LITTLE LAKE BOORT

ENVIRONMENTAL WATERING PLAN

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

PREPARED FOR THE
GOULBURN-MURRAY WATER CONNECTIONS PROJECT

GOULBURN-MURRAY
WATER

Version 11, July 2015

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Front cover photo: Little Lake Boort 2009, North Central CMA

The Little Lake Boort 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 CAMBPELL

Date: 24/10/2015

GMW representative signature:

Print name: Ross Plunkett

Date: 22.12.2015

EXECUTIVE SUMMARY

The Little Lake Boort 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 Little Lake Boort will be achieved for the GMW Connections Project. The main conclusions are summarised below.

Defining the environmental values of Little Lake Boort
Little Lake Boort is a bioregionally important wetland occupying 72 ha of the 595 ha Lake Boort Lake Reserve. It is a highly valued wetland providing drought refuge and habitat for a range of waterbirds, fish, reptiles and amphibians. It is also important to the township of Boort for social and economic values.

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

Little Lake Boort water management goal:
Maintain Little Lake Boort as a deep freshwater marsh, experiencing an infrequent dry phase, characterised by open water, associated mudflats and fringing aquatic vegetation, providing habitat for waterbirds, reptiles, amphibians and fish.

Defining the water required to protect the environmental values
A number of ecological objectives are 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:
Fill Little Lake Boort to full supply level (91.5 m AHD) and maintain inundation for four in six years. Allow water level to fluctuate by evaporation or as a result of operational management. Allow the lake to be completely dry for at least 12 months (excluding draw down).

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

The total volume required to fill and maintain levels in the wetland over approximately four years is 3,878 ML. The maximum volume ever likely to be required over any 12 month period (95^{th} percentile mean annual volume) is 1,778 ML.

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 Little Lake Boort demonstrates that the **outfall water provides benefit to the wetland and that the provision of mitigation water is warranted if it is managed for environmental purposes**. In particular, the outfall water received by the wetland contributes to providing open water habitat for a variety of flora and fauna species. If the volume of outfall water was to be reduced or removed, additional water would need to be secured to maintain the wetland's environmental values either by filling following a dry phase or in maintaining inundation.

The incidental water at the origin was 144 ML in the baseline year and the annualised baseline mitigation water volume was calculated as 96 ML. The Mitigation Water Commitment

for Little Lake Boort is 67%. This will be used to calculate the interim mitigation water share of any annually calculated water savings.

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. If the management of Little Lake Boort for recreational purposes in accordance with the VEAC recommendations does not allow for the maintenance of environmental values, then the need for mitigation water may not be justified and should be reviewed as part of the review process.

Infrastructure requirements

Little Lake Boort is currently maintained as a permanent open freshwater wetland, with top-ups generally provided via the irrigation system at a rate of 20 ML/day. The capacity of the existing infrastructure is limited to 80 ML/day at the automated regulator which, if operating at full capacity, would allow the wetland to be filled in approximately 12 days (assuming no losses and adequate capacity is available in the no. 3 channel). The current delivery infrastructure is considered adequate to deliver the desired water regime and no infrastructure upgrades are required 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 Little Lake Boort 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 decision-making process required to coordinate the implementation of the desired water regime for Little Lake Boort.

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ACKNOWLEDGEMENTS

The information contained in the Little Lake Boort Environmental Watering Plan (EWP) has been sourced from a variety of reports and field inspections and from individual knowledge and expertise.

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

- Rob O'Brien (Department of Primary Industries)
- Cherie Campbell, Caitlin Johns, Christine Reid, and Dr Todd Wallace (Murray-Darling Freshwater Research Centre)
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- Mark Tscharke (Parks Victoria)
- Ross Stanton and Lawrence Cameron (Goulburn-Murray Water)
- 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)
- Little Lake Boort Committee of Management
- Graham Hall, Bridie Velik-Lord, Rebecca Horsburgh, Peter McRostie, Lyndall Rowley (North Central CMA).

