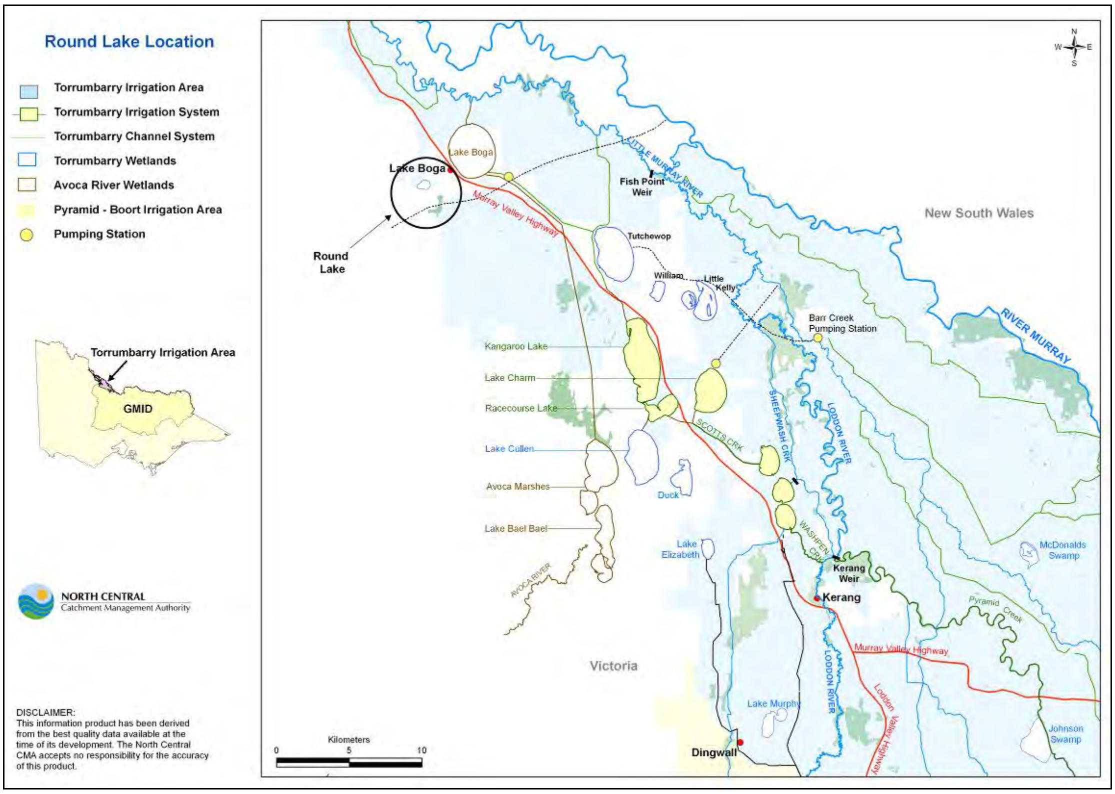

Figure 2: Location of Round Lake

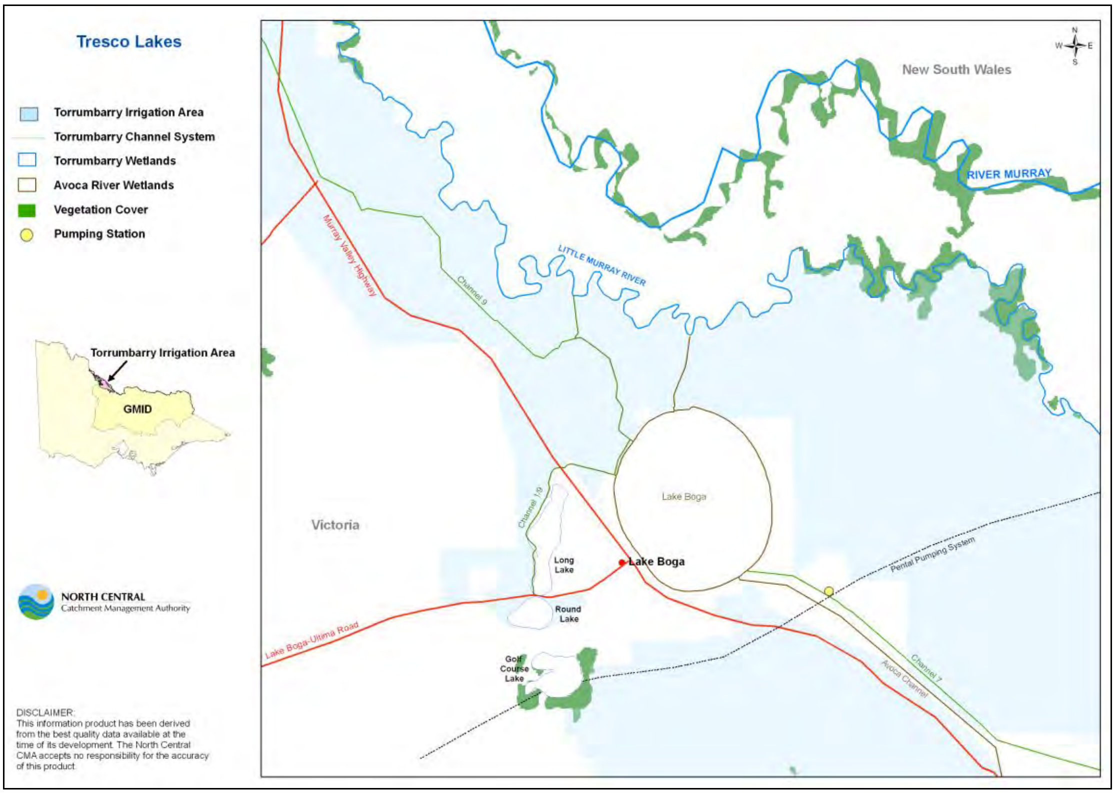

Figure 3: Tresco Lakes landscape map

2.1. Wetland context and current condition

Prior to European settlement, Round Lake was a deep freshwater marsh[1] (DSE 2009a). It would naturally have received floodwaters from backed-up Little Murray River flood flows and Lake Boga overflow via Lake Baker (Appendix B). Anecdotal evidence suggests that while Round Lake and Long Lake both received floodwaters, there was no connectivity with Golf Course Lake to the south (Appendix B).

The establishment of the Torrumbarry Irrigation System in the 1920s, construction of levees across the floodplain, and development of the Tresco horticultural catchment have resulted in significant changes to the hydrology of the lake. Until 2003, Round Lake received significant volumes of drainage water via Golf Course Lake to the south through a pipe connecting the two. Round Lake then overflowed into Long Lake via a deep connecting channel (Macumber 2009). The lake has also received fluctuating volumes of outfall water which have been recorded since 1998. It is currently a permanent, saline lake (DSE 2009c).

In more recent times, channel outfalls have reduced dramatically and as a consequence environmental water has been required to maintain salinity levels and suitable habitat for Murray Hardyhead within the lake. Environmental water has been consistently provided from the Murray Flora and Fauna Bulk Entitlement since 2004/05 (discussed further in Section 4).

Round Lake is an important refuge for Murray Hardyhead, as it is one of only six populations remaining in Victoria and South Australia. An assessment undertaken on 23 October 2009 (Campbell *et al.* 2009) also reported the following:

- It is currently dominated by the aquatic Large-fruit Tassel (*Ruppia megacarpa*) with Water-mat (*Lepilaena* sp.) and Charophytes (macroscopic algae) (Plate 1). Large-fruit Tassel exists across the entire inundated zone.
- A low cover of filamentous algae (*Rhizoclonium sp*) exists across the lake (Plate 1).
- Fringing Samphire Shrubland (EVC 101) was dominated by Blackseed Glasswort (*Halosarcia pergranulata ssp. pergranulata*) with other salt-tolerant species such as

[1] Deep Freshwater Marshes are generally less than 2 m deep and are inundated for longer than 8 months of the year (DCFL 1989a)

Seablite (*Suaeda sp.*), Ruby Saltbush (*Enchylaena tomentosa var. tomentosa*) and Australian Salt-grass (*Distichlis distichophylla*)

- Sharp Rush (*Juncus acutus ssp. acutus*) is present around most of the lake and dominates the north and east margins (Plate 2)
- Common Reed (*Phragmites australis*) is present in the inlet channel and on the dry northeast margin
- Small sections of Black Box (*Eucalyptus largiflorens*) trees occur on higher elevations (Plate 2)
- No exotic species were observed in the aquatic zone; however a number of species of moderate to high threat exist in the fringing vegetation.

No condition assessments have been undertaken of the site since 2009.

A summary of the wetland characteristics is provided in Appendix D.

Plate 1: Submerged aquatics (Source: MDFRC 2009)

Plate 2: Fringing vegetation (Source: MDFRC 2009)

2.2. Catchment setting

Round Lake is located within the Kerang Lake sub-catchment in the Murray Mallee bioregion. Its local catchment area is delineated by the distribution of surrounding lunettes and occupies approximately 75 to 110 ha (Macumber 2009). However, as a result of the small size of the local catchment area and losses associated with evaporation and infiltration, the contribution of local catchment runoff to the surface water balance is negligible with Round Lake now receiving virtually all of its water from the channel system (Macumber 2009).

Between 1903 and 2008, the annual average rainfall recorded at Lake Boga was 334 mm/year, with May to October being significantly wetter than November to April (Macumber 2009). An annual average of 312 mm/year fell during the prolonged drought conditions experienced between 1997 and 2008 (Macumber 2009). Maximum average temperatures within the Kerang region range from 31.5°C in January to 14°C in July, with minimum average temperatures falling to 4°C in July (Bureau of Meteorology 2009). The drought broke in 2010 and was followed immediately by wet years in both 2010 and 2011.

Round Lake is connected to the Torrumbarry Irrigation System via channel 1/9 (Figure 4). In the past it has received significant volumes of drainage water indirectly from the Tresco horticultural catchment via Golf Course Lake to the south.

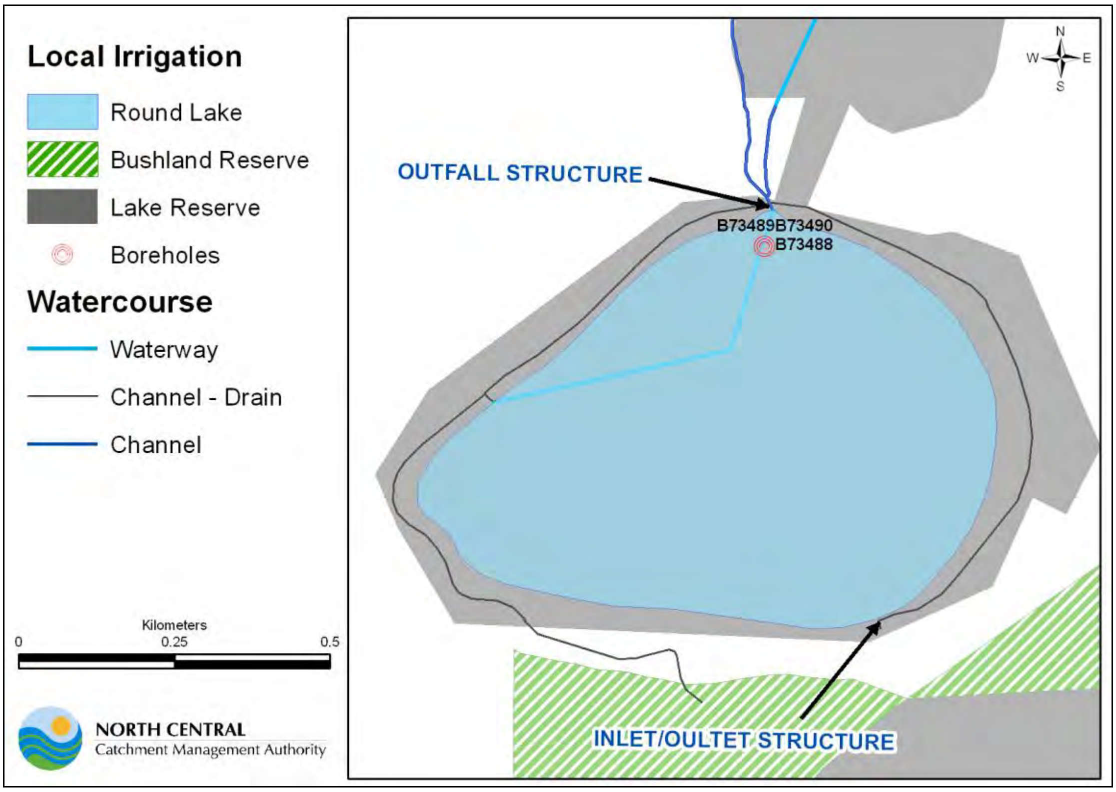

Figure 4: Inflow points at Round Lake

2.3. Land status and management

Round Lake currently forms part of the Long Lake and Round Lake Water Reserve, which occupies approximately 186 ha (Figure 4). It is classified for Water Supply, Regulation and Drainage under Section 4 of the *Crown Land (Reserves) Act 1978* and is managed by G-MW (DSE 2009a). This designation requires that the lake is managed for the storage and distribution of irrigation and domestic water, flood mitigation, and disposal of drainage water. Nature conservation and recreation are permitted to an extent consistent with the primary purpose (LCC 1988).

In 2009, the Victorian government endorsed (with amendments) the Victorian Environment Assessment Council (VEAC) recommendations for public land management. No recommendations for revised land status or management of Round Lake were provided within this assessment (DSE 2009d; VEAC 2008).

2.4. Cultural heritage

The Kerang Lakes area is known to be one of the most archaeologically significant areas within Victoria. To date however, no Aboriginal cultural heritage sites have been registered with Aboriginal Affairs Victoria (AAV).

2.5. Recreation

Recreational opportunities at Round Lake are limited. However, it is a valuable wetland for bird watching. Surrounding native vegetation is poor and extensive fringing Sharp Rush is relatively unattractive. Local duck hunting has occurred within the Tresco Drainage Lakes.

2.6. Legislative and policy framework

2.6.1. International agreements

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

- Japan–Australia Migratory Bird Agreement (JAMBA)
- China–Australia Migratory Bird Agreement (CAMBA)
- Republic of Korea–Australia Migratory Bird Agreement (ROKAMBA)

- Convention on the Conservation of Migratory Species of Wild Animals (also known as the Bonn Convention).

Round Lake is known to support species protected by each of the above international migratory bird agreements (Table 1). As wetland habitat for a number of protected species, Round Lake is required to be protected and conserved in accordance with these international agreements (DEWHA 2009).

2.6.2. Federal legislation

The *EPBC Act* is the key piece of legislation pertaining to biodiversity conservation within Australia. It aims to control potential impacts on matters of national environmental significance (MNES)[2].

Round Lake is one of six remaining sites known to support Murray Hardyhead, a species listed as Vulnerable under the Act. As mentioned in Section 2.6.1, a number of protected migratory waterbirds have also been recorded at the lake (Table 1). Actions that may significantly impact on any of these MNES are subject to assessment and approval by the Minister for the Environment, Heritage and the Arts. The GMW Connections Project works program is also subject to assessment and approval under the *EPBC Act*.

2.6.3. State legislation

Flora and Fauna Guarantee (FFG) Act 1988
The *FFG Act* aims to protect a number of identified threatened species and communities within Victoria. Round Lake is known to support a number of species both protected[3] and listed under the *FFG Act* (Table 1 and Table 3). Disturbance or collection of any of these threatened species will require a permit from the DELWP.

Environmental Effects Act 1978
Potential environmental impacts of a proposed development are subject to assessment and approval under the *Environmental Effects Act 1978*. As such, the GMW Connections Project works program and any associated environmental impacts are subject to assessment and approval under the Act (as discussed in Section 1.1).

Planning and Environment Act 1987
The removal or disturbance of native vegetation within Victoria is controlled by the implementation of a three-step process of avoidance, minimisation and offsetting under the *Planning and Environment Act 1987*. Any proposed removal or disturbance to native vegetation associated with the GMW Connections Project works program will require the implementation of the three-step process, assessment and approval under the Act.

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

Aboriginal Heritage Act 2006
All Aboriginal places, objects and human remains in Victoria are protected under the *Aboriginal Heritage Act 2006* (DPCD 2007). Although no sites at Round Lake are currently registered with AAV, the Kerang Lakes area is known to be one of the most archaeologically significant areas within Victoria (Section 2.4).

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

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[2] There are seven MNES that are protected under the EPBC Act, these are: World Heritage properties, National Heritage places, wetlands of international importance, listed threatened species and ecological communities, migratory species protected under international agreements, Commonwealth marine areas, and nuclear actions (including uranium mines) (DEWHA 2009).
[3] Includes plant taxa belonging to families or genera protected by the Act (DSE 2014).

lists are also listed as threatened under the *FFG Act*. Round Lake is known to support flora and fauna species that are included on advisory lists (Table 1 and Table 3).

3. Round Lake environmental values

The primary purpose of this EWP is to assess and advise on mitigating potential impacts on high environmental values supported by Round Lake. While the lake provides a number of broader ecological and landscape values (i.e. ecological processes, representativeness and distinctiveness in landscape), high environmental values have previously been defined by the conservation significance of the lake or species at an international, national or state level (SKM 2008; Hydro Environmental 2009; GMW 2013).

As such, in describing the values supported by the lake in the sections below, an emphasis is placed on identifying listed flora and fauna species, and vegetation communities followed by the broader ecological and landscape values. All listed values are presented in this section with full species lists provided in Appendix E.

3.1. Fauna

In the 1960s, both Round Lake and Golf Course Lake supported a diverse range of waterbird species, a host of aquatic plants and associated invertebrates, and several fish species (Appendix B). Some of the waterbirds observed at the time include Grey Teal (*Anas gracilis*), Hardhead (*Aythya australis*), Dotterels, Stints, Silver Gull (*Larus novaehollandiae*), and Grebes (Appendix B).

Currently, Round Lake is a high value wetland as it is one of only six remaining sites that currently support Murray Hardyhead (three in Victoria and three in South Australia). Additional native fish species including Bony Bream (*Nematalosa erebi*) and Flat-headed Gudgeon (*Philypnodon grandiceps*) have been recorded within the lake (Appendix E). Anecdotal evidence suggests that, along with Golf Course Lake, Round Lake does not appear to have supported large bodied native fish in the past (Appendix B). Records (Appendix E) indicate that in the past Round Lake has supported Tench (*Tinca tinca*), Redfin (*Perca fluviatilis*), Common Carp (*Cyprinus carpio*) and Goldfish (*Carassius auratus*); however they are not present within Round Lake today (pers. comm. Daniel Stoessel [DPI] 16 April 2010).

The lake also supports Saline Aquatic Meadow vegetation (EVC 842) dominated by Large-fruit Tassel across the inundated zone (Campbell *et al*. 2009). This attracts waterbird species for feeding including Black Swans (*Cygnus atratus)*. Various migratory waders are also attracted to Round Lake, including species protected by international agreements e.g. Common Greenshank (*Tringa nebularia*) and Marsh Sandpiper (*Tringa stagnatilis*). In total, more than 60 bird species have been recorded at Round Lake with records indicating that 13 are of conservation significance at an international, national and/or state level (Table 1 and Appendix E).

Table 1: Significant fauna species recorded at Round Lake

Scientific Name	Common Name	International Treaty	EPBC status	FFG status	DSE status
Birds					
Acrocephalus stentoreus	Clamorous Reed Warbler	B			
Anas rhynchotis	Australasian Shoveler				VU
Ardea modesta	Eastern Great Egret	C/J		L	VU
Aythya australis	Hardhead				VU
Biziura lobata	Musk Duck				VU
Chlidonias hybridus	Whiskered Tern				NT
Merops ornatus	Rainbow Bee-eater	J			
Oxyura australis	Blue-billed Duck			L	EN
Platalea regia	Royal Spoonbill				VU
Sterna caspia	Caspian Tern	C/J		L	NT
Stictonetta naevosa	Freckled Duck			L	EN
Tringa nebularia	Common Greenshank	B/C/J/R			
Tringa stagnatilis	Marsh Sandpiper	B/C/J/R			
Ardea alba	Great Egret	C/J		L	EN
Ardea intermedia	Intermediate Egret			L	EN
Fish					
Craterocephalus fluviatilis	Murray Hardyhead		VU	L	CR

Conservation Status:
- J/C/R/B: JAMBA/CAMBA/ROKAMBA/BONN International agreements listed in section 2.4.1
- EPBC Listed: VU – Vulnerable
- FFG listing: L – Listed as threatened
- DSE listing: EN – endangered, R – rare, VU – vulnerable, NT – near threatened, k – poorly known and suspected, but not definitely known, to belong to one of the categories (x, e, v or r) within Victoria (DSE 2007a).

3.2. Flora

According to DSE's pre-1750 Ecological Vegetation Class (EVC) mapping, prior to European settlement Round Lake was dominated by Samphire Shrubland (EVC 101) vegetation and surrounded by Woorinen Mallee (EVC 824) and Semi-arid Woodland (EVC 97) vegetation (DSE 2009f). Samphire Shrubland EVC is described as:

> 'Low open shrub layer to 0.5 m of succulent chenopods on saline clay pans. Found in association with the various halite salinas that have developed within evaporative basins or 'boinkas'. (DSE 2009g)

DSE's 2005 EVC mapping suggests that the above EVCs are still present; however Woorinen Mallee and Semi-arid Woodland EVCs are diminished in extent (DSE 2009h).

DSE's 2005 EVC mapping was based on aerial photograph interpretation, biophysical data and selective ground truthing of sites on a project-by-project basis over a number of years (DSE 2007b).

However, assessments undertaken by the Murray-Darling Freshwater Research Centre (Campbell *et al.* 2009) on 23 October 2009 identified that the lake is currently characterised by Saline Aquatic Meadow vegetation (EVC 842) fringed by Samphire Shrubland (EVC 101) and exotic vegetation. The results of the assessment show a marked difference to the mapped 2005 EVCs and are based on recently mapped, up to date and field verified information. Therefore, the EVCs reported by MDFRC are included in the EWP as opposed to the mapped 2005 EVCs.

Table 2 identifies the conservation status of the observed and mapped EVCs within Round Lake. Refer to Appendix F for a detailed map of EVCs observed in October 2009.

Table 2: Current EVCs within Round Lake and their bioregional conservation status (Campbell *et al*. 2009)

EVC No.	EVC	Bioregional Conservation Status*
842	Saline Aquatic Meadow	n/a
101	Samphire Shrubland	Least Concern

*Murray Mallee bioregion

One Victorian rare or threatened flora species (VROTS) has been recorded at Round Lake (Table 3 and Appendix E). Mealy Saltbush (*Atriplex pseudocampanulata*) is considered rare within Victoria (DSE 2005a). VEAC (2008) identified this species as a rare and threatened flood-dependent flora species. New Holland Daisy (*Vittadinia* sp.) is protected by the *FFG Act* (DSE 2009e).

Table 3: Significant flora species recorded in Round Lake

Common Name	Scientific Name	Origin	EPBC status	FFG status	DELWP status
Mealy Saltbush	*Atriplex pseudocampanulata*				r
New Holland Daisy	*Vittadinia sp.*			P	

Conservation Status:
- FFG listing: L – Listed as threatened, P – Protected (DSE 2009e)
- DSE listing: r – rare, v – vulnerable, k – poorly known and suspected, but not definitely known, to belong to one of the categories (x, e, v or r) within Victoria (DSE 2005a).

3.3. Representativeness and distinctiveness

Round Lake is classified as the least depleted wetland category within Victoria - the permanent saline lake. It is estimated that the area of permanent wetlands across Victoria has decreased by only 2% since European settlement (DNRE 1997). Table 4 illustrates the area and proportion of permanent saline wetlands across various defined landscapes.

Table 4: Current area of permanent saline wetlands across the landscape

	North Central region	GMID	Murray Mallee
Permanent saline lakes (ha)	2,362	2,314	114.72
Round Lake	2%	2%	36%

Round Lake is distinctive as it is one of only three remaining sites within Victoria (one of six within Australia) that currently supports the *EPBC Act* listed Murray Hardyhead, one of which is a translocation site (Lake Koorlong). The other sites within Victoria are the Cardross Lakes and Lake Koorlong (Backhouse *et al.* 2008a; Backhouse *et al.* 2008b; Stoessel *et al.* 2009).

4. Hydrology

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

4.1. Natural water regime

Round Lake is located within the Kerang Lakes sub-catchment approximately 6 km south of the Little Murray River. Its natural water supply would have been floodwater from Lake Baker to the north that was fed from the overflow of Lake Boga combined with the water that backed up from the Little Murray River system (Appendix B). It would have been inundated in winter and spring, with draw-down resulting from evaporation and seepage. Round Lake and Long Lake both received floodwaters, however anecdotal evidence suggests that there was no connectivity with Golf Course Lake to the south (Appendix B).

Nearby Lake Boga was well connected to the Little Murray River. Naturally, as water levels rose in the Murray River, the Little Murray River would experience high flows delivering water into Lake Boga. If the Avoca River flooded at the same time, water flowed northward from the Avoca Marshes, through the Mystic Park area via a wide and shallow waterway into Lake Manor and Lake Boga (Appendix B).

Rainfall and flooding were highly variable in this part of the catchment under natural conditions (Appendix B).

4.2. History of water management

Construction of the Torrumbarry Irrigation System and development of the adjacent Tresco horticultural catchment resulted in significant changes to the hydrology of the wetland changing it from an intermittent[4] to a permanent lake operated as an irrigation drainage basin (Table 5).

Table 5: Round Lake wetting/drying calendar

93/94	94/95	95/96	96/97	97/98	99/00	00/01	01/02	02/03	03/04	04/05	05/06	06/07	07/08	08/09
W	W	W	W	W	W	W	W	W	W	W	W	W	W	W

09/10	10/11	11/12	12/13	13/14
W	W	W	W	W

Until 2003, Round Lake received significant volumes of drainage water indirectly from the Tresco horticultural catchment to the south. Tile drains (constructed in the 1950s/1960s) and surface run-off entered Golf Course Lake to the south which, in wetter periods, would flow into Round Lake via a pipe connecting the two. Round Lake then overflowed into Long Lake via a deep connecting channel (Macumber 2009).

The lake has also received fluctuating volumes of outfall water from channel 1/9 which enters the lake to the north (Figure 5). Since 1999, water levels have fluctuated between 66.4 m AHD and 67.3 m AHD or 90 cm (Figure 6). Low levels in February 2002 corresponded with a period of extremely high salinity levels, reaching approximately 40,000 EC (Macumber 2009 and Figure 6).

From around 2003, drainage into Golf Course Lake, and subsequent inflows into Round Lake, reduced in response to increased irrigation efficiencies and prolonged drought conditions (Macumber 2009). Attempts were made to deliver freshwater into Golf Course Lake to protect its environmental values by injecting significant volumes of fresh channel water into Round Lake, elevating the lakes water level and forcing water through the pipeline into Golf Course Lake. This approach was not efficient and eventually Golf Course Lake salinity levels rose and almost all of the previous environmental values were lost (Appendix B).

[4] Alternatively wet and dry but less frequently and regularly than seasonal wetlands. Surface water persists for months to years (extended from Paijmans *et al.* 1985, cited in Boulton and Brock 1999).

GMW constructed earthen embankments at the north and south of Round Lake to prevent flows passing into both Golf Course Lake and Long Lake (date unknown). It is now managed in relative isolation from the adjacent wetlands (Appendix B). Since 2004/05, Round Lake has received environmental water allocations to counteract declining outfall and drainage volumes in order to maintain salinity levels and provide suitable habitat for Murray Hardyhead (Figure 5). The Lake requires around 475ML of fresh water inflows to maintain levels and salinity in an average year. Water level fluctuations from late 2004 have reduced to 60 cm between 66.7 m AHD and 67.3 m AHD (Figure 6). Inflows have generally occurred in in late winter-early spring prior to the Murray Hardyhead peak breeding season, continuing over the summer and autumn months with the highest water levels experienced in winter (Macumber 2009).

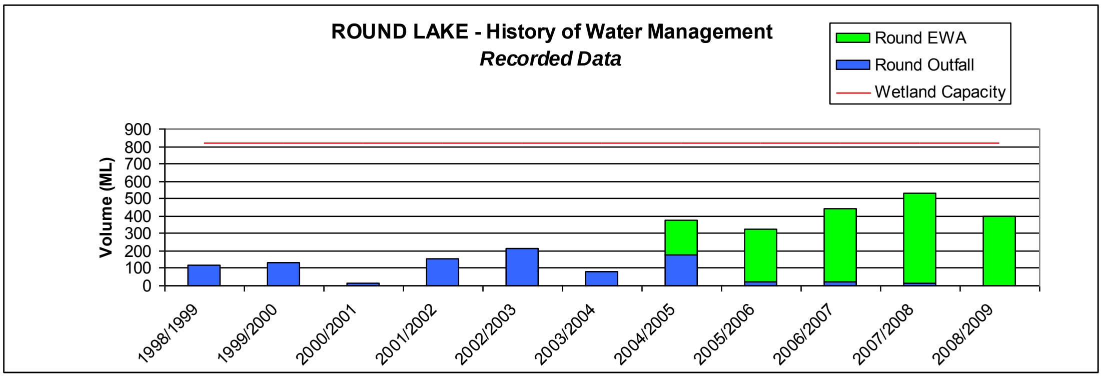

Figure 5: Recorded volumes received by Round Lake from outfalls and environmental allocations

Salinity within Round Lake is inversely correlated to surface water levels (Figure 6). Prior to 2003, salinity levels and the salt load within the lake rose steadily, peaking in 2003 at 40,000 EC (Macumber 2009). This reflects the more saline nature of inflows received from Golf Course Lake. Water delivered via channel 1/9, which largely replaced inflows from Golf Course Lake, is less than 300 EC. Consequently, salinity levels within the lake have fallen since 2003 and monthly water quality samples taken between 2011 and 2014 indicate that the salinity range in the Lake is between 27000 to 39300 EC. The annual rate of decline in salinity between 2003 and 2008 was approximately 1500 EC/yr (Macumber 2009).

The true salinity tolerance of Murray Hardyhead is unknown as tolerance levels of populations may differ significantly due to genetic and non-genetic adaptations. In addition, tolerance levels may differ throughout the life cycle (i.e. between egg, larvae and adult stages). Although adults have been recorded in waters with salinity greater than 40,000 EC (Backhouse *et al.* 2008a; Backhouse et al. 2008b), little is known about the salinity tolerance of eggs and larvae (Ellis and Kavanagh 2014), which affects the ability of the Murray Hardyhead to breed under saline conditions.

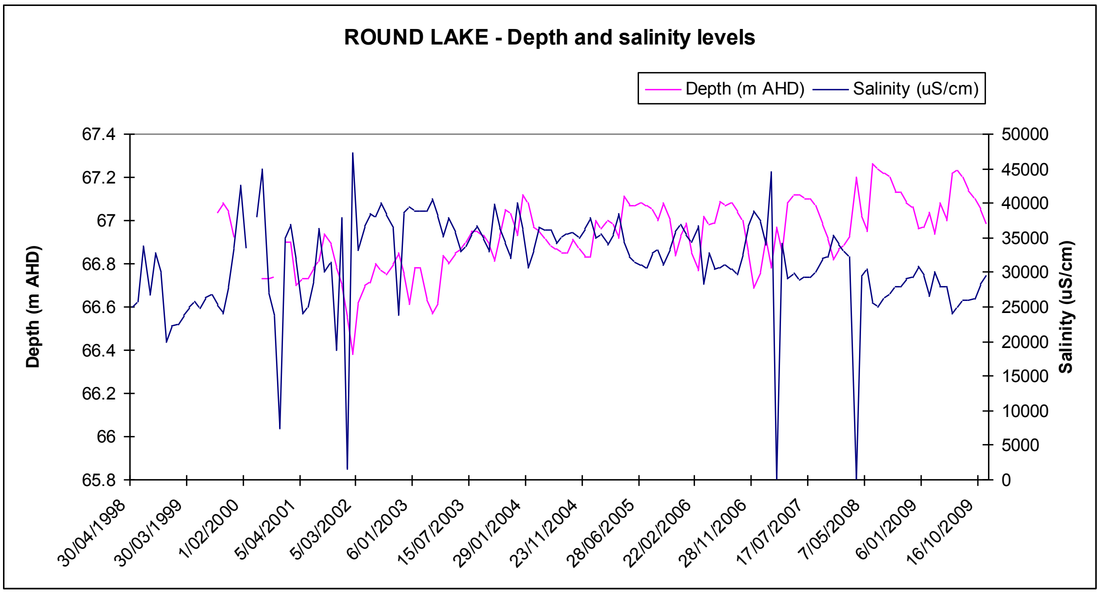

Figure 6: Depth and salinity levels within Round Lake between 1999 and 2009 as recorded by DPI.

4.2.1. Recorded outfalls and GMW Connections Project

Outfall data for Round Lake has been recorded by G-MW since 1997/98 (Figure 5). Anecdotal evidence and records indicate that outfall volumes have decreased significantly, although not necessarily reflected in Figure 5.

The baseline water year, 2004-2005, has been selected to quantify the savings as part of water savings projects (DSE 2009i). The comparison of estimated water savings with a baseline year is necessary to convert the savings to water entitlements and ensure that there are no impacts on service delivery or reliability for existing entitlement holders (DSE 2008a). This baseline year is used to guide the quantification of mitigation water required for wetlands (discussed in Section 5), taking into account the average annual patterns of availability.

Round Lake received a recorded total of 178 ML of outfall water in 2004-2005. The timing of the outfalls over the irrigation period of September to May is shown in Figure 7.

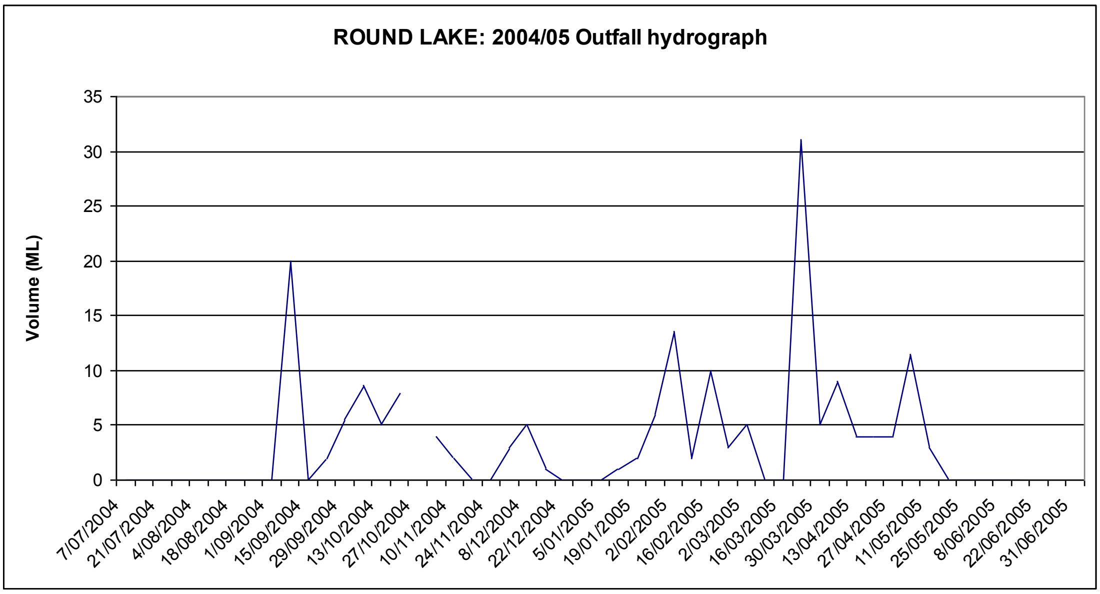

Figure 7: Round Lake outfall hydrograph

4.2.2. Unrecorded outfalls

In addition to the recorded outfalls reported for channel 1/9, Macumber (2010) indicates that unrecorded outfalls have been received by Round Lake over the years which have contributed to its surface water balance.

Modelling undertaken by Macumber (2010) illustrated that a total of 462 ML would be required to maintain actual surface water levels recorded in 2004/05; however a combined total of 378.1 ML was received (outfalls and environmental water allocations). Therefore, an additional 84 ML of unrecorded outfalls were received by Round Lake over 2004/05.

4.3. Surface water/groundwater interactions

As previously mentioned, Round Lake forms a component of the Tresco Lakes (Figure 3 above). Each of these wetlands is bound to the east by a lunette, indicating a period of groundwater discharge by capillary rise. The Tresco Lakes traverse the boundary between the Parilla Sand and Shepparton formation.

Groundwater behaviour in the vicinity of Tresco Lakes is highly dependent on the status of nearby Lake Boga. When Lake Boga is full (ranging from 68 m AHD to 70 m AHD), a significant hydraulic gradient to the west exists. Therefore, Round Lake receives groundwater lost from Lake Boga when it is full which impacts the salinity levels within the lake and its groundwater inflow and outflow potential. When Lake Boga is empty however, groundwater movement is towards the northwest and Round Lake no longer receives groundwater from Lake Boga.

Following construction of the Torrumbarry Irrigation System in the 1920s, groundwater levels began to rise dramatically (Appendix B). Consequently, low lying depressions and wetlands became susceptible to shallow saline groundwater levels (Appendix B). Long Lake, the floor of which is approximately 3 m below the managed surface water levels at Round Lake, is a groundwater discharge zone.

At present, there is a strong downward hydraulic gradient beneath Round Lake, which has increased in strength in conjunction with regional groundwater declines and high manipulated surface water levels (Section 4.2).

A freshwater lens (approximately 36 m in depth) has developed beneath Lake Boga which is situated within more saline regional groundwater. Therefore, higher groundwater salinities are prevalent to the east of Lake Boga (58,594 uS/cm to 70,313 uS/cm) than in areas adjacent to it, which are impacted by groundwater movement (e.g. 2344 uS/cm to 6094 uS/cm) at the northern end of the lake. The monitoring record shows salinity levels of 6825 uS/cm and 11,770 uS/cm occurring between Lake Boga and Round Lake, illustrating localised groundwater recharge. Refer to Table 6 and Figure 8.