The EWP was updated in April 2015 (Version 11), in consultation 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
CoM	Committee of Management
CMA	Catchment Management Authority
CP	Connections Project
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
ETAC	Environmental Technical Advisory Committee
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
SWET	Savings at Wetlands from Evapotranspiration daily Time-Series
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 Cap-equivalent (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 from GMW Connections Project 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 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*, 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 Framework…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 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 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, for which EWPs needed 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
- identify if there is a need to provide mitigation water and, if so, determine the quantification of mitigation water
- identify the infrastructure requirements
- identify potential 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).

1.5. Development process

The Little Lake Boort EWP was initially developed in collaboration with key stakeholders including Goulburn–Murray Water (GMW), NVIRP, 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 [DEDJTR]) 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.

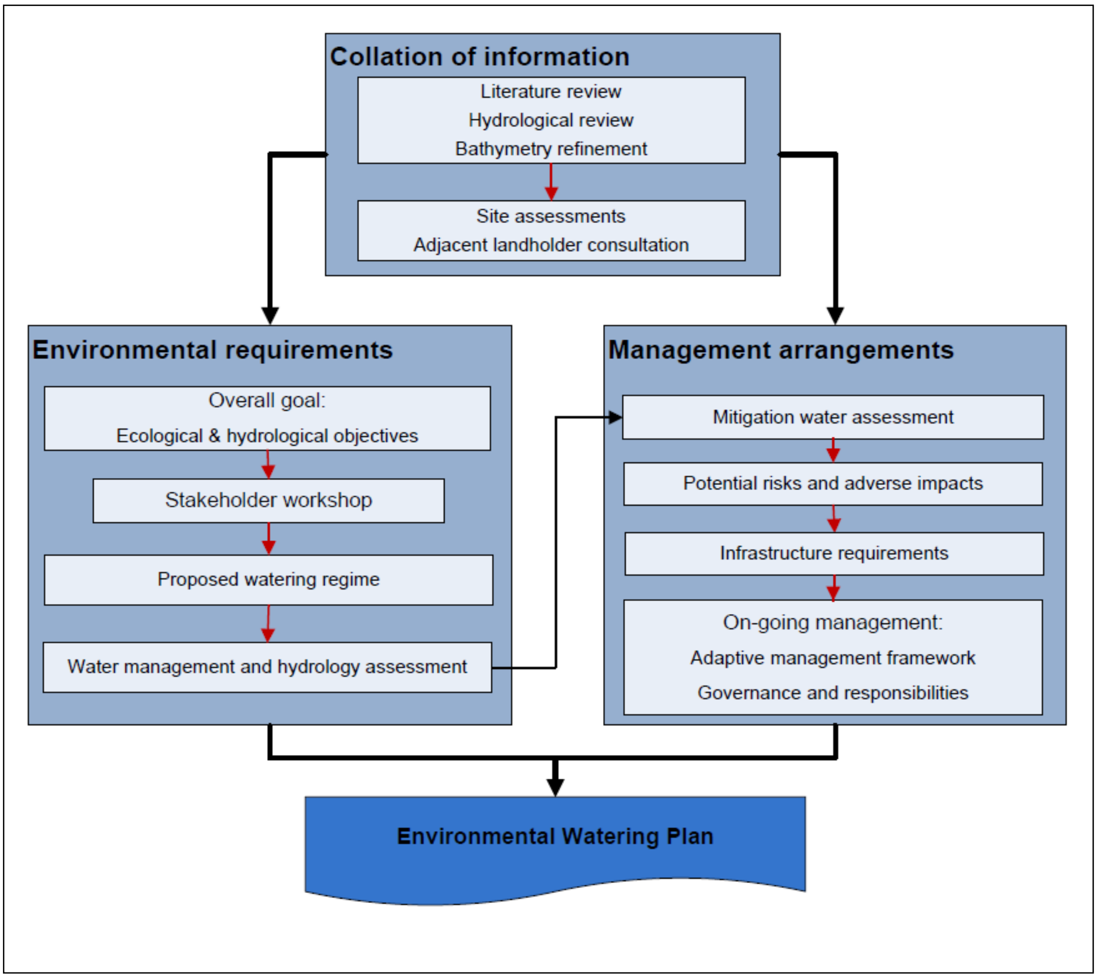


Figure 1: EWP development process

1.5.1. Consultation and engagement

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

The TAC was convened by NVIRP to oversee the development of the EWPs to ensure quality, completeness and practicality. The committee includes representation from CMAs, GMW, 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 GMW Connections Project Environmental Technical Advisory Committee (ETAC) now includes representation from CMAs, GMW, DEWLP, 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 water requirements for Little Lake Boort.

Consultation was also undertaken with the Little Lake Boort Committee of Management (CoM) (2 March 2010) who have had a long association with the wetland and proven interest in maintaining its environmental value. A summary of the information sourced from this process is provided in Appendix B.

1.5.2. The 2015 Review

This review has been completed in consultation with the CMAs, GMW, DEWLP 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 ETAC, comprising departmental representatives (see Appendix A for membership). Outcomes from the ecological objectives review were used in the 2015 review of this EWP. This version of the EWP (Version 11) has been 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 addressed 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. Little Lake Boort

Little Lake Boort is a 72 ha open freshwater wetland situated in the township of Boort (Archards Irrigation 2010) (Figure 2). It is a wetland of bioregional importance (NLWRA, cited in NCCMA 2005) providing drought refuge for waterbirds, fish, reptiles and amphibians. It is also highly valued for its social and economic values.

Little Lake Boort is relatively shallow with a flat floor at an elevation of around 90.0 m AHD. It has no lunette and is situated at a higher elevation than the bed of adjacent Lake Boort (Bartley Consulting 2010). It forms part of the Lake Boort Lake Reserve, which occupies 595 ha, and is currently managed by a CoM which is a sub-committee of the Loddon Shire (DSE 2009a). At full supply level (FSL), 91.5 m AHD, Little Lake Boort has a storage capacity of 935 ML and a maximum depth of 1.7 m (Archards Irrigation 2010).