Table 6: Groundwater salinity in bores adjacent to Lake Boga and the Tresco Lakes (Source: Macumber 2009)

Bore (nests)	Screen (m)	Salinity	
		(mg/L)	uS/cm
73481	13 to 16	1277	1995
73480	36 to 39	3213	5020
73490	5 to 7	7533	11,770
73489	25 to 28	19,053	29,770
73488	34 to 37	37,669	58,858
73487	40 to 43	4176	6478
73486	46 to 49	17,238	26,934
73485	12 to 15	12,825	20,039
73484	31 to 34	58,490	91,391

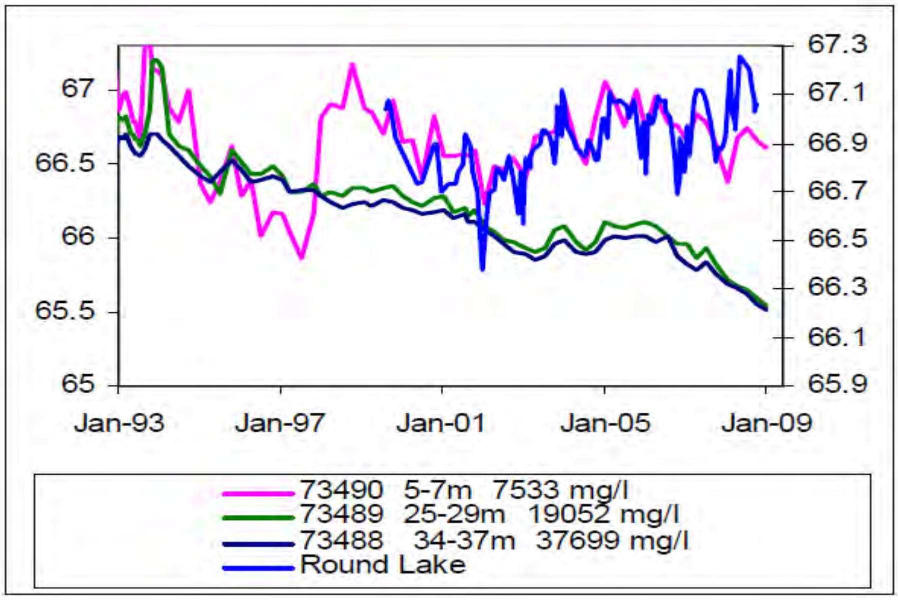

Figure 8: Hydrographs of the 73488-90 piezometer nest and Round Lake surface water levels for the period between 1993 and 2009. This figure illustrates the clear relationship in levels between the fresher water in the shallow bore (73490) and that of the surface water within Round Lake. (Source: Macumber 2009)

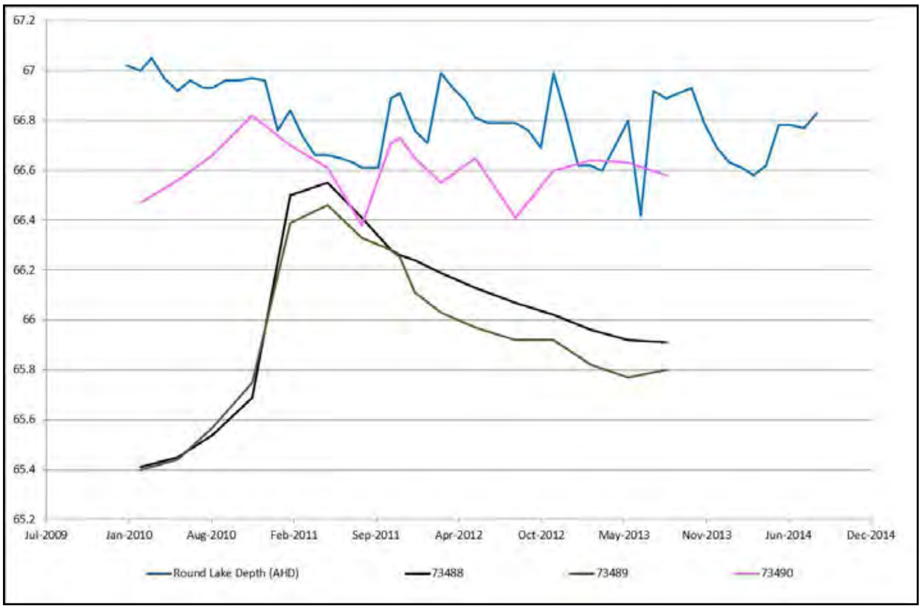

Figure 9: Hydrographs of the 73488-90 piezometer nest and Round Lake surface water levels for the period between 2009 and 2014. The relationship between the shallow bore (73490) and the surface water in Round Lake is consistent with Figure 8 (Source: Victorian Water Measurement Information System)

As illustrated in Figure 6, salinity levels within Round Lake have been steadily falling since 2004 in response to changed management practices (i.e. inflows provided by the channel system rather than saline drainage water from Golf Course Lake). An average decline of 1500 EC/year has been experienced in Round Lake between 2003 and 2008. As salinity levels aren't increasing, Macumber (2009) reports that Round Lake experienced a net loss of salt via groundwater flushing which is sufficient to counter the salt gain from surface water inflows. This likely reflected the manipulated, high water levels in Round Lake and low regional groundwater levels being influenced by the previous dry state of Lake Boga, and the influence of nearby Golf Course and Long Lakes. The area has since flooded during the 2010 and 2011 floods Table 7 provides an estimate of annual salt and water loss from Round Lake resulting from groundwater flushing.

Table 7: Annual salt (tonne) and seepage (ML) loss from Round Lake (2004-2005) (Source: Macumber 2009)

Lake depth (m)	Net salt loss tonne/yr	Salt 'in'	Salt 'out' (seepage)	Seepage volume at 21 gm/L (ML/yr)
		tonne		
1.5	291	60	351	17
2.0	457	60	517	24
2.5	623	60	683	32
3.0	790	60	850	41

4.4. Surface water balance

The methods used to calculate the volumes required to provide the desired water regime for Round Lake (Section 5.3) are summarised below.

4.4.1. Savings at Wetlands from Evapotranspiration daily Time-series

A daily surface water balance has been modelled in order to identify the hydrological attributes of Round Lake. The model used is a simplified version of the Savings at Wetlands from Evapotranspiration daily Time-Series (SWET) (Gippel 2005a, Gippel 2005b, Gippel 2005c).

This model has been approved by the Murray Darling Basin Authority for estimating the wetland surface water balance. Modelling the daily water balance enables managers to quantify the volumes required in providing the desired water regime. It also allows for consideration of variability in climatic conditions and wetland phase.

A surface water balance and associated calculations to define the hydrological characteristics of Round Lake was undertaken as part of the development of the EWP. Components are discussed in brief below. Actual figures are provided in Appendix G.

This information is utilised for the estimation of volumes required for the desired water regime (Section 5.3).

The main components of the model are outlined below:

- **Time Series:** the daily time step is set up to run from May 1891 to end of 2009.
- **Wetland capacity:** volume required to fill the lake to the targeted supply level, i.e. fluctuating water levels in Round Lake between 66 m AHD and 67.2 m AHD (Macumber 2009).
- **Infiltration:** volume required to fill the underlying soil profile. Calculation of this volume has been adapted from measurements undertaken by G-MW (G-MW 2008a). The following assumptions were included in the application of the SWET model for Round Lake (Gippel 2005a, Gippel 2005b, Gippel 2005c):
  - Infiltration (ML) = Soil cracking (%) x area of wetland (ha) x depth (mm))/100
  - Soil cracking – 25% of surface area
  - Average depth of 300mm
  - Ongoing losses via infiltration are considered negligible due to the low permeability of the underlying soil (G-MW 2008b)
- **Rainfall/runoff:** this includes rainfall directly falling onto the lake and surface run-off. Surface water inflows/run-off: an average volumetric figure of 0.2 ML/ha/year for the Kerang area (DPI and HydroEnvironmental 2007). Round Lake has virtually no local catchment area and relies solely on inflows via the irrigation system and rainfall. Therefore, in modelling the surface water balance for the lake, 0.1 hectares was used in acknowledging the negligible contribution of local catchment runoff to the surface water balance of the lake. The contributing volume is dependent on the rainfall intensity (15-40%).
- **Climate data:** SILO DataDrill including wind data (Bureau of Meteorology)

- **Evaporation data:** a modelled approach (combination of the Penman-Monteith method with a deBruin adjustment; recommended by the CSIRO) to assessing evaporation at the lake has been incorporated into the water balance (McJannet *et al*. 2009).

Please note:

- *Groundwater is not included in the model (Gippel 2010). While groundwater may contribute in some circumstances it is not readily quantifiable or not easily factored into the model.*
- *The model has been set up so as to manage water levels at a single target level (67.2 m AHD). Therefore, it is not possible to model fluctuating water levels (different target levels) overtime in order to test various management scenarios.*

The modelling produces a range of volumes required to operate the lake in accordance with the optimal regime specified in Section 5.3. The modelling results for Round Lake are presented in Section 5.3 and Appendix G.

4.4.2. Alternative modelling approach

Macumber (2009) calculated the volume of water required to maintain Round Lake within specified levels following assessment of:

- the geology, geomorphology, aquifers, and regional and local groundwater flow systems
- the nature of the lake-aquifer interactions
- previous filling regimes and the relationship to surface water and salinity levels.

The modelling undertaken by Macumber (2009) differs to the above simplified SWET method as it uses some different parameters. The calculated volumes are based on:

- the ‘dry climate’ regime experienced since 1997 rather than long-term climatic data
- evaporation data from Kerang which is very similar to the data of nearby Swan Hill, however covers the recent dry period from 1997
- pan evaporation data recorded at the Kerang Model Farm (1433 mm/yr)
- previous reports that the contribution of local catchment runoff to the surface water balance is negligible.

The results are presented in Section 5.3

4.5. Operational uses

Round Lake is a drainage basin operated as a terminal system filled by rainfall, channel outfalls from the G-MW 1/9 channel (either as operational outfall or environmental water), drainage water and groundwater. No operational plans or procedures exist for the G-MW management of the lake.

Round Lake is used as an operational outfall, although the onset of drought initiatives and efficiency programs has considerably reduced outfall volumes. There are no existing diversion licences from Round Lake.

4.5.1. Drainage

Round Lake currently forms part of the Long Lake and Round Lake Water Reserve. It is classified for Water Supply, Regulation and Drainage under Section 4 of the *Crown Land (Reserves) Act 1978* and is managed by G-MW (DSE 2009a). This designation requires that the lake is managed for the storage and distribution of irrigation and domestic water, flood mitigation, and disposal of drainage water.

Round Lake received significant volumes of drainage water indirectly from the Tresco horticultural catchment to the south until 2003. Tile drains and surface run-off entered Golf Course Lake which, in wetter periods, would flow into Round Lake via a pipe connecting the two. Round Lake then overflowed into Long Lake via a deep connecting channel (Macumber 2009).

GMW constructed earthen embankments at the north and south of Round Lake to prevent flows passing into both Golf Course Lake and Long Lake (date unknown).

5. Management objectives

Previous management recommendations for Round Lake relate to maintaining salinity levels and providing suitable habitat for the populations of Murray Hardyhead. Table 8 provides an outline of information and previous management recommendations for Round Lake.

Table 8: Previous management recommendations

Source	Wetland Type	Objectives	Dur.	Timing	Freq.
Backhouse *et al.* 2008a and 2008b	Permanent saline lake	• Supply environmental water to Round Lake annually as required to maintain suitable water quality (no target provided)	-	-	Each year
Macumber 2009		• Maintain salinity levels in Round Lake to provide suitable conditions for Murray Hardyhead (25,000 to 40,000 EC) ○ Provide an annual allocation of ~420 to 460 ML[5] to maintain the lake (countering losses to evaporation and outseepage) ○ Commence inputs in September		September	Each year

Additional recommendations made by Stoessel (2010) include:

- Alter the Round Lake water regime to one that more mirrors that of the natural environment with peak water height in spring to early summer, and a natural evaporative drawdown in autumn-winter.
- Increase water height within Round Lake in the spring-early summer period to the present high water mark of 67.2 m AHD, and allow an evaporative drawdown over autumn winter to a base level of 66.8 m AHD (to maintain salinity below 35,000 EC).
- Install a dissolved oxygen probe within Round Lake to monitor oxygen within the system.
- Ensure that water quality parameters are continued to be regularly monitored.

5.1. Water management goal

The water management goal for Round Lake has been derived from a variety of sources including previous management goals, local expertise and knowledge, water availability and feasibility of delivery, and has been appraised by agency stakeholders and technical experts (wetland workshop, Appendix A, Table A2). It takes into consideration the values the wetland supports, the current wetland condition and potential risks that need to be managed.

The water management goal is largely focussed on providing suitable habitat for Murray Hardyhead both in water quality and aquatic vegetation (as outlined in Table 9 below). However, the desired water regime is also likely to provide suitable habitat for a variety of waterbirds (e.g. swans, coots, ducks and waders). This aligns with the recent management of Round Lake during which time a variety of additional fauna species have been observed at the lake (Table 3 and Appendix E).

Round Lake water management goal:
Maintain Round Lake as a permanent, saline lake that provides suitable habitat for the threatened Murray Hardyhead and Saline Aquatic Meadow (EVC 842) vegetation, particularly Large-fruit Tassel and Charophytes (macroscopic algae), while also providing suitable waterbird habitat.

[5] Awaiting confirmation on volumes required.

5.2. Ecological objectives and hydrological requirements

Ecological objectives and hydrological requirements have been identified in determining a desired water regime to support high environmental values in Round Lake (Table 9). The process for identifying ecological and hydrological objectives closely follows that recommended in FLOWs: a method for determining environmental flow requirements in Victoria (DNRE 2002). The ecological objectives outline the outcomes desired from delivery of the desired water regime.

Water dependent environmental values including habitat, species/communities and processes were identified from local anecdotal information, relevant reports, condition assessments, and records (such as the FIS and Atlas of Victorian Wildlife (AVW) databases).

Ecological objectives were identified based on the environmental values in terms of the physical conditions (habitat objectives), species and/or biota (biodiversity objectives), and biological processes (process objectives) needed in order to achieve the water management goal.

Habitat objectives identify habitat components considered critical in achieving the water management goal. While it is recognised that each habitat component will support an array of fauna species, examples of previously recorded listed species whose habitat requirements closely align with a specific component have been provided as potential indicator species. Those species and communities of international, national and state conservation significance were given highest priority as were those that are indicative of integrated ecosystem functioning.

The objectives were expressed as one of four types of target, which are related to the present condition/functionality of the value:

- Reinstate – no longer considered to occur
- Restore/Rehabilitate – severely impacted and only occur to a reduced extent
- Maintain – not severely impacted but are desirable as part of the ecosystem
- Reduce – have increased undesirably at the expense of other values.

Hydrological requirements describe the water regimes required for achieving ecological outcomes (ecological objectives) (DNRE 2002). All values identified have components of their life-cycle or process that are dependent on particular water regimes for success e.g. colonially breeding waterbirds require certain timing, duration and frequency of flooding to successfully breed and maintain their population. Requirements for the three components of a water regime[6] were identified and described for all of the ecological values (Campbell, Cooling & Hogan 2005).

The ecological objectives and hydrological requirements for Round Lake were developed in conjunction with agency stakeholders and technical experts at the Wetland Workshop held on 25 February 2010. The ecological objectives and hydrological requirements were reviewed in 2015 in consultation with GMW, the CMAs, DELWP and Parks Victoria. The review found that the ecological objectives were still appropriate for Round Lake (GMW 2015).

Table 9: Round Lake proposed ecological objectives and hydrological requirements

Ecological objective	Justification	Hydrological requirement
1. Habitat objectives		
1.1 Maintain the health of Saline Aquatic Meadow vegetation (EVC 842)	• Key aquatic species in saline lakes where Murray Hardyhead occurs (Backhouse *et al.* 2008a). • Murray Hardyhead use the aquatic plants as both a spawning substrate and shelter (Stoessel 2010) • Food for waterbirds (e.g. swans, coots, ducks and waders)	• Maintain permanency by delivering water annually • *Ruppia spp.* are known to occur in hypersaline lakes containing up to about 70,000 ppm total dissolved salts (>100,000 EC) (Sainty and Jacobs (2003). • *Lepilaena* spp. are known to have a broad salinity tolerance range (Walsh and Entwistle (1994); Nielsen *et a*l. (2003). The species present at Round Lake is currently unknown.

[6] Timing, frequency and duration

Ecological objective	Justification	Hydrological requirement
		Saline Aquatic Meadow vegetation is considered likely to persist while maintaining salinity levels within Round Lake below 40,000 EC in order to provide suitable habitat for the Murray Hardyhead. However, this needs to be monitored and adaptively managed (Section 8 and Appendix J).
2. Species/community objectives		
2.1 Maintain populations of Large-fruit Tassel (*Ruppia megacarpa*)	Linked closely to habitat requirements • Key aquatic species in saline lakes where Murray Hardyhead occurs. • Murray Hardyhead are known to spawn amongst vegetation (Stoessel 2010) • Food for waterbirds (e.g. swans, coots, ducks and waders) • Key primary producer and extremely important to retain in regional wetland mix.	• Maintain permanency by delivering water annually • *Ruppia spp.* are known to occur in hypersaline lakes containing up to about 70,000 ppm total dissolved salts (>100,000 EC) (Sainty and Jacobs (2003). Therefore, Large-fruit Tassel is likely to persist at Round Lake if salinity levels are maintained below 40,000 EC in order to provide suitable habitat for the Murray Hardyhead.
2.2 Maintain and support breeding of Murray Hardyhead	• Linked closely to habitat requirements • A Federal and State listed threatened species • Maintaining genetic diversity amongst remaining populations	• Maintain permanency by delivering water annually • Maintain salinity levels between 25,000 to 35,000 EC. This range is based on recorded salinity levels within Round Lake (Figure 6), expert opinion, and recommendations by Macumber (2009): 25,000 to 35,000 EC • Fluctuate range to reflect the requirements of their life cycle and habitat[7]
2.3 Maintain Charophytes (macroscopic algae) persisting in the lake	• Stabilise sediment and minimise turbidity • Colonized by macroinvertebrates • Food source for waterbirds (e.g. swans) Source: Sainty and Jacobs (2003)	Maintain permanency by delivering water annually • Charophytes can grow in fresh, brackish and saline waters (Sainty and Jacobs (2003); Roberts and Marston 2000). The species of Charophyte at Round Lake is currently unknown. It is considered likely that the Charophytes within Round Lake will persist while maintaining salinity levels below 40,000 EC in order to provide suitable habitat for the Murray Hardyhead. However, this needs to be monitored and adaptively managed (Section 8 and Appendix J).

5.3. Desired water regime

A desired water regime has been defined for Round Lake and is presented below. This regime is based on the ecological objectives and hydrological requirements outlined in Section 5.2.

The proposed regime closely aligns with the more recent management of Round Lake which maintained it as a permanent saline lake. This regime is based on maintaining suitable habitat for the threatened Murray Hardyhead, Saline Aquatic Meadow (EVC 842) vegetation (particularly Large-fruit Tassel) for which Round Lake is highly valued.

Figure 9 below illustrates the various components of the lake (e.g. open water and fringing mudflats, Saline Aquatic Meadow, Charophytes) that are being targeted by the water regime.

[7] Ensure revision of recommendations incorporates research developments.

Timing: permanent inundation. Fresh inflows provided in late winter – early spring (September). Timed to occur prior to Murray Hardyhead peak breeding season[8] (Macumber 2009).

Frequency of wetting: Provide fresh inflows annually (~ 420 to 460 ML/yr (Macumber 2009)) to top up the water level and regulate the salinity between 25000 and 40000 EC.

Duration: Permanent inundation required.

Extent and depth: Greater than 66.8 m AHD (2.58 m) and less than 67.2 m AHD[8] (2.98 m).

The extent and depth of the inundated zone can vary. The minimum depth will be determined by the depth required to maintain recommended salinity levels within the optimal range. Macumber (2009) reports that water levels should be maintained above 66.8 m AHD (2.58 m) and below 67.2 m AHD (2.98 m) to keep salinity levels between 25,000 and 34,000 EC which aligns with the recommended optimal range of 25,000 and 35,000 EC. The rates of rise and fall should be kept to a minimum to allow vegetation and fish movement in or out of the draw-down or fill zones. Previously, water has been delivered at a rate of 10 ML/day equating to a 10 cm rise in four days which is considered an appropriate rate of delivery.

Variability: Permanent inundation required. The size of inflows may vary between 420 to 460 ML/yr depending on evaporation rates and salinity levels (Macumber 2009). The size and frequency of inflows will be linked closely to salinity requirements and must incorporate any advances in the understanding of species' requirements.

Wetland water regime:
Provide fresh inflows annually to maintain depth, to ensure permanent inundation and to regulate salinity levels between 25000 and 40000 EC. Fresh flows should be delivered in late winter/early spring (September) to coincide with the peak breeding season of Murray Hardyhead and counter high evaporation rates.[9]

Note: Fresh flows should be delivered throughout the irrigation supply season allowing the water levels to fluctuate slightly with the highest inputs occurring in late winter/spring.

The salinity levels in the lake should be allowed to fluctuate yearly between 25,000 (in spring-early summer) and 35,000 EC[8] (in autumn/winter). Allow the lake to drawdown via evaporation over autumn/winter with inflows delivered in early spring. Fresh inflows at this stage will promote vegetation and zooplankton growth which are important to breeding success (pers. comm. I. Ellis, [MDFRC], November 2009), and are also likely to trigger the onset of spawning (Stoessel 2010).

Please refer to the figures in Appendix G for the modelled desired water regime.