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

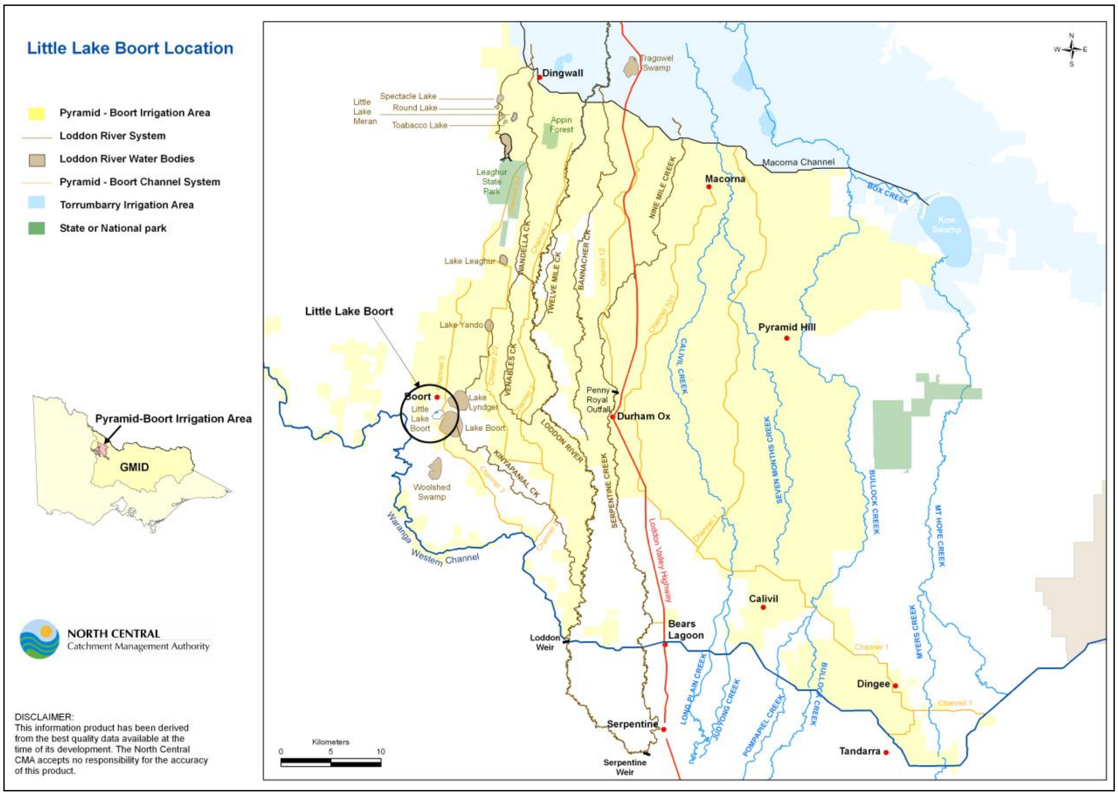


Figure 2: Location of Little Lake Boort

2.1. Wetland context and current condition

DSE's interactive mapping tool suggests that Little Lake Boort was a permanent open freshwater lake prior to European settlement (DSE 2009b). However, locals have advised that Lake Boort and Little Lake Boort were originally a single, intermittent[1] wetland that was naturally inundated by Kinypanial Creek floodwaters (Appendix B). Little Lake Boort is the slightly elevated section of the larger wetland. Anecdotal evidence indicates that the wetland was dominated by River Red Gum (*Eucalyptus camaldulensis*) trees which were cleared from its base in 1962 with Black Box (*Eucalyptus largiflorens*) on slightly higher elevations (Appendix B).

The establishment of the Pyramid-Boort Irrigation System in the 1920s/1930s, particularly construction of the no. 3 channel and road that now separates Lake Boort and Little Lake Boort (Figure 3), has resulted in significant changes to the hydrology of the wetland. It is disconnected from the floodplain and relies solely on water supplied via the irrigation system. Little Lake Boort has been maintained as a permanent open freshwater lake, only drying out

[1] 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).

in 1962, 1982 and 2002/03. A range of water sources discussed in Section 4.2 have been used to maintain inundation.

Little Lake Boort provides habitat for waterbirds, reptiles and amphibians. An assessment undertaken in October 2009 (Campbell *et al*. 2009) reported the following main components:

- The fringing vegetation is predominantly urban parkland with a small area of River Chenopod Woodland (EVC 103) to the southeast. Black Box trees in this area are in moderate to good health. (Plate 1)
- A narrow bank of Fennel Pondweed (*Potamogeton pectinatus*) and Charophytes exists at the waterline and extends approximately 5 m into the wetland
- Fringing emergent reed beds such as Cumbungi (*Typha* sp.), Common Reed (*Phragmites australis*) and River Club-sedge (*Schoenoplectus tabernaemontani*) exist in sections of the wetland (Plate 2)
- The fringing riparian vegetation is highly modified and in most areas dominated by exotic species, a number of which are of moderate to high threat including Spear Thistle (*Cirsium vulgare*) and Ox-tongue (*Helminthotheca echioides*).