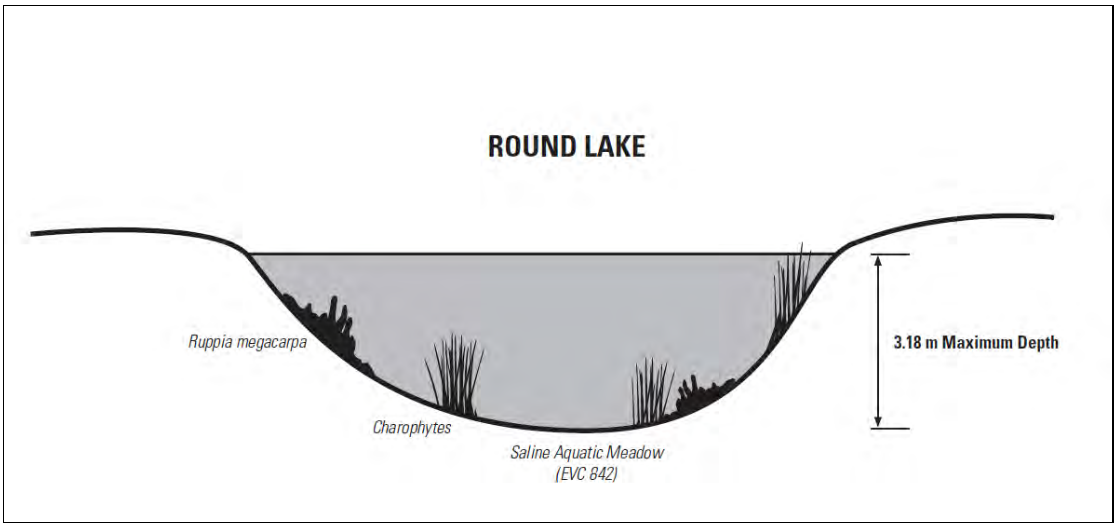

Figure 10: Schematic of wetland areas to be targeted (not to scale)

[8] Refer to Appendix K: comparison of bathymetric information and vegetation mapping.
[9] This aligns with the regime described for shallow permanent open freshwater marshes which are less than 5 m deep and are permanently inundated

The volumes of water required to maintain levels at 67.2 m AHD are provided in Table 10 to give an indication of the volumes required to provide the desired water regime for Round Lake. These volumes reflect the results from the SWET modelling (model described in Section 4.4 and results presented in Appendix G). As noted above, it is not possible to model a range of target levels in order to test various management scenarios.

Table 10: Volumes required to maintain levels at 67.2 m AHD (SWET modelling output)

Result	
Mean long-term (LT) annual controlled inflow requirement	475 ML/year
95th percentile of mean LT annual controlled inflow requirement	550 ML/year
Average LT controlled inflow requirement for filling period	475 ML
Record length	118
No. of periods	118
Years with no inflow	0 in 118
No. of draw downs over record	118
No. of draw downs not fully drawn down	106
% of draw downs not fully drawn down	90%
95th percentile duration of full period (months)	9.0
50th percentile duration of full period (months)	8.3

A brief description of each the main results follows:

- **Mean long-term annual controlled inflow requirement**: the total amount of water to be put into the lake annually in a controlled fashion to achieve the specified level and the desired regime (excluding natural inflows from rainfall and local catchment runoff). This is the average over the modelled period. A mean long term annual volume of 475 ML is required to fill and maintain levels at 67.2 m AHD[10].
- **95th percentile of mean long-term annual controlled inflow requirement**: an estimate of the maximum volume ever likely to be required over any 12 month period (550 ML).
- **Average long-term controlled inflow requirement for filling period**: the total amount of water to be put into the lake in a controlled fashion to achieve the desired water level regime of permanent inundation. This excludes natural inflows from rainfall and local catchment runoff. Therefore, the maximum volume required to fill Round Lake and maintain levels at 67.2 m AHD would be approximately 475 ML.

Similarly, Macumber (2009) calculated that between 420 to 460 ML/yr will be required to provide the desired water regime and maintain salinity levels within the recommended range of 25,000 and 35,000 EC.

Please note: due to the variability of inflows to the lake, particularly in response to current climate conditions, determination of inflows from local rainfall and runoff in any one year will need to be undertaken by the environmental water manager when water is planned. Surface water inflows into Round Lake and rainfall will vary considerably from year to year, depending on seasonal conditions.

5.4. Mitigation water

The volume of water that is required to offset the impact of GMW Connections Project on wetlands that have become reliant on this water to support high environmental values is termed ‘mitigation’ water. The potential impact of GMW Connections Project considered in the Round Lake EWP is related mainly to a reduction in outfalls. Other potential impacts to the lake will be managed in accordance with the Water Change Management Framework (GMW 2013) and Site Environmental Management Plans.

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

1. Water savings are the total (gross) volumes saved less the volume of water required to ensure no net impacts due to the project on high environmental values

[10] It is recognised that this represents the maximum target level and must be reassessed in determining the magnitude of water level fluctuation required in any one year. In doing so, the options presented in Macumber (2009) should be consulted.

2. Using the same baseline year (2004–05) as that used to quantify savings, taking into account the long-term average annual patterns of availability.
3. The mitigation water will be deployed according to the EWP.
4. Sources of mitigation water will be selected to ensure water can be delivered in accordance with the delivery requirements as specified in the environmental water plans. Water quality will need to be considered for all sources of water to ensure it is appropriate.

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

A process for calculating mitigation water based on the best available information has been developed and involves the application of a series of steps that includes:

Step 1: Describe the desired water or flow regime

Step 2: Determine the baseline year incidental water contribution

Step 3: Assess dependency on baseline incidental water contributions

Step 4: Calculate the annualised baseline mitigation water volume

Step 5: Calculate the mitigation water commitment

Step 6: Calculate the LTCE mitigation water volume

5.4.1. Round Lake mitigation water

Step 1: Describe the desired water or flow regime

The desired water regime for Round Lake is delivering water on an annual basis to maintain it as a permanent saline lake. Further detail is provided in Section 5.3.

Step 2: Determine the baseline year incidental water contribution[11]

This step determines the baseline year incidental water for each hydrological connection assessed (e.g. outfalls, leakage and seepage) and the incidental water contribution both as it leaves the irrigation system and as it arrives at the wetland.

Leakage and seepage have not been accounted for within the following steps. However, preliminary calculations to estimate the potential contributions to Round Lake from leakage and seepage from channel 1/9 were completed based on the localised impact assessment method outlined in the Water Change Management Framework (GMW 2013). The results indicate that a range of 2 ML/year to 6 ML/year may be received by Round Lake (Appendix H). However, if future GMW Connections Project actions are likely to impact the potential for leakage and seepage to reach Round Lake (i.e. lining the main supply channel or decommissioning other channels within 200 m of the lake), an analysis will be triggered in accordance with the Water Change Management Framework.

Therefore, only one hydrological connection (recorded and unrecorded outfalls) is included within the mitigation water assessment and the potential contributions from leakage and seepage are excluded.

The baseline year (2004-05) outfall volume recorded at the regulating structure was 178 ML, refer to Section 4.2.1.

The delivery or outfall channel to Round Lake is approximately 60 m, a portion of which is piped beneath Lake Boga-Ultima Road. Therefore, losses associated with leakage or seepage from the delivery channel are considered negligible at Round Lake and 100% (or 178 ML) of this outfall volume is estimated as having contributed to the lake's water balance in 2004-05.

[11] Incidental water contributed in the baseline year for each hydrological connection i.e. outfall water, seepage and leakage of a supply channel within 200 m of the wetland.

Macumber (2010) identified that an additional 84 ML of unrecorded outfalls were received by Round Lake in 2004/05.

The determination of the baseline year incidental water contribution is summarised in Table 11.

Table 11: Determination of the baseline year incidental water contribution determination

Hydrological connection or incidental water source (e.g. Outfall #)	Baseline year incidental water at origin (Gross) (ML)	Estimated losses between origin (irrigation system) and wetland (for baseline year) (ML)	Baseline year incidental water contribution at the wetland (Net) (ML)
Outfall #ST043937			
Recorded outfalls	178	0	178
Unrecorded outfalls	84	0	84
Total	**262**	**0**	**262**

Step 3: Assess dependency on baseline incidental water contributions

The Water Change Management Framework (GMW 2013) specifies criteria to be applied in assessing whether mitigation water is required for a wetland or waterway with high environmental values. These criteria have been assessed for Round Lake with the results presented in Table 12.

Table 12: Mitigation water dependency assessment

Criteria by which mitigation water may be assessed as not required	Link between incidental water (losses) and environmental values
1. Mitigation water may be assessed as not required where:	
1.1 There is no hydraulic connection (direct or indirect) between the irrigation system and the wetland or waterway	A delivery channel (~60 m) delivers outfall water to Round Lake from the outfall regulating structure.
1.2 The water does not reach the wetland or waterway with environmental values (e.g. the outfall is distant from the site and water is lost through seepage and evaporation before reaching the area with environmental values)	The delivery channel is short (~60 m) a portion of which is piped. There are no impediments or diversions restricting outfalls being delivered to Round Lake. 100% of this outfall water is estimated to have reached Round Lake with losses associated with leakage and seepage from the short delivery channel considered to be negligible.
2. Mitigation water may be assessed as not required where the wetland or waterway receives water from the irrigation system:	
2.1 That is surplus to the water required to support the environmental values (e.g. changing from a permanently wet to an intermittently wet or ephemeral regime is beneficial or has no impact)	The lake does not have more water than is required to support the desired state of the environmental values, it is currently maintained as a permanent saline lake.
2.2 That occurs at a time that is detrimental to the environmental values	In 04/05, losses were occurring between September and May (Figure 7). They were occurring at a time that would counteract high evaporation losses therefore maintaining surface water and salinity levels within Round Lake.
2.3 That is of poor quality (or results in water of poor quality entering a site e.g. seepage resulting in saline groundwater intrusions to wetlands) and the removal of which would lead to an improvement in the environmental values	Losses (Irrigation outfalls) are of acceptable water quality, although the turbidity of water could be an issue for aquatic plant growth.
3. Mitigation water may be assessed as not required where the environmental values:	
3.1 Do not directly benefit from the contribution from the irrigation system (e.g. River Red Gums around a lake may not directly benefit from an outfall and may be more dependent on rainfall or flooding)	Losses reach the lake and maintain water and salinity levels within suitable ranges for Murray Hardyhead and Saline Aquatic Meadow vegetation.
4. Mitigation water may be assessed as not required where the removal of the contribution from the irrigation system does not:	
4.1 Increase the risk of reducing the environmental values (e.g. outfalls form a very small proportion of the water required to support the environmental values and their removal will not increase the level of risk)	Losses reach the lake and maintain water and salinity levels within suitable ranges for Murray Hardyhead and Saline Aquatic Meadow vegetation.

Criteria by which mitigation water may be assessed as not required	Link between incidental water (losses) and environmental values
4.2 Diminish the benefits of deploying any environmental water allocations (over and above the contribution from the irrigation system).	If outfall volumes were reduced or removed, additional water would need to be secured for providing freshwater inflows to maintain water and salinity levels in order to maintain suitable habitat for Murray Hardyhead or Saline Aquatic Meadow vegetation.

The assessment process of the requirement for mitigation water for Round Lake suggests that **mitigation water is required to maintain the high environmental values.** In particular, mitigation water would provide annual freshwater inflows that would maintain water and salinity levels and contribute to maintaining suitable habitat for Murray Hardyhead (a federally listed species). If outfall volumes were to decline or were removed, additional water would need to be secured to maintain Round Lake as a permanent saline lake.

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

The BMW volume is expressed as the baseline incidental water contributions divided by the number of years in the cycle of the desired water regime. Mitigation water is required each year to maintain Round Lake as a permanent saline lake.

As there are currently no other more efficient infrastructure options for delivering mitigation water, the BMW is calculated at the outfall # ST043937 (gross).

Gross BMW

$$= \frac{\text{Baseline year incidental water contribution at origin}_{(\text{Gross})}\ \text{(Step 2)}}{\text{The inherent cycle (years) of the desired water regime (Step 1)}}$$

= 262 ML / 1 (annually)

= 262 ML

Step 5: Calculate the mitigation water commitment (MWC)

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

MWC (%)

$$= \frac{\text{Gross BMW}_{(\text{McDonalds Swamp 2004/05})}\ \text{(Step 4)}}{\text{Baseline incidental water contributions at origin}_{(\text{Gross})}\ \text{(Step 2)}}$$

= (262/262) x 100

= 100%

The overall MWC for Round Lake is 100%.

Step 6: Calculate the LTCE mitigation water volume

The LTCE mitigation water volume is used to account for mitigation water when reporting against the net savings target. This volume is calculated by multiplying the mitigation water commitment (Step 5) by the baseline mitigation water volume (Step 4) and the LTCE conversion factor.

Please note: calculation and confirmation on the LTCE conversion factor is required from DSE. This will be decided at or near the end of GMW Connections Project.

5.5. Other water sources

The annualised baseline mitigation water volume represents approximately 55% of the long term annual volume of water required in order to provide the desired water regime (475 ML). GMW Connections Project are only accountable for mitigating any potential impact from the project i.e. for provision of mitigation water as a proportion of the total outfall, seepage and leakage volumes received by the lake if they are supporting significant environmental values. As such, it is important that the environmental water holder secures additional sources of water to maintain Round Lake as a permanent saline lake with water and salinity levels within acceptable ranges. The most likely additional sources of water will be existing and future environmental entitlements.

Discussion of potential sources of water to provide the desired water regime to Round Lake follows.

5.5.1. Murray flora and fauna bulk entitlement

In 1987, an annual allocation of 27,600 ML of high security water was committed to flora and fauna conservation in Victorian Murray wetlands. In 1999, this became a defined entitlement for the environment (DSE 2006). Each year, a prioritisation process is utilised to decide on the best use of the available water (based on River Murray allocations). An annual distribution program identifies wetlands that will receive a portion of the entitlement utilising a decision flowchart (DSE 2006). As of 2011, the Victorian Environmental Water Holder is responsible for allocating water to environmental assets.

5.5.2. 75 GL environmental entitlement

Water savings generated by GMW Connections Project will provide up to 75 GL to be vested in the Victorian Environmental Water Holder as an Environmental Water Entitlement. This environmental water is in addition to Government's commitments to provide water for the Living Murray process and will be used to help improve the health of stressed wetlands and waterways in Northern Victoria and the River Murray (NVIRP 2010).

In addition, Stage 2 of GMW Connections Project will generate up to 200 GL of water savings, which will be allocated to the environment. This water will be available for use across the Murray Darling Basin.

5.5.3. Commonwealth environmental water

Under Water for the Future the Australian Government has committed to purchase water in the Murray-Darling Basin over 10 years. The program will complement a range of other measures to address sustainable water management in the Basin. The Commonwealth Environmental Water Holder, in DoE, will manage the Commonwealth's environmental water.

The *Water Act 2007* provides that “the Commonwealth Environmental Water Holder must perform its functions for the purpose of protecting or restoring environmental assets so as to give effect to relevant international agreements”. Wetlands of International Importance (Ramsar) are considered priority environmental assets for use of the commonwealth environmental water (DEWHA 2008). Whilst Round Lake is not a wetland of international importance, it is a refuge for species listed under other International conventions. It is also one of six remaining wetlands to support the federally listed Murray Hardyhead (three in South Australia and three in Victoria). As such, a case for the receipt of Commonwealth environmental water could be made.

6. Potential risks or adverse impacts

An important component of the EWPs is the identification of potential risks, limiting factors and adverse impacts associated with the delivery of the desired water regime. The annualised baseline year mitigation water volume represents 55% of the mean long-term annual volume required (475 ML/year). Awareness of the potential risks and impacts will influence future intervention and long-term condition monitoring undertaken at Round Lake, will inform the adaptive management of the water regime and the provision of mitigation water (Section 8).

Table 13 outlines the risks, limiting factors and potential impacts associated with the provision of mitigation water as a component of the desired water regime that need to be considered by GMW Connections Project in conjunction with the environmental water manager.

Appendix I outlines a range of additional risks and limiting factors identified which may arise as a direct result of, or in association with, implementing the desired water regime at Round Lake. It is envisaged that these additional risks and limiting factors will be considered in the future management of the lake (i.e. management plan).

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

Table 13: Potential risks, impacts and mitigation measures associated with the provision of mitigation water to Round Lake

Risks/limiting factors	Impacts	Mitigation measures
Inappropriate desired water regime and mitigation water (i.e. timing, frequency, quantity, rate)	Loss of high environmental values Failure to achieve identified objectives and overall water management goal	Review mitigation water recommendations in light of emerging information on the requirements of the Murray Hardyhead (e.g. breeding season, delivery rate), *Lepilaena sp.* and Charophytes. Ensure that the delivery capacity is sufficient to facilitate delivery of required volumes at critical times (e.g. delivery share)
Delivery of mitigation water causes adverse impacts on habitat, surrounding land, etc	Adverse impacts may result from delivery of mitigation water e.g. Flooding of adjacent land, fluctuations in turbidity and salinity.	Build management and delivery of mitigation water into environmental water management framework

7. Water delivery arrangements

Round Lake receives outfalls from the 1/9 channel via a drop-board outfall structure and short delivery channel approximately 60 m in length (Figure 11). The reported capacity of channel 1/9 is 40 ML/day. The outfall structure has a maximum capacity of 30 ML/day (pers. comm. Ross Stanton [G-MW] 22 March 2009) while the capacity of the delivery channel is unknown. A 450 mm pipe passes water beneath Lake Boga-Ultima Road.

At present, Round Lake is operated as a terminal system with earthen embankments preventing flows between Golf Course Lake to the south (bank approximately 1.08 m high) and Long Lake to the north (bank approximately 1.8 m high). FSL is at 67.40 m AHD (Archards Irrigation 2010).

Delivery of environmental water in 2009 to maintain water and salinity levels occurred at a rate of 8-10 ML/day. A delivery rate of 10 ML/day equates to a 10 cm rise in four days which is considered a suitable rate of delivery.

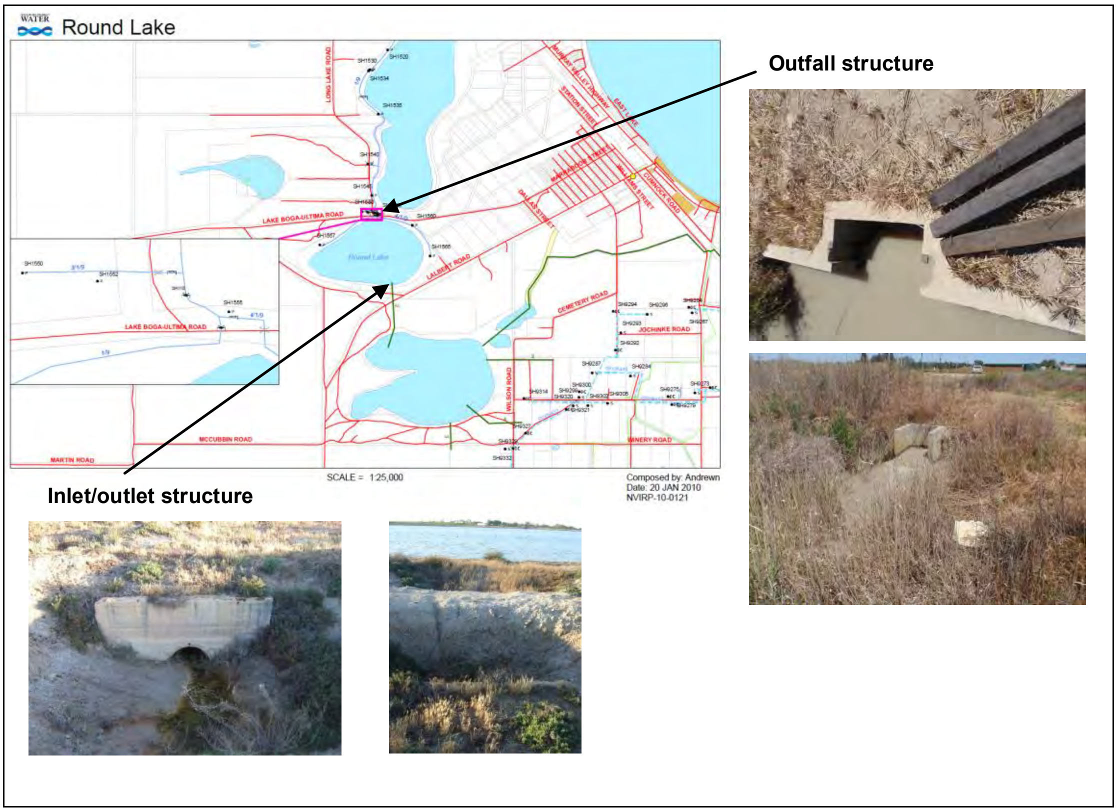

Figure 11: Round Lake Infrastructure

7.1. GMW Connection Project works program – channel 1/9

The Stage 1 GMW Connections Project works program includes delivering an automated backbone for the water distribution system, rationalising spur channels, connecting farm water supply to the backbone and upgrading metering on up to 50% of customer supply points in the GMID.

Within the immediate vicinity of Round Lake channel 1/9, on which the Round Lake outfall structure is located, is not part of the automated backbone. Approximately 5 km (to the north-western margin of Lake Boga) of the channel may be rationalised as part of the GMW Connections Project. However; it is recommended that the 1/9 channel is retained to ensure Round Lake is able to receive environmental water or alternative supply arrangements are sought, particularly as the lake supports a federally listed fish species.

GMW Connections Project are responsible for “retain(ing) infrastructure and improving where practicable, where it will be required for delivering environmental water….” (GMW 2013). A review of the infrastructure requirements and supply arrangements will need to be undertaken if channel 1/9 is considered for rationalisation. Similarly, the potential impact of providing a new supply point will need to be investigated if the current supply point is likely to alter.

7.2. Infrastructure requirements

As noted previously, the infrastructure servicing Round Lake must be retained to ensure environmental water delivery is possible. Therefore, the immediate infrastructure and channel system servicing should not be rationalised as part of the GMW Connections Project works.

At present, Round Lake is maintained as a permanent saline lake, with top-ups provided via the irrigation system at a rate of 10 ML/day, a rate considered appropriate for maintaining suitable habitat for Murray Hardyhead. The current delivery infrastructure is considered adequate to deliver these smaller flows and no infrastructure upgrades are recommended.

However, additional upgrade options to improve operational management of Round Lake delivery infrastructure could be undertaken.

- Unrecorded outfalls were received by Round Lake between 2000 and 2003 and have been quantified (Macumber 2009). It is recommended that the existing drop-board outfall structure is upgraded with an automated regulator. This will improve operational management by minimising losses (bar leakage) and enhancing safety and useability. Allowing more operational control over flows delivered to Round Lake is particularly important as maintaining suitable habitat for the federally listed Murray Hardyhead is an ecological objective.
- In addition, replacement of the earthen embankments prohibiting flows to Golf Course and Long Lake with automated regulating structures would improve operational control and potential connectivity between the three wetlands.

As the works and potential upgrade options are beyond the irrigation delivery system being upgraded by the GMW Connections Project, it is not considered to be the responsibility of the GMW Connections Project to fund or undertake the works.

8. Adaptive management framework

A key GMW Connections Project principle is that an adaptive management approach is adopted to ensure an appropriate response to changing conditions (Section 9.4, GMW 2013).

Adaptive management is a continuous management cycle of assessment and design, implementation, monitoring, review and adjustment. Table 14 shows how the adaptive management approach will be applied in the context of this EWP.

Table 14: Adaptive management framework

Adaptive management phase	Application to this EWP (Responsible agency)	When (Sections 15 and 19, NVIRP 2010)
Assessment and design	Assessment identifies environmental values, their water dependencies, and the potential role of incidental water. Design determines the desired water regime to support environmental values and determines any mitigation water commitment. Details of both these phases are documented in this EWP. (GMW Connections Project)	2010
Implementation	Implementation is the active management of environmental water, of which mitigation water may form a portion, consistent with this EWP. (North Central CMA)	Continuous
Monitoring (and reporting)	Monitoring is gathering relevant information to facilitate review and enable any reporting obligations to be met. Two types of monitoring are required. Compliance monitoring is checking that the intended water regime is applied. Performance monitoring is used to inform the review of the effectiveness of the interim mitigation water contribution to achieving the water management goal by monitoring individual objectives. (North Central CMA).	Annual
Review	Review is evaluating actual results against objectives and identifying any improvement opportunities which may be needed. (GMW Connections Project, until responsibilities transferred to other agencies)	2015, 2020, 2025, etc
Adjustment	Adjustment is determining whether changes are required following review or after considering any new information or scientific knowledge and making any design changes in an updated version of the EWP. (GMW Connections Project, until responsibilities transferred to other agencies, adjustment is limited to the extent that the new information relates to the impact of the GMW Connection Project at the time of the impact occurred, and only insofar as the new information could change the mitigation outcomes)	2015, 2020, 2025, etc

8.1. Monitoring and reporting

It is assumed that if mitigation water is supplied in accordance with the desired water regime proposed within the EWP then environmental values potentially impacted by GMW Connections Project will be maintained. GMW Connections Project will report, annually, on the contribution, or provision, of "GMW Connections Project Mitigation Water" towards achieving the water regime (Section 18, GMW 2013). This will be done through liaison with other agencies in relation to monitoring and then reporting whether:

- Mitigation water was available for delivery to the wetland or waterway
- A decision was made that water was required for the wetland or waterway for that year

- Mitigation water was delivered to the wetland or waterway in accordance with the desired water regime proposed within the EWP (i.e. quantity, timing, duration, frequency)
- The ecological objectives were achieved or are being achieved

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

However, Appendix J provides some suggested components identified during the preparation of this EWP to be considered in preparing a monitoring program for the lake.

8.2. Review

Periodic reviews provide the opportunity to evaluate monitoring results in terms of compliance, ecological objectives and to learn from implementation.

It is expected this EWP will be reviewed in 2015, 2020 and every five years thereafter, or at any time, if requested by the Victorian Minister for Water or Commonwealth Minister for the Environment (Sections 15 and 19, GMW 2013). The GMW Connections Project is responsible for reviews until such time as responsibility is transferred.

8.3. Adjustment

Adjustments may be made to:

- operational management
- management hypotheses and, perhaps, to ecological objectives
- cope with unexpected issues.

These adjustments will be incorporated into the EWP.

9. Governance arrangements

A summary of the roles and responsibilities of the various bodies relating to the delivery and review of management and mitigation measures is provided in Table 15 (GMW 2013). The table outlines the roles and responsibilities before and during the implementation of GMW Connections Project in the modified GMID.

Table 15: Roles and responsibilities

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during GMW Connections Project implementation
GMW Connections Project (until such time as responsibility is transferred)	• identify and account for water savings, subject to audit by DELWP accredited auditor • Lead the assessment and development processes for management and mitigation measures including developing and gaining approval to the WCMF (which guides the development of EWPs and the assessment of mitigation water). • Maintain short-list of all wetlands, waterways and groundwater dependent ecosystems for mitigation. • Identify and source mitigation water required to implement management and mitigation measures including the adaptive development of EWPs. • Retain or provide infrastructure to deliver water to wetlands and waterways. • Convene and chair the Environmental Technical Advisory Committee. • Convene the Expert Review Panel	• Apply, review and, as necessary, develop amendments and gain approval to updated versions of the WCMF. • Provides resources to enable monitoring and review of management and mitigation measures • Establish protocols for transfer of responsibility to relevant agencies. • Coordinate with other agencies to deliver management and mitigation measures. • Arrange for the provision of delivery and measurement infrastructure including capacity and operational flexibility for mitigation water.
Catchment Management Authority	• Identify and inform GMW Connections Project of opportunities for best practice. • Inform GMW Connections Project of its infrastructure requirements to deliver environmental water. • Participate in the Environmental Technical Advisory Committee.	• Advise Environmental Water Holder and system operator on priorities for use of environmental entitlements (including mitigation water) in line with recommendations outlined in the EWPs • Implement the relevant components of Environmental Watering Plans. • Operate, maintain and replace, as agreed, the infrastructure required for

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during GMW Connections Project implementation
	• Agree to implement relevant components of Environmental Watering Plans. • Agree to implement other relevant regional management and mitigation measures required due to the implementation of GMW Connections Project.	delivery of mitigation water, where the infrastructure is not part of the G-MW irrigation delivery system. • Report on environmental outcomes (e.g. wetland or waterway condition) from the delivery of the water, in the course of normal reporting on catchment condition. • Where agreed conduct the periodic review of EWPs and report results to GMW Connections Project. • Manage and report on other relevant catchment management and mitigation measures required due to the implementation of GMW Connections Project.
Land Manager (Public and private as relevant)	• Identify and inform GMW Connections Project of opportunities for best practice. • Participate in the Environmental Technical Advisory Committee. • Agree to implement relevant components of Environmental Watering Plans. • Agree to implement other relevant regional management and mitigation measures required due to the implementation of GMW Connections Project.	• Implement the relevant components of Environmental Watering Plans. • Operate, maintain and replace, as agreed, the infrastructure required for delivery of mitigation water, where the infrastructure is not part of the G-MW irrigation delivery system. • Where agreed, participate in the periodic review of relevant EWPs. • Manage and report on other relevant catchment management and mitigation measures required due to the implementation of GMW Connections Project.
System Operator	• Identify and inform NVIRP of opportunities for best practice. • Participate in the Environmental Technical Advisory Committee. • Agree to implement relevant components of Environmental Watering Plans. • Administer management and operational arrangements.	• Implement the relevant components of Environmental Watering Plans, namely delivery of mitigation water. • Operate, maintain and replace, as needed, the infrastructure required for delivery of mitigation, or other, water, where the infrastructure is part of the G-MW irrigation delivery system. • May negotiate transfer of ownership of infrastructure to the environmental water/land manager for provision of mitigation water if it is no longer required for the public distribution system, in accordance with the principles set out in the WCMF. • Where the infrastructure assets are due for renewal or refurbishment, the water corporation will undertake the upgrade to the best

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during GMW Connections Project implementation
		environmental practice, including any requirements to better provide Environmental Water Reserve, and to remain consistent with the current WCMF. • Report annually on the availability and delivery of water for mitigating environmental impacts as part of reporting upon meeting obligations under its bulk entitlement. In some instances, it will be appropriate to measure mitigation flows to ensure mitigation volumes of water are delivered.
DELWP	• Identify and inform GMW Connections Project of opportunities for best practice. • Participate in the Environmental Technical Advisory Committee. • Arrange funding to enable environmental water manager, catchment manager and land manager to deliver agreed measures.	• Participate in the periodic review of the Water Change Management Framework and relevant EWPs.
Environmental Water Holder		• Hold and manage environmental entitlements, including mitigation water that becomes a defined entitlement. • Consult with CMAs in identifying priority wetlands, waterways and groundwater systems for environmental watering. Plan and report on the use of environmental entitlements. • Negotiate with Commonwealth Environmental Water Holder to arrange delivery of Commonwealth environmental water.

9.1. Framework for operational management

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

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

Delivery of environmental water to Round Lake requires the coordination of information, planning and monitoring among a number of agencies.

A framework for operational management outlining the relevant roles and responsibilities is presented in Figure 12. This has been developed to describe the decision-making process required to coordinate implementation of the desired water regime for Round Lake. The various government bodies and their roles will change over time. Therefore, this framework should be taken as a guide only.

The main components are:

- assessment of current conditions i.e. wetland phase, climatic conditions, etc.
- identification of potential water sources and preparation of relevant information for submission of water bid
- coordination of the environmental water delivery and adaptive management process.

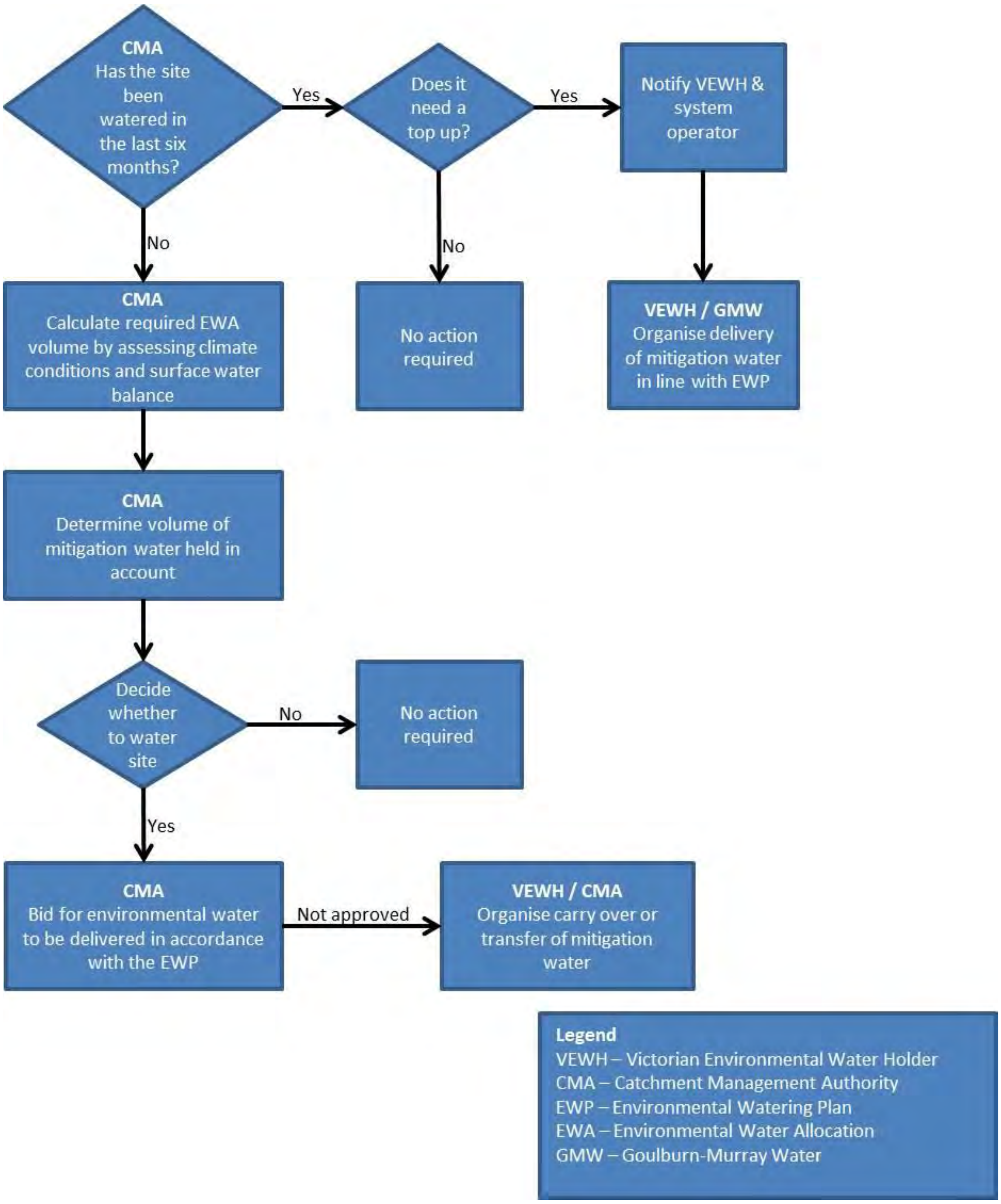

Figure 12: Operational management framework

10. Knowledge gaps

The Round Lake EWP has been developed using the best available information. However, a number of information and knowledge gaps exist which may impact on recommendations and/or information presented in the EWP. These are summarised below.

10.1. Works program

Further information on the NVIRP works program in the vicinity of Round Lake needs to be confirmed to more specifically assess the potential impacts on the lake, particularly whether:

- channel 1/9 will be considered for rationalisation and any alternative supply arrangements
- the current supply point is likely to be altered and details of any potential alternative supply points.

10.2. Round Lake

- As Round Lake is one of six remaining sites supporting the endemic Murray Hardyhead, it is imperative that advances in the understanding of species' requirements are incorporated into the EWP. In particular, any requirements that directly impact the desired water regime (i.e. salinity tolerance levels, spawning habitat requirements) must be immediately included in future revisions of the plan and in any subsequent management plans developed for the lake.
- The genus of Charophytes occurring at Round Lake and consequently the corresponding salinity tolerance levels are currently unknown. When reviewed, the recommendations within the EWPs must incorporate additional information on Charophytes within Round Lake as it becomes available. It is recommended that Charophytes within Round Lake are identified in order to inform the desired water regime.
- The species of *Lepilaena sp.* occurring at Round Lake and consequently the corresponding salinity tolerance levels are currently unknown. When reviewed, the recommendations within the EWPs must incorporate additional information on species requirements within Round Lake as it becomes available. It is recommended that the species is identified in order to inform the desired water regime.
- Continued monitoring and evaluation of groundwater and surface water data is recommended to ensure no detrimental impacts from implementation of the water regime (Appendix J). In particular, long term monitoring of the salinity levels within Round Lake is essential to ensure water quality remains within the recommended optimal ranges and protects Murray Hardyhead from salinity spikes particularly during times of spawning and recruitment of the species.
- The relationships between hydrology and ecological response in wetlands are complex. Therefore, it will be important that monitoring and adaptive management is undertaken to enable decisions to be made based on the best available information (Appendix J). In particular, it is critical that research developments into the habitat requirements of Murray Hardyhead inform the adaptive management of the desired water regime for Round Lake.

10.3. Roles and responsibilities

- GMW Connection Project is responsible for addressing knowledge gaps associated with the GMW Connections Project works program in the vicinity of Round Lake listed under Section 10.1.
- GMW Connections Project and DELWP are responsible for addressing knowledge gaps associated with the Murray Hardyhead. DELWP is responsible for implementing the Murray Hardyhead Recovery Plan in Victoria and will work together with GMW Connections Project to incorporate new requirements for the species in to the EWP.
- GMW Connections Project is responsible for revising the EWP to incorporate any additional information on *Ruppia megacarpa,* Charophytes and *Lepilaena sp.*

requirements within Round Lake as it becomes available, until such time as responsibility is transferred.

- DELWP and the North Central CMA are responsible for monitoring, evaluating data, and adaptive management of Round Lake.