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

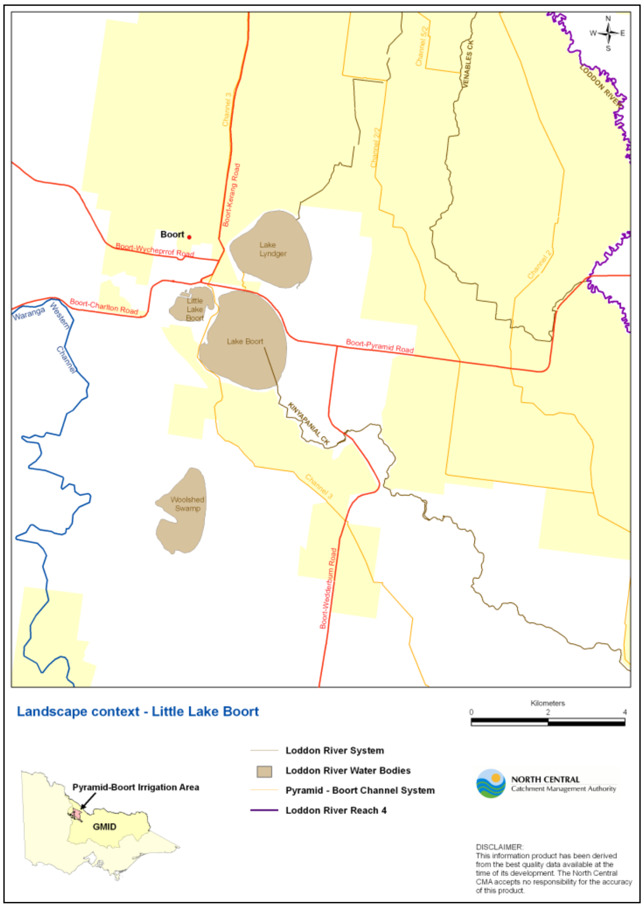


Figure 3: Little Lake Boort landscape map

Plate 1 Urban parkland and Riverine Chenopod Woodland vegetation (Source: MDFRC 2009)

Plate 2: Fringing aquatic reed beds (Source: MDFRC 2009)

2.2. Catchment setting

Little Lake Boort is located within the Wandella Creek sub-catchment of the Loddon River basin. It lies within the Victorian Riverina bioregion. Little Lake Boort has virtually no local catchment area, relying solely on water delivered via the irrigation system (pers. comm. Barry Kennedy [CoM], 15 February 2010).

Little Lake Boort is situated within the township of Boort. As such, surrounding land use consists of residential and recreational facilities including the caravan park, tennis club, bowling club, and swimming pool. The town water supply (Coliban Water Storage facility) exists on the north-western margin of the wetland (Appendix C).

Rainfall in the Boort region averages 394 mm/year, with May to October being significantly wetter months than November to April (Bureau of Meteorology 2009). Maximum average temperatures range from 31.3°C in January to 13.9°C in July, with mean minimum temperatures falling below 5°C between June and August (Bureau of Meteorology 2009).

Little Lake Boort is connected to the Pyramid–Boort Irrigation System and receives outfalls from channel no. 3 in conjunction with additional sources of water (Figure 4). Channel no. 3 and a nearby siphon have a capacity of 100 ML/day while the regulator has a reported capacity of 80 ML/day (Hillemacher and Ivezich 2008). Little Lake Boort also functions as a temporary off-stream storage.