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Appendix A: NVIRP TAC, Wetland workshop participants and GMW Connections Project ETAC

Table A1: NVIRP TAC members - 2009

Name	Organisation and Job title
Anne Graesser	Manager – Natural Resources Services Goulburn Murray Water
Carl Walters	Executive Officer SIR Goulburn Broken CMA
Emer Campbell	Manager – NRM Strategy North Central CMA
Jen Pagon	Catchment and Ecosystem Services Team Leader Department of Primary Industries
John Cooke	Manager Sunraysia Department of Sustainability and Environment
Ross Plunkett	Executive Manager Planning NVIRP
Tamara Boyd	State Parks and Environmental Water Coordinator Parks Victoria
Observers	
Andrea Joyce	Program Leader – Wetlands and Environmental Flows Department of Sustainability and Environment
Bruce Wehner	Ranger Parks Victoria
Caroline Walker	Executive Assistant to Executive Manager Planning NVIRP
Chris Solum	Environmental Program Manager NVIRP
Michelle Bills	Strategic Environmental Coordinator North Central CMA
Pat Feehan	Consultant Feehan Consulting
Paulo Lay	Senior Policy Officer Department of Sustainability and Environment
Rebecca Lillie	Project Officer North Central CMA

Table A2: Wetland workshop participants – 25 February 2010

Name	Organisation and Job title
Andrea Joyce	Program Leader – Wetlands and Environmental Flows Department of Sustainability and Environment
Bridie Velik-Lord	Environmental Flows Officer North Central CMA
Cherie Campbell	Senior Ecologist Murray Darling Freshwater Research Centre
Chris Solum	Environmental Program Manager NVIRP
Emer Campbell	Manager NRM Strategy
Geoff Sainty	Wetland Specialist Sainty and Associates Pty Ltd
Karen Weaver	Biodiversity and Ecosystem Services Department of Sustainability and Environment
Lyndall Rowley	Research and Development Project Officer North Central CMA
Mark Tscharke	Senior Ranger Parks Victoria
Pat Feehan	Consultant Feehan Consulting
Rebecca Lillie	Project Officer North Central CMA
Rob O'Brien	Senior Environmental Officer Department of Primary Industries
Shelley Heron	Manager – Water Ecosystems Kellogg Brown and Root

Table A3: GMW Connections Project ETAC members - 2015

Name	Organisation and Job title
Aaron Gay	Regional Manager, Environment and Natural Resources Department of Environment, Water, Land and Planning
Andrea Keleher	Program Manager – Healthy Landscapes Department of Environment, Water, Land and Planning
Bruce Wehner	Ranger Parks Victoria
Carl Walters	Executive Officer SIR Goulburn Broken CMA
Emer Campbell	Manager – NRM Strategy North Central CMA
Neil McLeod	Irrigation Officer – Dairy and Irrigation Department of Economic Development, Jobs, Transport and Resources
Ross Plunkett	Manager Environment and Water Savings GMW Connections Project
Observers	
Chris Solum	Environmental Project Manager GMW Connections Project
Josie Lester	Environmental Project Officer GMW Connections Project

Appendix B: Community Interaction/Engagement

Rob O'Brien, Department of Primary Industries

Community Engagement purpose

An important component of the EWPs involves identifying the goal, underlying environmental objectives and wetland type for each of the wetlands being assessed for the GMW Connections Project. This requires an understanding of physical attributes, the history and the main biological processes associated with each of the wetlands.

In many cases, adjoining landholders have had a long association with a wetland and have developed a good understanding that is useful to include in the development of the EWPs. This is particularly important if only limited monitoring records exist.

Method

A targeted community/agency engagement process was developed for the first round of EWPs developed in early 2009. A list of people with a good technical understanding of each wetland was developed by the technical working group (DPI, DSE and North Central CMA representatives).

This list included key adjoining landholders that have had a long association with the wetland and proven interest in maintaining its environmental value. A minimum of 2 landholders were invited to provide input for each wetland.

Other community and agency people that can provide useful technical and historic information include G-MW water bailiffs, duck hunters (Field & Game Association), bird observers and field naturalists. These people often possess valuable information across several of the wetlands currently being studied.

The method of obtaining information was informal and occurred at the wetland (e.g. oral histories, interviews). The information has been captured in brief dot point form and only technical information and observations are to be noted that will add value to the development of the EWP.

A list of participants has been recorded however all the comments have been combined for each of the wetlands so individual comments are not referenced back to individuals.

List of community and agency participants (Round Lake)

- Tom Lowe (field naturalist)
- John Jobson (landholder)
- Barry Free (landholder)
- Peter Keostveld (G-MW)

Note: the results below document the comments received from the community members approached as part of the community engagement process. However, if new information comes to light this can be amended and redistributed accordingly.

Information provided to the community

It is important that the people approached for this information have a brief, straight summary of the purpose of the EWPs and type of information that will be useful to include in the planning process. Refer to summary below (adapted from Rob O'Brien, DPI 2009):

We are currently completing a study for NVIRP Northern Victoria Irrigation Renewal Project. It involves completing plans for Lake Leaghur, McDonalds Swamp, Little Lake Meran, Lake Meran, Little Lake Boort, Round Lake and Lake Yando.

As part of this it would be valuable to gather information that is broadly described below with a focus on the water regime and associated wetland values. It's recognised that these wetlands have been altered significantly since European settlement and the expansion of irrigated agriculture.

Providing information on these changes and how these influenced and altered the wetlands is important. It is particularly important to collate information or observations over more recent times, such as the last 30 - 50 years.

- *What was the original (pre-European settlement) condition of the wetland, including any details of the water regime and values (environmental, cultural)?*
- *What broad changes to the wetlands have occurred, particularly changed water regimes, as agricultural development influenced the floodplains and wetland?*
- *What connection does the wetland have to the floodplain to provide floodwater, or local catchment runoff?*
- *To what extent does the current irrigation supply channel have on the water regime over time?*
- *During more recent times (last 50yrs?) how did the productivity of the wetland vary with the altered water regimes?*
- *Describe the health of the wetland and notable plants and animals (both aquatic/terrestrial) associated with its water management.*
- *Comment on pest plants (boxthorn, willows, cumbungi etc)*
- *What influence has grazing domestic stock had on the reserve, both positive and negative effects?*
- *Given the history and current condition what type of water regime would be needed to achieve the best environmental results for the wetland?*
- *What other management practices could be adopted to improve the environmental value of the wetland?*

Pre European Settlement Condition

- Round Lake is located on the northern floodplains, which were influenced by the Avoca River, the Loddon River and the Murray River and Little Murray River systems. Floodwater behavior was dependent on the volume and timing of these interacting waterways, wetlands and floodplains.
- Round Lake is part of an interacting wetland system situated west of Lake Boga and adjoins Long Lake to the north.
- Another wetland, Gold Course Lake, is situated immediately south of Round Lake but is not hydrologically connected. Golf Course Lake never functioned as a lake but more a Mallee depression with no obvious water supply.
- Gold Course Lake has a Mallee and floodplain catchment area to the south and southeast that may have produced watershed during very wet periods.
- Round Lake is also situated on fringe Mallee and appears to be a Mallee depression with no obvious nearby catchment area.
- Round and Long Lakes would have received floodwater from Lake Baker to the north that was fed from the overflow of Lake Boga combined with the water that backed up from the Little Murray River system.
- Rainfall and flooding was highly variable in this section of the catchment under natural conditions.
- Lake Boga was well connected to the Little Murray River. As the water levels rose in the Murray River, the Little Murray would experience high flows delivering water into Lake Boga. If the Avoca River flooded at the same time, water would have flowed northward from the Avoca Marshes, through the Mystic Park area and onto Lake Manor and Lake Boga.

- The banks of the Little Murray River were almost treeless and this may have been due to the water regime not favoring Red Gum recruitment.
- The watercourse for Avoca water between the Mystic Park and Lake Boga was very wide and shallow and could spread 1 mile wide.
- Many of the inland lakes all joined together and could be boated between during flood times in a flat- bottom boat.
- The natural flooding of the northern floodplain was variable however normally filled, flushed and fell away quite quickly.
- Lake Kunett is a low-lying Mallee depression west of Long Lake. It was a natural salt lake prior to European settlement.
- The Tresco Drainage Lakes and nearby Lake Boga and Lake Kunett would have influenced each other via the groundwater system.

Changed Management

- The Tresco Drainage Lakes and other nearby wetlands would have contained a greater diversity of native plants and animals than what is present today.
- Round Lake and the other adjoining wetlands were dramatically impacted as part of European Settlement.
- The rivers that determined the flooding regime of the Tresco Drainage Lakes were manipulated to suit European Settlers and this changed natural water regime, which altered the character of the districts waterways and wetlands.
- Basic river regulation began in the mid 1800's, first to secure stock and domestic water, then later for irrigation use.
- The natural salt lakes, Lake Kunett, Lake Kelly and Spences Lake were important salt harvesting lakes and salt was transported by Paddle Steamers via the Murray River in the early years.
- There were plans to widen the waterway from the Little Murray River into Lake Boga to allow Paddle Streamers access into Lake Boga. This would allow the salt that was being harvested at Lake Kunett to be carted a much shorter distance, compared to carting it to Swan Hill, reducing freight costs.
- Long Lake was maintained as a freshwater storage lake and a pump located on the western side supplied water into a channel system that serviced dry land areas to the west.
- Groundwater level began to rise dramatically with the development of the irrigation supply system and irrigated agriculture.
- Low lying depressions and wetlands became susceptible to high saline groundwater levels and this increased salinity altered their character limiting the plants and animals that could exist there.
- Wetlands that have their water supply diminished or removed are susceptible to high saline groundwater conditions and usually deteriorate becoming increasing saline.
- Long Lake was removed from the irrigation and floodplain system and became increasingly saline. The GMW channel following the western side of the wetland leaked and seeped significantly, further salinising the adjoining Long Lake.
- The Tresco Horticultural district original irrigation supply system was very inefficient and resulted in huge amounts of water being lost causing groundwater levels to rise and significant salinity problems particularly on the majority of the low lying areas.
- The Tresco Horticultural area originally supported a significant citrus industry of over 1000 acres.
- Early furrow or flood irrigation systems in the Tresco horticultural district resulted in more water entering the already elevated groundwater system, further aggravating the salinity problem.
- Golf Course Lake was taken over by GMW to provide a drainage outfall for the Tresco Horticultural district.

- With the Tresco area being irrigated and supporting horticultural crops there was a need for improved drainage. The original drainage schemes commenced in the 1920's.
- Tough economic times for the districts farmers occurred in the 1940's and this was followed by a series of wet years in the 1950's further aggravating the salinity problems.
- In the 1950's and 1960's tile drainage systems where installed in conjunction with deepening the main drains system which provided relief from salinisation and resulted in significant drainage flows into Golf Course Lake and then onto Round Lake.
- Lake Boga has been managed primarily a deep freshwater lake for most of the last century and possibly accumulated a lot of silt over that time.
- Lake Boga dried in 1915 however was filled a few months later.
- A local history book by Grant Angus (Between the Rivers) provides a good description of the areas development.
- The GMW channel that follows the western side of Long Lake provides outfall flows into Round Lake. This has assisted in maintaining the water levels in the lake.
- There are no irrigation supply channels that can deliver fresh water into Golf Course Lake, only the drainage flows from the Tresco Horticultural district enter this wetland.
- A concrete pipe has been installed from the north end of Golf Course Lake to the southern end of Round Lake (1950's/60's?). This was to allow water to flow northward out of Golf Course Lake into Round (& Long) if the drainage flows overfilled Gold Course Lake.
- During the wet periods water did flow from Gold Course Lake into Long Lake however with changed irrigation practices and diminishing drainage flows it is believed the storage of Golf Course Lake alone, is sufficient to receive all of the drainage flows eventuating off the Tresco Horticultural district.
- There has been an enormous improvement in irrigated agriculture in the Tresco Horticultural district with most farm utilizing highly efficient systems that result in minimal drainage or exporting of nutrients.

Environmental Values

- In the 1960's Round Lake and Golf Course Lake supported a diverse range of waterbird species, a host of aquatic plants and associated invertebrates, and several fish species. Some of the waterbirds include Grey Teal, Hardhead Duck, Green Shanks, Dotterels, Stints, Sand Pipers, Marsh Terns, Silver Gulls, Marsh sandpipers, Blue Bill Ducks, Grebes.
- Long Lake was maintained as a deep freshwater lake in the mid 1900's and supported a significant fishery, particularly Murray Cod.
- Golf Course and Round Lakes did not appear to support large bodied fish.
- The waterbird diversity dropped in Golf Course Lake and Round Lake as the salinity of the wetlands increased.
- The salinity of these wetlands and many of the districts wetlands increased after the wet period in the 1970's.
- In the 1980's Golf Course Lake was considered to possess the highest environmental values of all the Tresco Drainage Lakes. Golf Course Lake appeared slighter fresher and there were healthy populations of the threatened salt tolerant native fish, Murray Hardyhead, and good waterbird numbers.
- In the late 1990's the drainage flows off the horticultural catchment reduced significantly and resulting in lower water levels in Golf Course Lake and increasing salinity levels. Increased salinity levels caused environmental decline particularly the loss of Murray Hardyhead but also reduced waterbird usage.
- Attempts were made to deliver freshwater into Golf Course Lake to protect the environmental values by injecting significant volumes of fresh channel water into Round Lake, elevating the lakes water level and forcing water through the pipeline into Golf Course Lake. This approach was not efficient and eventually Golf Course Lake salinity levels rose and almost all of the previous environmental values lost.

- Round Lake currently is considered to possess the highest environmental values of all of the Tresco Drainage Lakes. It supports the threatened Murray Hardyhead fish and good numbers of waterbirds.
- The volume of outfall have reduced over time into Round Lake and Environmental water has been delivered periodically to maintain the lake levels and keep the salinity levels within a range that can support key species, particularly Murray Hardyhead.
- Lake Boga needs to be recognized for the environmental values it possesses.
- Some of the local people value Round Lake as it currently supports good numbers of waterbirds however the small native salt tolerant fish, Murray Hardyhead, is not as well valued.
- During recent tough times, with water becoming increasingly scarce and valuable, some surrounding landholders view the water being delivered into Round Lake as wasteful, particularly when they are suffering lost production including the death of some of their permanent plantings.

Suggested Future Management

- Round lake could be managed as a permanent saline lake, with fluctuating water levels.
- There is no support for refilling Golf Course Lake to increase its environmental values as it compromises is primary use as providing drainage relief to the valuable horticultural district.
- The local community expressed a need to better communicate environmental water delivery and objectives using several communication methods.
- There is an increasing need to undertake pest plant and animal work, particularly rabbit control across all land tenures to protect both the environment and agricultural production.

Key Points

- Round Lake was originally a wetland depression, on the edge of the Mallee and northern floodplains that received variable flood flows from the combined Avoca and Little Murray floodplain systems.
- Round Lake has been dramatically altered over time since European settlement and is currently being managed as a permanent saline lake.
- The management of Round Lake needs to be considered in the context of the other nearby wetlands as they will influence each other (i.e. groundwater leakage).
- The views on the environmental value are quite varied however there is limited objection to maintain Round Lake it for waterbird usage. Murray Hardyhead are not as well valued.
- There would be significant objections to filling Golf Course Lake with environmental water as it would jeopardise its primary function of providing drainage relief for the Tresco Horticultural district.
- Community members expressed an interest in increasing the community and agency interaction in regards to the management of the Tresco Drainage Lakes and the delivery of environmental water allocations.

Appendix C: Contour Plan and Rating Table Archards Irrigation (2010)

ARCHARDS IRRIGATION
P.O. BOX 327
LEITCHVILLE ROAD
COHUNA 3568
PH: 03 5453 2664
FAX: 03 5456 3226
www.archards.com.au
survey@archards.com.au

PROJECT NUMBER: 3711
CLIENT: NCCMA

PROJECT: TRESCO DRAINAGE LAKES

PLAN TITLE: CONTOUR PLAN & CAPACITY TABLE

SITE LOCATION: ROUND LAKE
LAKE BOGA-ULTIMA ROAD
LAKE BOGA 3584

PROJECTION: MGA 94 ZONE 54

HORIZONTAL DATUM: GDA 94

HEIGHT DATUM: AHD

SURVEY BY: DC

SURVEY DATE: 30/11/2009

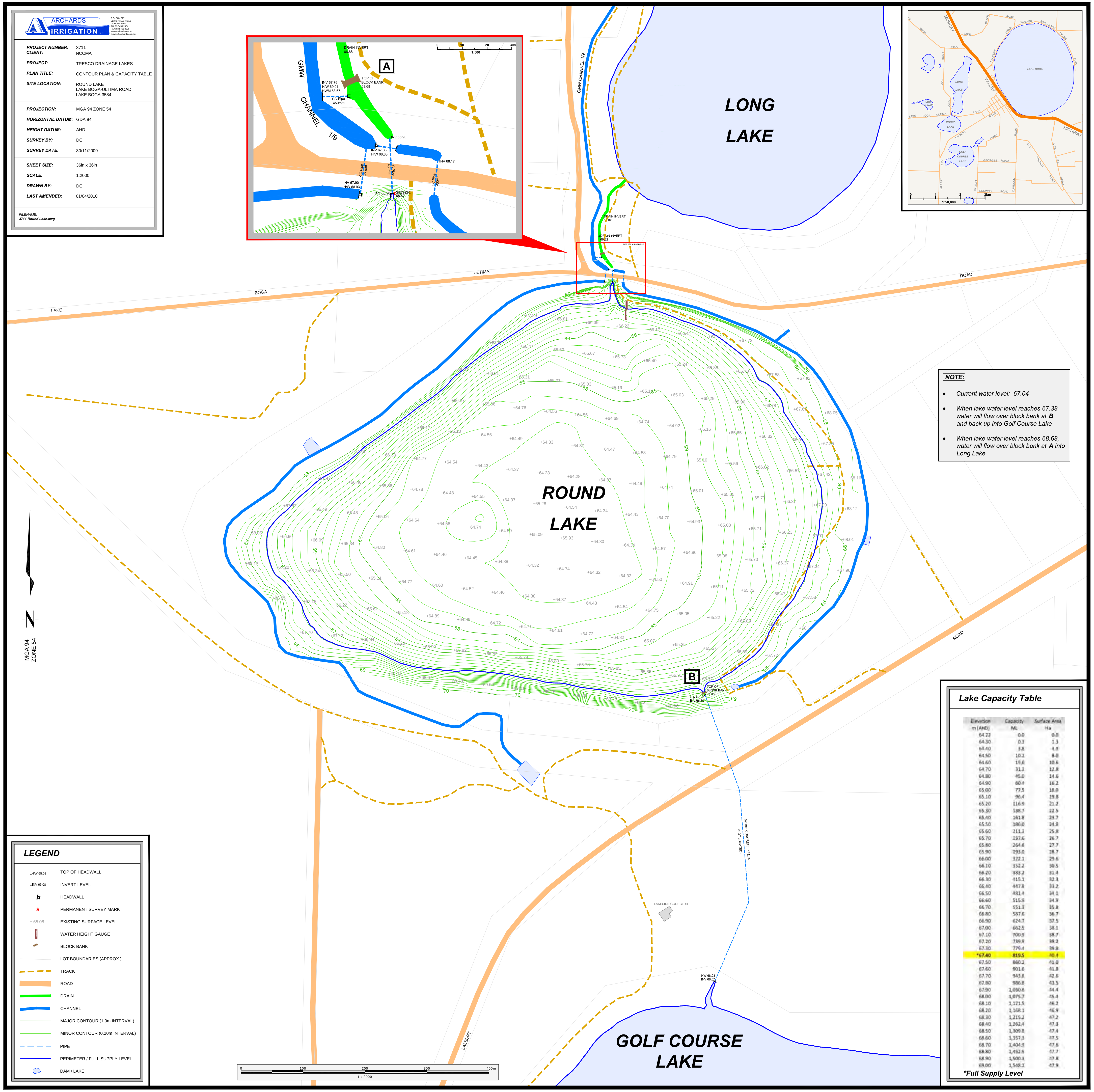
SHEET SIZE: 36in x 36in

SCALE: 1:2000

DRAWN BY: DC

LAST AMENDED: 01/04/2010

FILENAME:
3711 Round Lake.dwg



NOTE:

- Current water level: 67.04
- When lake water level reaches 67.38 water will flow over block bank at **B** and back up into Golf Course Lake
- When lake water level reaches 68.68, water will flow over block bank at **A** into Long Lake

LEGEND

- TOP OF HEADWALL
- INVERT LEVEL
- HEADWALL
- PERMANENT SURVEY MARK
- EXISTING SURFACE LEVEL
- WATER HEIGHT GAUGE
- BLOCK BANK
- LOT BOUNDARIES (APPROX.)
- TRACK
- ROAD
- DRAIN
- CHANNEL
- MAJOR CONTOUR (1.0m INTERVAL)
- MINOR CONTOUR (0.20m INTERVAL)
- PIPE
- PERIMETER / FULL SUPPLY LEVEL
- DAM / LAKE

Lake Capacity Table

Elevation m (AHD)	Capacity ML	Surface Area Ha
64.22	0.0	0.0
64.30	0.3	1.3
64.40	3.8	4.9
64.50	10.2	8.0
64.60	19.6	10.6
64.70	31.3	12.8
64.80	45.0	14.6
64.90	60.4	16.2
65.00	77.5	18.0
65.10	96.4	19.8
65.20	116.9	21.2
65.30	138.7	22.5
65.40	161.8	23.7
65.50	186.0	24.8
65.60	211.3	25.8
65.70	237.6	26.7
65.80	264.8	27.7
65.90	293.0	28.7
66.00	322.1	29.6
66.10	352.2	30.5
66.20	383.2	31.4
66.30	415.1	32.3
66.40	447.8	33.2
66.50	481.4	34.1
66.60	515.9	34.9
66.70	551.3	35.8
66.80	587.6	36.7
66.90	624.7	37.5
67.00	662.5	38.1
67.10	700.9	38.7
67.20	739.9	39.2
67.30	779.4	39.8
*67.40	819.5	40.4
67.50	860.2	41.0
67.60	901.6	41.8
67.70	943.8	42.6
67.80	986.8	43.5
67.90	1,030.8	44.4
68.00	1,075.7	45.4
68.10	1,121.5	46.2
68.20	1,168.1	46.9
68.30	1,215.2	47.2
68.40	1,262.4	47.3
68.50	1,309.8	47.4
68.60	1,357.3	47.5
68.70	1,404.9	47.6
68.80	1,452.5	47.7
68.90	1,500.3	47.8
69.00	1,548.2	47.9

*Full Supply Level

Appendix D: Wetland characteristics

Characteristics	Description
Wetland Name	Round Lake
Wetland ID	7627 366715
Wetland Area	40 ha at 67.4 m AHD, 186 ha reserve
Conservation Status	Bioregionally Important Wetland
Land Manager	G-MW
Surrounding Land Use	Dryland cropping and grazing
Water Supply	Natural: Backed-up Murray River flood flows Current: Channel outfalls (1/9) • 300 EC • Channel capacity of 40 ML/day, Outfall regulating structure capacity 30 ML/day
1788 Wetland Classification	Category: Deep freshwater marsh
1994 Wetland Classification	Category: Permanent saline wetland Subcategories: Shallow (<5m
Wetland Capacity	820 ML, *FSL 67.4 m AHD* (Archards Irrigation 2010)
Outfall Volumes	Recorded: 178 ML (04/05) Unrecorded: 84 (04/05) 87 ML (98/99 to 08/09 average or recorded values)

Appendix E: Flora and fauna species list

Compiled: September 2009

Sources:

Campbell *et al*. (2009)

DCFL (1990a)

DCFL (1990b)

DSE (2009a)

Hardie (2000)

McGuckin (1999)

Saddlier *et al.* (2009)

Data Source: 'Threatened Fauna 100' © The State of Victoria, Department of Sustainability and Environment.

Data Source: 'Threatened Flora 100' © The State of Victoria, Department of Sustainability and Environment.

Data Source: 'Aquatic Fauna Database', Copyright - The State of Victoria, Department of Sustainability and Environment.

Updated: February 2015

Sources:

eBird Website (2014)

North Central Catchment Management Authority bird records (2014)

Common Name	Scientific name
Fauna - native	
Australasian Grebe	*Tachybaptus novaehollandiae*
Australasian Shoveler	*Anas rhynchotis*
Australian Magpie	*Gymnorhina tibicen*
Australian Pelican	*Pelecanus conspicillatus*
Australian Raven	*Corvus coronoides*
Australian Reed-Warbler	*Acrocephalus australis*
Australian Shelduck	*Tadorna tadornoides*
Australian White Ibis	*Threskiornis molucca*
Australian Wood Duck	*Chenonetta jubata*
Black Kite	*Milvus migrans*
Black Swan	*Cygnus atratus*
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*
Black-fronted Dotterel	*Elseyornis melanops*
Black-shouldered Kite	*Elanus axillaris*
Black-tailed Native Hen	*Gallinula ventralis*
Black-winged Stilt	*Himantopus himantopus*
Blue-billed Duck	*Oxyura australis*
Bony Bream	*Nematalosa erebi*
Brown Falcon	*Falco berigora*
Brown Goshawk	*Accipiter fasciatus*
Budgerigar	*Melopsittacus undulatus*
Caspian Tern	*Sterna caspia*
Chestnut Teal	*Anas castanea*
Clamorous Reed Warbler	*Acrocephalus stentoreus*
Common Froglet	*Crinia signifera*
Common Greenshank	*Tringa nebularia*
Crested Pigeon	*Ocyphaps lophotes*
Darter	*Anhinga melanogaster*

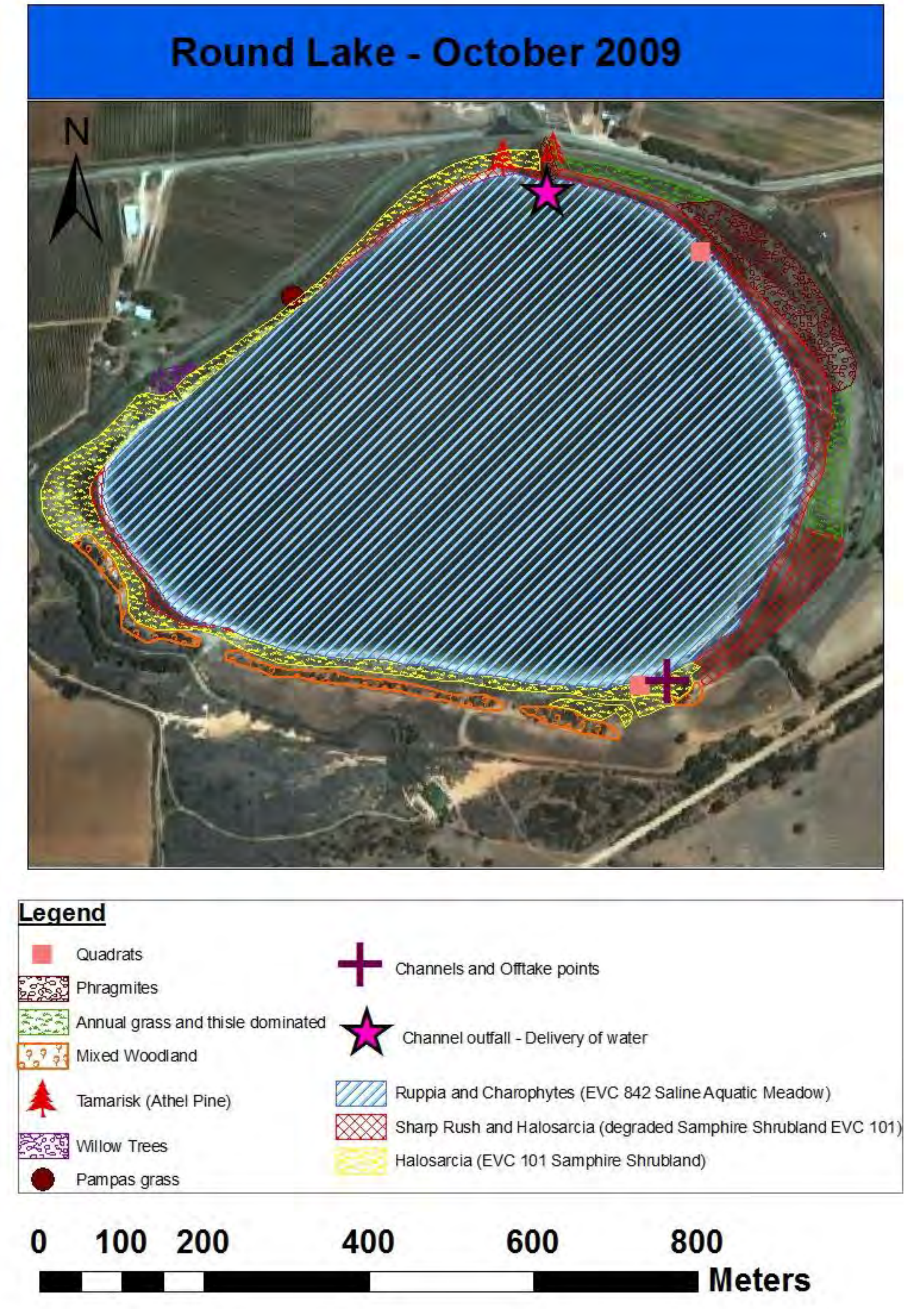
Common Name	Scientific name
Dusky Moorhen	*Gallinula tenebrosa*
Eastern Great Egret	*Ardea modesta*
Eurasian Coot	*Fulica atra*
Flat-headed Gudgeon	*Philypnodon grandiceps*
Freckled Duck	*Stictonetta naevosa*
Galah	*Eolophus roseicapilla*
Gull-billed Tern	*Gelochelidon nilotica*
Great Cormorant	*Phalacrocorax carbo*
Great Crested Grebe	*Podiceps cristatus*
Great Egret	*Ardea alba*
Grey Fantail	*Rhipidura albiscarpa*
Grey Teal	*Anas gracilis*
Hardhead	*Aythya australis*
Hoary-headed Grebe	*Poliocephalus poliocephalus*
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*
Intermediate Egret	*Ardea intermedia*
Little Black Cormorant	*Phalacrocorax sulcirostris*
Little Grassbird	*Megalurus gramineus*
Little Pied Cormorant	*Microcarbo melanoleucos*
Little Raven	*Corvus mellori*
Magpie-lark	*Grallina cyanoleuca*
Marsh Sandpiper	*Tringa stagnatilis*
Masked Lapwing	*Vanellus miles*
Murray Hardyhead	*Craterocephalus fluviatilis*
Musk Duck	*Biziura lobata*
Musk Lorikeet	*Glossopsitta concinna*
Nankeen Kestrel	*Falco cenchroides*
Noisy Miner	*Manorina melanocephala*
Pacific Heron	*Ardea pacifica*
Pacific Black Duck	*Anas superciliosa*
Pink-eared Duck	*Malacorhynchus membranaceus*
Purple Swamphen	*Porphyrio porphyrio*
Rainbow Bee-eater	*Merops ornatus*
Red-capped Plover	*Charadrius ruficapillus*
Red-kneed Dotterel	*Erythrogonys cinctus*
Red-necked Avocet	*Recurvirostra novaehollandiae*
Red-rumped Parrot	*Psephotus haematonotus*
Royal Spoonbill	*Platalea regia*
Rufous Whistler	*Pachycephala rufiventris*
Sacred Kingfisher	*Todiramphus sanctus*
Silver Gull	*Chroicocephalus novaehollandiae*
Silvereye	*Zosterops lateralis*
Singing Honeyeater	*Lichenostomus virescens*
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*
Spotted harrier	*Circus assimilis*
Straw-necked Ibis	*Threskiornis spinicollis*
Superb Fairy-wren	*Malurus cyaneus*
Swamp Harrier	*Threskiornis spinicollis*
Wedge-tailed Eagle	*Aquila audax*
Welcome Swallow	*Hirundo neoxena*
Whiskered Tern	*Chlidonias hybridus*
Whistling Kite	*Haliastur sphenurus*
White-breasted Woodswallow	*Artamus leucorynchus*
White-faced Heron	*Egretta novaehollandiae*

Common Name	Scientific name
White-necked Heron	*Ardea pacifica*
White-fronted Chat	*Epthianura albifrons*
White-plumed Honeyeater	*Lichenostomus penicillatus*
Willie Wagtail	*Rhipidura leucophrys*
Zebra Finch	*Taeniopygia guttata*
Fauna - exotic	
Common Carp	*Cyprinus carpio*
Common Starling	*Sturnus vulgaris*
Eastern Gambusia	*Gambusia holbrooki*
European Goldfinch	*Carduelis carduelis*
Goldfish	*Carassius auratus*
House Sparrow	*Passer domesticus*
Redfin Perch	*Perca fluviatilis*
Tench	*Tinca tinca*
Flora - native	
Australian Salt Grass	*Distichlis distichophylla*
Black Box	*Eucalyptus largiflorens*
Blackseed Glasswort	*Halosarcia pergranulata ssp. pergranulata*
Blown Grass	*Agrostis avenacea*
Charophyte	*Charophyte*
Common Reed	*Phragmites australis*
Creeping Monkey Flower	*Mimulus repens*
Creeping Saltbush	*Atriplex semibaccata*
Cumbungi	*Typha sp.*
Dillon Bush	*Nitraria billardieri*
Filamentous algae	*Filamentous algae*
Flat-top Saltbush	*Atriplex lindleyii*
Glasswort	*Halosarcia pergranulata ssp. pergranulata*
Grassy Bindweed	*Convolvulus remotus*
Grey Copperburr	*Sclerolaena diacantha*
Hairy Willow-herb	*Epilobium hirtigerum*
Hedge Saltbush	*Rhagodia spinescens*
Honey-myrtle	*Melaleuca sp. (planted)*
Jointed Rush	*Juncus articulatus*
Large-fruit Tassel	*Ruppia megacarpa*
Mealy Saltbush	*Atriplex pseudocampanulata*
New Holland Daisy	*Vittadinia sp.*
Nodding Saltbush	*Einardia nutans ssp. nutans*
Prickly Saltwort	*Salsola tragus*
Red Sandspurrey	*Spergularia rubra*
Rounded Noon-flower	*Disphyma crassifolium ssp. clavellatum*
Ruby Saltbush	*Enchylaena tomentosa var. tomentosa*
Seablite	*Suaeda australis*
Short-leaf Bluebush	*Maireana brevifolia*
Small Loosestrife	*Lythrum hyssopifolia*
Tufted Bluebell	*Wahlenbergia communis*
Variable Spear Grass	*Austrostipa variabilis*
Wallaby Grass	*Austrodanthonia setacea*
Water-mat	*Lepilaena sp.*
Weeping Pittosporum	*Pittosporum phylliraeoides*
Windmill Grass	*Chloris truncata*
Flora - exotic	
African Boxthorn	*Lycium ferocissimum*

Common Name	Scientific name
Annual Beard-grass	*Polypogon monspeliensis*
Barley Grass	*Hordeum sp.*
Blue Sow-thistle	*Sonchus asper ssp. glaucescens*
Brome	*Bromus sp.*
Buck's-horn Plantain	*Plantago coronopus*
Buck's-horn Plantain	*Plantago coronopus ssp. coronopus*
Cape Weed	*Arctotheca calendula*
Cat's Ear	*Hypochoeris radicata*
Coast Barb-grass	*Parapholis incurva*
Common Heliotrope	*Heliotropium europaeum*
Common Sow Thistle	*Sonchus oleraceus*
Curled Dock	*Rumex crispus*
Darnel	*Lolium temulentum*
Gazania	*Gazania sp.*
Great brome	*Bromus diandrus*
Hairy Hawkbit	*Leontodon taraxacoides ssp. taraxacoides*
Horehound	*Marrubium vulgare*
Ice Plant	*Mesembryanthemum crystalinum*
Kikuyu	*Pennisetum clandestinum*
Little Medic	*Medicago minima*
London Rocket	*Sisymbrium irio*
Maltese Cockspur	*Centauria melitensis*
Oat	*Avena sp.*
Onion Weed	*Asphodelus fistulosos*
Ox-tongue	*Helminthotheca echioides*
Ox-tongue	*Picris echioides*
Paradoxical Canary-grass	*Phalaris paradoxa*
Prickly Lettuce	*Lactuca serriola*
Prickly Pear	*Opuntia sp.*
Prickly Sow Thistle	*Sonchus asper*
Rats-tail Fescue	*Vulpia myuros*
Red Brome	*Bromus rubens*
Rough Sow-thistle	*Sonchus asper s.l.*
Scarlet Pimpernal	*Anagallis arvensis*
Scotch Thistle	*Onopordum acanthium*
Sharp Rush	*Juncus acutus ssp. acutus*
Slender Barb-grass	*Parapholis strigosa*
Small-leaf Burr Medic	*Medicago praecox*
Spear Thistle	*Cirsium vulgare*
Spiny Rush	*Juncus acutus*
Stinkwort	*Dittrichia graveolens*
Tamarisk	*Tamarix aphylla*
Tree Tobacco	*Nicotiniana glauca*
White Mustard	*Sinapis alba*
Wild Oat	*Avena fatua*
Wild Sage	*Salvia verbanaca*

Appendix F: Vegetation composition maps

Vegetation composition mapping 2009



Appendix G: Hydrology (SWET OUTPUT)

set	Wetland Name	Round Lake						
		Degrees	Degrees	Minutes				
set	Latitude	-35.47020	-35.00	28.2121				
set	Longitude	143.60934	143.00	36.5605				
		Metres (AHD)						
	Altitude	69					Runoff coefficient	
		ha	m^2	ML/ha/yr	ML/yr	Rainfal Total (ML)	Mean	Max.
set	Local contributing catchment area	0.1	1000	0.2	0.02	326 0	0.061	0.2
		%area	Depth					
set	Initial loss to wetland bed parameters	0.25	300					
		Mean	Max					
set	Assumed average wetland bed runoff coeff	0.150	0.40					
		ML/d						
adjust	Notional artificial wetland filling inflow rate	8						
		mm/day						
adjust	Maximum artificial filling rate	25						

	Management parameters	Day	Month	Start day
adjust	Earliest start to fill	1	9	244
adjust	Latest start to fill	31	12	
adjust	Duration wet cycle - includes filling	274	9	
adjust	Duration dry cycle - includes drawdown	92	3	
set	Start condition	Wet		Years
set	Maximum wet-dry cycle length			1

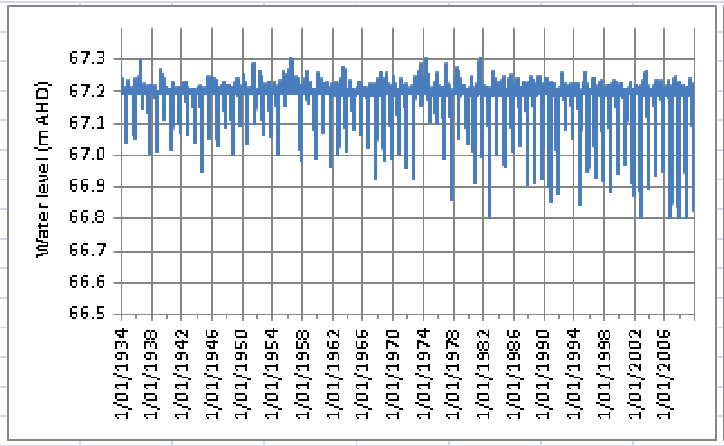
To operate the model

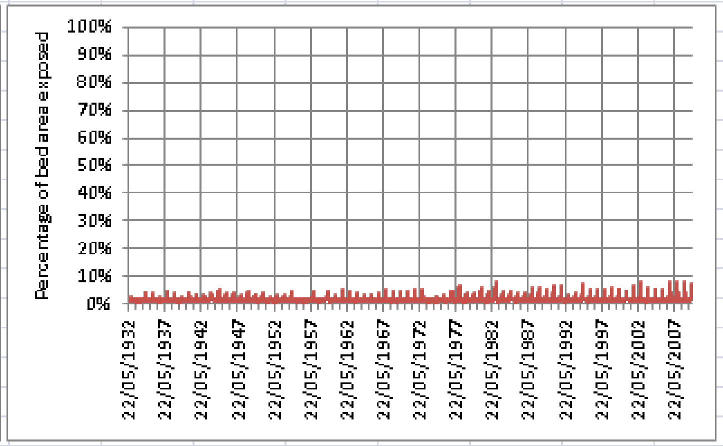
First fill in the required input data cells.
Calculation is set to Manual, so
when ready press Function9 (F9) key
It takes 20 seconds to re-calculate and plot