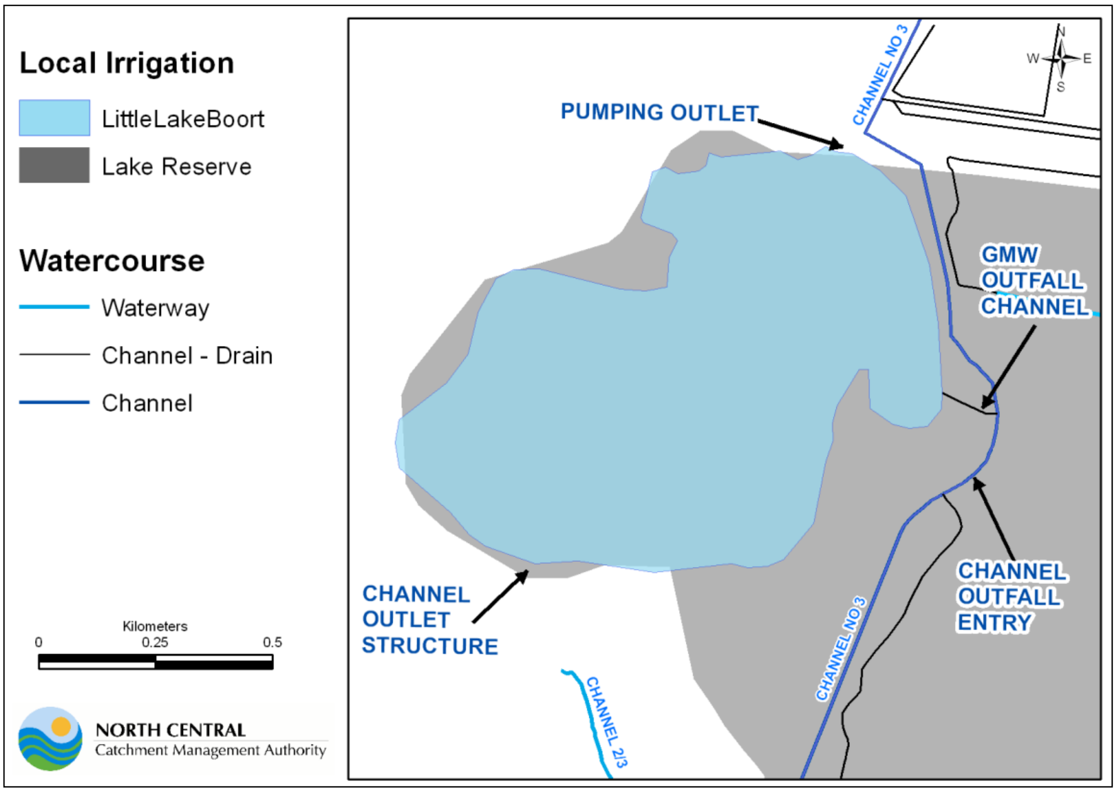


Figure 4: Inflow points at Little Lake Boort

2.3. Land status and management

Little Lake Boort currently forms part of the Lake Boort Lake Reserve, which occupies 595 ha (DSE 2009a). It is classified as a Lake Reserve and is managed by a CoM which is a sub-committee of the Loddon Shire (DSE 2009a). This designation requires that the wetland is managed for recreation, nature conservation, scientific study, water supply and drainage. Additional uses are permitted where appropriate and 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. Little Lake Boort was classified as a recreation area under the *Crown Land (Reserves) Act 1978*. A series of VEAC recommendations relating to the establishment of National Parks took effect on 29 June 2010. Recreation areas are managed for recreation, parks and gardens, with facilities provided for community purposes and education. In addition, features of cultural significance, natural surroundings and the local character and quality of the landscape will be maintained or restored where relevant and compatible with the primary purpose (VEAC 2008; DSE 2009c).

2.4. Cultural heritage

Cultural heritage values are abundant on productive wetlands throughout the district, including Lake Boort and Little Lake Boort, which were originally one large wetland. At the time of writing, 34 sites of Aboriginal archaeological significance have been recorded and registered with Aboriginal Affairs Victoria (AAV). This includes 27 scar trees, three mounds, three artefact scatters, and one burial site.

2.5. Recreation

Little Lake Boort is situated within the township of Boort and is surrounded by residential development and several recreational facilities. It is highly valued as it supports a range of activities (water skiing, walking path, bird watching, etc). In particular, it is extremely important to the township of Boort, attracting up to $1 million per year from tourism (pers. comm. Barry Kennedy [CoM] 2 March 2010). Little Lake Boort directly supports:

- Water skiing
- Bird watching
- Fishing
- Passive recreation (walking, picnicking)

In addition, a number of recreational facilities are situated on the margin of, and benefit from, Little Lake Boort including:

- Bowling Club
- Swimming Club
- Tennis Club
- Caravan Park.

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).

Little Lake Boort 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, Little Lake Boort is required to be protected and conserved in accordance with these international agreements (DEWHA 2009).

2.6.2. Federal legislation

The *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* is the key piece of legislation pertaining to biodiversity conservation within Australia. It aims to control potential impacts on matters of national environmental significance (MNES)[2].

Little Lake Boort is known to support protected migratory waterbirds. In addition, records also indicate that additional species listed under the Act have been observed at Little Lake Boort (Table 1). Actions that may significantly impact 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 *Flora and Fauna Guarantee (FFG) Act 1988* aims to protect a number of identified threatened species and communities within Victoria. Little Lake Boort is known to support a number of species listed under the *FFG Act* (Table 1). Disturbance or collection of any of these threatened species will require a permit from the DELWP.

[2] There are seven Matters of NES 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).