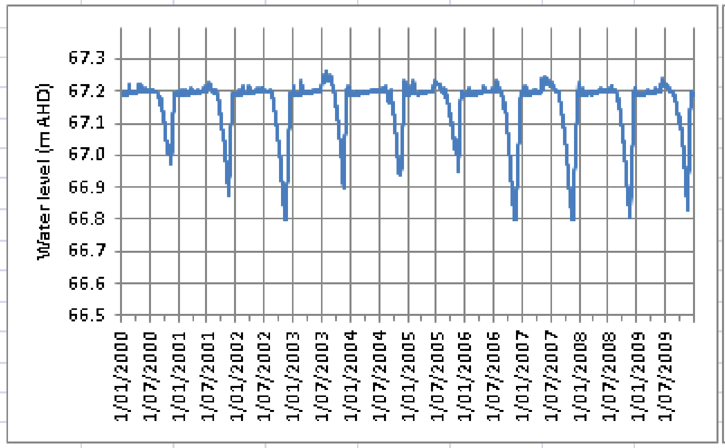
		Day	Month	
adjust	Irrigation year start	1	9	
		Elevation	Volume	Area
adjust	Target level	67.2	739900	392000
		Elevation	Volume	Area
set	Wetland spill level	67.38	779400	398000
		Elevation	Tolerance for drawdown (m)	
adjust	Lowest wetland level	66.8	0.1	
			1 = Pan; 2 = Modelled	
choose	Factored Pan evaporation or modelled ET method?		2	

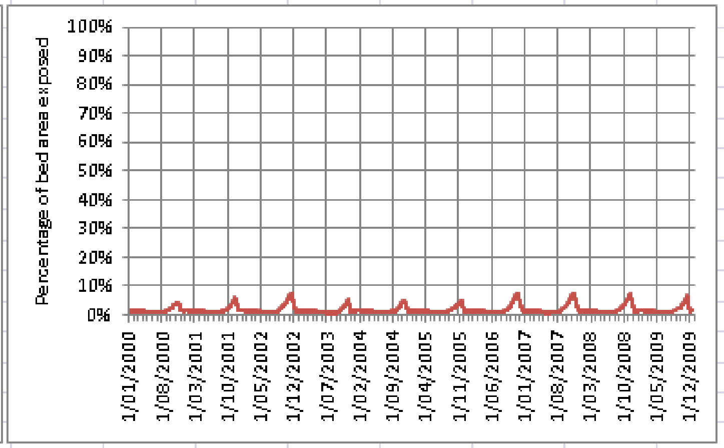
RESULT			
	ML/year	P95 (ML/yr)	Years with no inflow
Mean long-term annual artificial water inflows	475	550	0 in 118 years
	ML	No. Periods	Record length (years)
Average water inflows for filling periods	475	118	118
Drawdowns over record (number of)	118		
Drawdowns not fully drawn down (number of)	106		
Drawdowns not fully drawn down (percentage)	90%		
95th percentile duration of full period (months)	9.0		
50th percentile duration of full period (months)	8.3		

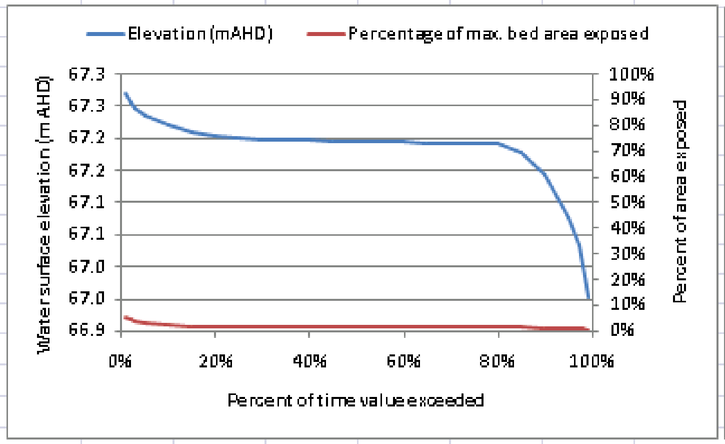
Fill cycle length (yr)	No. cycles
1	118
2	
3	
4	
5	
6	
7	
8	
9	
10	

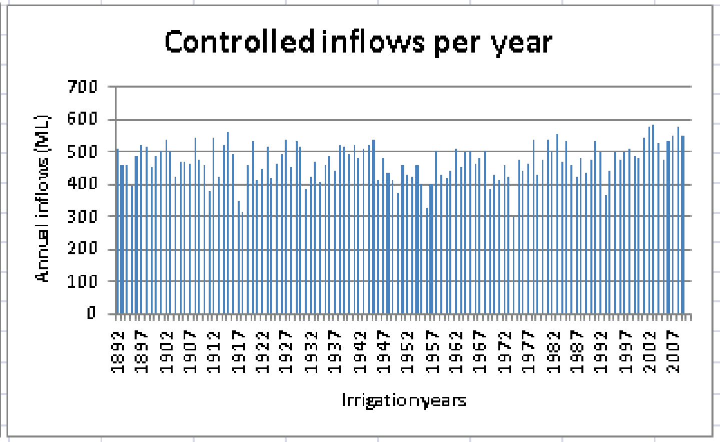












Appendix H: Preliminary leakage and seepage loss contribution calculations

Wetland	Wetland within 200 m of main supply channel (Yes/no)	Length of channel (m) <200 m	Channel width (m)	Irrigation channel	Seepage Calculation Figures					Seepage Range (min - max)	
					Channel width category	5 mm/day (ML/yr)	10 mm/day (ML/yr)	15 mm/day (ML/yr)	20 mm/day (ML/yr)	ML/yr (@ 5 mm/day)	ML/yr (@20 mm/day)
Round Lake	Yes	220	5 to 7	channel 1/9	10 m	7	14	20	27	1.54	5.94

Taken from WCMF Draft 19 March 2010 (*Table 14 Estimated volumes of seepage per year from 1000 m of channel for different channel widths and seepage rates*)

Chanel width (m)	Chanel half-width (m)	Seepage Rate in mm/day			
		5 mm/day (ML/yr)	10 mm/day (ML/yr)	15 mm/day (ML/yr)	20 mm/day (ML/yr)
10	**5**	**7**	**14**	**20**	**27**
20	**10**	**14**	**27**	**41**	**54**
40	**20**	**27**	**54**	**81**	**108**

Assumptions/Notes
Preliminary calculations were only completed for wetlands within 200 m of a main supply channel as recommended by the WCMF (19 March 2009)
Seepage rates are based on 1,000 m of channel. Where less than 1000 m is within 200 m of the wetland, seepage rates have been reduced proportionally
Seepage rates are site specific, depending on local conditions. Therefore, a range of seepage volumes for each wetland was determined using the minimum and maximum seepage rates specified in the WCMF 19 March 2010
Channel lengths, channel widths and channel distance from wetlands were measured using Google maps

Appendix I: Additional risks and limiting factors

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

Risks/limiting factors	Impacts	Mitigation measures
Delivery of Water		
Loss of Murray Hardyhead from Round Lake	Loss of high environmental values and inability to achieve objectives and goal Potential change to management regime	Review recommendations in light of emerging information on the requirements and status of the Murray Hardyhead in Round Lake. Consider Round Lake as a potential translocation site if suitable conditions exist.
Inappropriate desired water regime	Loss of high environmental values and inability to achieve objectives and goal	Regular monitoring before, during and after watering events e.g. IWC or vegetation composition, water quality and groundwater Adaptively manage watering regime and delivery. Re-model volumes required in light of changing climatic conditions and wetland phase.
Uncontrolled removal of drop boards at outfall structure	Inappropriate water delivery compromising high environmental values	Upgrade current infrastructure to allow improved operational management at Round Lake (Section 7.2)
Ineffective delivery (e.g. salinity spike requires water to be delivered at a greater capacity)	Loss of high environmental values and inability to achieve objectives and goal	Upgrade current infrastructure to allow improved operational management and capacity at Round Lake (Section 7.2)
Inefficient operational management resulting in a lack of connectivity between Golf Course, Round and Long Lakes	Lack of connectivity in wet years Inefficient drainage from surrounding land	Upgrade current infrastructure to allow improved operational management between Golf Course, Round and Long Lakes (Section 7.2)
Limited water availability (i.e. no environmental water allocation to provide the desired water regime)	Failure to achieve identified objectives and overall water management goal	Ensure sufficient information is collected for prioritisation in environmental allocation processes. Regularly review rainfall and climate data to utilise natural inflows where possible. Re-model volumes required in light of changing climatic conditions and wetland phase.
Climatic variability	Variability in water availability (e.g. wet seasons during a planned dry phase)	Adaptive management of watering regime and delivery options. Re-model volumes required in light of changing climatic conditions and wetland phase.
Poor water quality (i.e. temperature fluctuations, high turbidity, salinity spikes)	Loss of Murray Hardyhead from Round Lake Reduced primary production (turbid water), limiting resources for aquatic invertebrates, fish and waterbirds. Excessive algal growth	Monitoring of groundwater levels, salinity and nutrient inputs in conjunction with a regular water quality monitoring program. Adaptively manage watering regime and delivery in line with species requirements. Re-model volumes required in light of changing climatic conditions and surface water levels.

Risks/limiting factors	Impacts	Mitigation measures
Ecological Response		
Inappropriate delivery of desired water regime	No successful breeding events	Seasonal water delivery, regular monitoring (i.e. Murray Hardyhead Recovery team) and adaptive management of watering regime. Review recommendations in light of emerging information on the requirements and status of the Murray Hardyhead in Round Lake.

Appendix J: Monitoring program recommendations

It is not a requirement of GMW Connections Project to provide long-term condition or intervention monitoring nor does this document represent a comprehensive management plan for Round Lake. However, recommendations have been made below for variables to be monitored in order to assess the response to the provision of the desired water regime and inform its adaptive management.

In accordance with the National Recovery Plan for the Murray Hardyhead it is recommended that a water quality, habitat and population monitoring plan is prepared for Round Lake (Backhouse *et al.* 2008a). This would provide critical information for the adaptive management of the EWP and must incorporate current monitoring practices conducted by the Murray Hardyhead Recovery Team.

1. Long Term condition monitoring

Long term condition monitoring is recommended in order to evaluate any changes to wetland values (particularly vegetation) over time. It should be noted that condition monitoring is recommended to be conducted in conjunction with intervention monitoring to comprehensively evaluate any changes to Round Lake.

Vegetation Condition and Distribution

It is recommended that the condition and distribution of vegetation communities, including exotic species, at Round Lake are assessed regularly in accordance with the statewide Index of Wetland Condition (IWC) method. The IWC not only provides useful information on the condition and distribution of vegetation but also highlights indicators of altered processes (threatening processes). As Saline Aquatic Meadow vegetation (EVC 842), particularly Large-fruit Tassel and Charophytes, provides important habitat for Murray Hardyhead it is recommended that vegetation is assessed at least annually however this should be adaptively managed.

In addition, information on vegetation communities gathered on aerial photography during this project has been digitised and is available in a GIS format to enable comparison in distribution over time (distribution mapping) (Baldwin et al. 2005).

Groundwater Monitoring

Long term monitoring of groundwater within the Tresco Lakes area including within the immediate vicinity of Round Lake is currently conducted by DEDJTR and local volunteers. It is recommended that this monitoring continue in order to identify potential risks associated with the delivery of the desired water regime and for consideration in adaptive management. In particular, given the groundwater connectivity amongst the Tresco Lakes monitoring the response to changed conditions such as the inundation of Lake Boga is critical.

It is recommended that the monitoring plan recommended above includes a groundwater monitoring component setting out the monitoring objectives, the linkages with other monitoring programs, the monitoring approach, and the reporting and review process.

Macumber (2009) provided the following proposal of a drilling program to provide additional information on the groundwater interactions and flow between the various Tresco Lakes and Lake Boga.

A further 6 piezometer nests are recommended to be added to the existing monitoring bores in the vicinity of the Tresco Lakes and Lake Boga (Figure J1). The existing network of three sites to cover the Tresco Lakes is inadequate and does not cover lake losses passing to the west of Round Lake whenever Lake Boga is full.

- To the east of Round Lake, nests 5 and 6 cover the groundwater flow from Lake Boga.

- A shallower bore is required spanning the sand interval from 6 to 8 m at Bore 73487.Two nests, (3 and 4) will monitor the relationship between Golf Course Lake and Round Lake. The piezometer nests at each site will have a shallow and deeper bore spanning intervals of 7-10 m and 27-30 m.

- Two additional nests screened (sites 1 and 2) at similar intervals will be established to the west of Round Lake in order to monitor westerly groundwater flow at times when Lake Boga is full, thereby forcing a strong westerly groundwater flow towards Round and Long Lakes and into the Mallee.

Figure J1: Existing and proposed groundwater monitoring bores in the vicinity of the Tresco Lakes and Lake Boga (Source: Macumber 2009)

2. Intervention Monitoring

Monitoring the response of key environmental values to the provision of water is imperative in informing adaptive management of the desired water regime. Monitoring will also assess the success of implementation, the achievement of ecological objectives and the progress towards achieving the water management goal outlined in Section 5.

It is essential that analysis of monitoring results is regularly undertaken in order to develop an understanding of changes occurring at the lake.

Vegetation

A number of photo points and objectives for long term vegetation monitoring need to be established for Round Lake to enable the assessment of changes in wetland condition over time. It is recommended that photos are taken from these points, facing the same direction, regularly (annually, if not more regularly) to capture vegetation condition and distribution. It is recommended that a database be compiled in order to store details of the monitoring photos captured. In order to determine if any significant change has occurred in the amount of aquatic habitat within the lake, a number of photos were taken by the Murray Hardyhead Recovery Team and visual comparisons made with historical photos of the system. These photos should be referred to in future monitoring at Round Lake.

It is important that the response of vegetation is monitored. A number of previous surveys and records are available to provide baseline data in order to evaluate any response (such as Charophytes being impacted by the turbidity of water delivered). Snapshot assessments following water delivery should incorporate the components outlined in Table J1. A database of any previous flora records has been compiled for Round Lake and should be updated following regular monitoring.

Table J1: Components of vegetation intervention monitoring

Component	Target	Method	Objective
Vegetation distribution	Saline Aquatic Meadow	• Distribution mapping	Habitat objective, species/community objectives
Vegetation condition		• IWC, quadrates	Habitat objective, species/community objectives
Species diversity	Additional species with a focus on submerged aquatic macrophyte habitat	• Species list comparison	Habitat objective, species/community objectives

Fish

It is recommended that the monitoring currently conducted by the Murray Hardyhead Recovery Team informs the adaptive management of the water regime.

In response to the DSE's emergency watering plan to try to prevent the extinction of Murray Hardyhead in Victoria (DSE 2007, cited in Stoessel 2009) monitoring of Round Lake has been conducted biannually since November 2007 (Stoessel 2007, 2008a, 2008b, 2009).

Surveys are conducted in autumn and spring (Table J3) to investigate the success of spawning and subsequent recruitment.

Table J2: Components of intervention monitoring of fish

Date surveyed	Method			Source:
	Bait traps	Double winged fyke nets	Small seine nets (7 m x 1 m x 0.5 mm)	
18-19th May 2009	n/a	4	2	Stoessel (2009)
20-21st November 2007	10	4	5	Stoessel (2007)
24-25th November 2008	n/a	4	5	Stoessel (2008b)
April 2008	10	4	5	Stoessel (2008a)

Bait traps and fyke nets are set overnight in a range of representative habitats for a minimum of 12 hrs. Where the small seine was deployed it was carried approximately 15m towards the centre of the lake, then strung out between two operators and hauled back to the shore.

Water Quality

It is currently unknown whether a detailed water quality monitoring program has been developed as recommended in the National Recovery Plan for the Murray Hardyhead, *Craterocephalus fluviatilis* (Backhouse *et al.* 2008a). However it is understood that a recent review of water quality has been undertaken by ARI. A water quality monitoring program would assess water quality in conjunction with water level fluctuations and is essential for the adaptive management of the desired water regime. Table J4 identifies elements to be considered as part of the water quality monitoring program.

Table J3: Components of intervention monitoring for water quality

Component	Target	Method		Objective
Water quality	Electrical conductivity	Conductivity metre	Water quality meter	Habitat objectives, 2.1, 2.2
	pH	pH meter		
	Turbidity	Turbidity meter		
	Dissolved oxygen	Oxygen meter		
	Nutrients	Laboratory analysis		

Appendix K: Contour and vegetation map

Round Lake
Contours and Vegetation

Legend

Contours

Round Lake Contours (0.5m)
- Round Lake Contours (0.5m)
- Round Lake Contours (0.1m)

Watercourse

Type
- River
- Stream
- Channel
- Connector

Roads
- Freeway
- Highway
- Major Road
- Arterial Road
- Road
- Residential Street
- Track
- Parcel

Vegetation - MDFRC 2009

Weeds
- Pampas Grass
- Willow
- Tamarisk
- Willow
- Sharp Rush and Halosarcia
- Annual grass and Thistle

Native Vegetation
- Ruppia and Charophytes
- Mixed Woodland
- Common Reed (part of Tall Marsh EVC 821)
- Blackseed Glasswort, salt bush and grasses (EVC 101)

Infrastructure
- Channel outfall
- Outlet and Offtake points

Meters
160 80 0 160

1:5,000

N W E S

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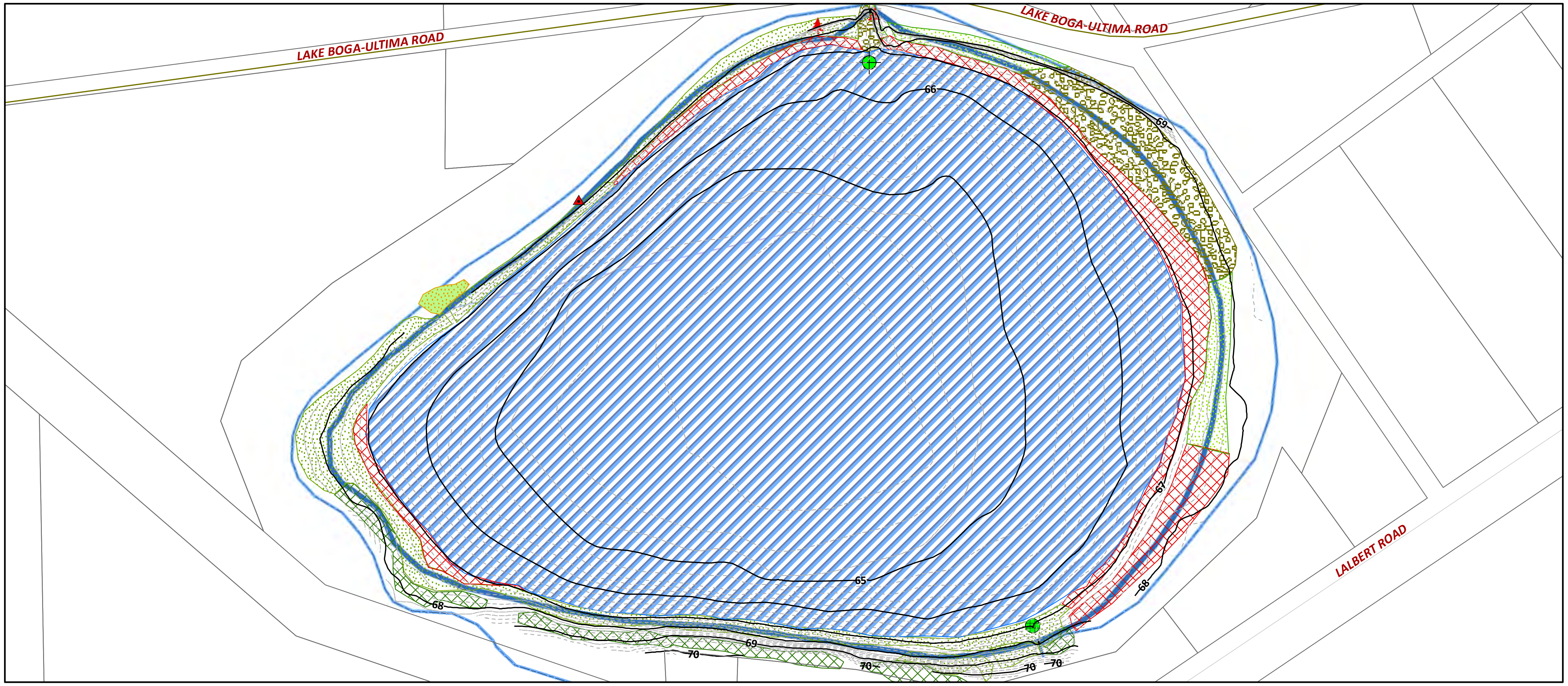

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