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 to 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 a 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).

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

3. Little Lake Boort environmental values

The primary purpose of this EWP is to assess and advise on mitigating potential impacts on high environmental values supported by Little Lake Boort. While it is recognised that the wetland 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 wetland 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 wetland in the sections below, an emphasis is placed on identifying listed flora and fauna species, and vegetation communities followed by the broader ecological and landscape values. All listed values have been presented in this section with full species lists provided in Appendix E.

3.1. Fauna

Anecdotal evidence suggests that consistently high numbers of waterbirds have been recorded at the lake even in times experiencing high levels of recreational use (Appendix B). In particular, ducks, swans, and pelicans regularly occur at Little Lake Boort returning to the lake to roost and feed at night (Appendix B). Over 80 bird species have been recorded at Little Lake Boort over time. Records indicate that 16 species observed are protected by either international agreements (CAMBA/JAMBA/Bonn/ROKAMBA), national (*EPBC Act*) or state (*FFG Act*) legislation (Table 1 and Appendix E).

In addition, Little Lake Boort is known to have supported fish and amphibian species including a number protected by national and state legislation such as Freshwater Catfish (*Tandanus tandanus*) and Growling Grass Frog (*Litoria raniformis*). Anecdotal evidence also indicates that it used to support large numbers of Water Rat (*Hydromys chrysogaster*) and Long-necked Turtle (*Chelodina longicollis*). Goannas (*Varanus* sp.), Carpet Pythons (*Morelia* sp.) and Wallabies have been observed in adjoining Black Box vegetation to the southeast of the Little Lake Boort. Refer to Appendix B.

Table 1: Significant species recorded at Little Lake Boort

Common Name	Scientific Name	International treaty	EPBC status	FFG status	DELWP status
Birds					
Australasian Shoveler	*Anas rhynchotis*				VU
Baillon's Crake	*Porzana pusilla*			L	VU
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*				NT
Caspian Tern	*Hydroprogne caspia*	C/J		L	NT
Clamorous Reed Warbler	*Acrocephalus stentoreus*	B			
Eastern Great Egret	*Ardea modesta*	C/J		L	VU
Freckled Duck	*Stictonetta naevosa*			L	EN
Grey-crowned Babbler	*Pomatostomus temporalis*			L	EN
Hardhead	*Aythya australis*				VU
Intermediate Egret	*Ardea intermedia*			L	CR
Latham's Snipe	*Gallinago hardwickii*	B/C/J/R			NT
Musk Duck	*Biziura lobata*				VU
Nankeen Night Heron	*Nycticorax caledonicus*				NT
Pacific Swift	*Apus pacificus*	C/J/R			
Pied Cormorant	*Phalacrocorax varius*				NT
Rainbow Bee-eater	*Merops ornatus*	J			
Swift Parrot	*Lathamus discolour*		EN	L	EN
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	C		L	VU
Whiskered Tern	*Chlidonias hybridus*				NT
Amphibians					
Growling Grass Frog	*Litoria raniformis*		VU	L	EN
Fish					
Freshwater Catfish	*Tandanus tandanus*			L	EN
Golden Perch	*Macquaria ambigua*				VU

Common Name	Scientific Name	International treaty	EPBC status	FFG status	DELWP status
Conservation Status: • J/C/R/B: JAMBA/CAMBA/ROKAMBA/Bonn International agreements listed in section 2.4.1 • EPBC listing: EN – Endangered, VU – Vulnerable • FFG listing: L – Listed as threatened (DEPI 2013) • DELWP listing: CR – Critically endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened, DD – Data deficient (DEPI 2013)					

3.2. Flora

Pre-1750 DSE ecological vegetation class (EVC) mapping describes vegetation within Little Lake Boort prior to European settlement as Red Gum Swamp (EVC 292) surrounded by Wetland Formation vegetation (EVC 74). The characteristic species of wetland formation have not been described and requires on-site inspection to determine its components which may consist of wetland, herbland, sedgeland or other wetland-associated EVCs (DSE 2009a). Recent DSE EVC mapping suggests that Little Lake Boort is still characterised by the above EVCs; however the extent of surrounding vegetation has diminished (DSE 2009a).

DSE's 2005 EVC mapping is 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 2007).

However, assessments undertaken by the Murray-Darling Freshwater Research Centre (Campbell *et al.* 2009) on 22 October 2009 identified that the wetland is currently more accurately described as an open water wetland with a fringe of species poor Aquatic Herbland vegetation (EVC 653) with small patches of Tall Marsh vegetation (EVC 821). A fringe of modified Riverine Chenopod Woodland (EVC 103) also exists to the southeast (Campbell *et al.* 2009). The results of the assessment show a marked difference to the mapped 2005 EVCs. Because this mapping was based on up to date and field verified information, the EVCs reported by MDFRC are included within the EWP as opposed to the mapped 2005 EVCs.

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

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

EVC No.	EVC Name	Bioregional Conservation Status
653	Aquatic Herbland	Vulnerable
103	Riverine Chenopod Woodland	Vulnerable
821	Tall Marsh	Depleted

According to the state-wide Flora Information System (FIS) database and other relevant reports, a single flora species of conservation significance, Pale Spike-sedge (*Eleocharis pallens*), has been recorded at Little Lake Boort. This species was recorded by MDFRC on 22 October 2009. VEAC (2008) identified this species as a rare and threatened flood-dependent flora species. The status of Pale Spike-sedge is 'poorly known' according to the advisory list (DSE 2005a). No flora species listed under the federal *EPBC Act* or the *FFG Act* are known to have been recorded within Little Lake Boort.

3.3. Representativeness and distinctiveness

Little Lake Boort is currently classified as a deep freshwater marsh characterised by open water (DSE 2009d). Deep freshwater marshes are often drained to facilitate agricultural activities including grazing or cropping, and have subsequently decreased in extent across the landscape. The area of deep freshwater marshes across Victoria is estimated to have decreased by approximately 70% since European settlement (DNRE 1997). Table 3 illustrates the area of deep freshwater marshes across various defined landscapes and the proportion of which is occupied by Little Lake Boort. Little Lake Boort is an example of the most depleted wetland category within Victoria.

Table 3: Current area of deep freshwater marsh wetlands across the landscape

	North Central region	GMID	Victorian Riverina
Deep freshwater marshes (ha)	4880	7297	6364
Little Lake Boort	<2%	<1%	1%

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

Little Lake Boort is situated within the Wandella Creek sub-catchment in the Loddon River basin. The Loddon River floodplain and its wetlands experienced highly variable rainfall and flooding conditions. Little Lake Boort was originally characterised by Red Gum Swamp (EVC 292) vegetation (Appendix B).

It would have been filled and flushed from intermittent Loddon River floods in winter and spring with flows provided via Kinypanial Creek floodwaters. During wet periods the Kinypanial Creek would also receive water from the Borung Hills to the south. In more significant floods the overflow from Woolshed Swamp also reached Lake Boort (Appendix B).

4.2. History of water management

In the 1920s, Little Lake Boort was annexed from Lake Boort as a result of the establishment of the Pyramid-Boort irrigation area, particularly the no. 3 channel (and an associated road) which now separates the two wetlands. Little Lake Boort is now disconnected from the floodplain and has virtually no local catchment area. It relies solely on water delivered via the irrigation system (Appendix B).

Locals have advised that Little Lake Boort was cleared of the River Red Gums that once dominated its base, an indication of its previously intermittent nature, in 1962 (pers. comm. Barry Kennedy [CoM] 2 March 2010).

Following development of the irrigation system, Little Lake Boort has been maintained as a permanent lake, receiving significant volumes of water via the no. 3 channel. It is only known to have dried out in 1962, 1982 and 2002 (Appendix B). Water levels were very low in 2003, 2007 and 2009. Refer to Table 4 and Figure 5.

Since the development of the EWP, Little Lake Boort has been wet in every year and no drying phase has occurred at the Lake (GMW 2015). Environmental water deliveries were made to Little Lake Boort in 2010/11 and 2012/13.

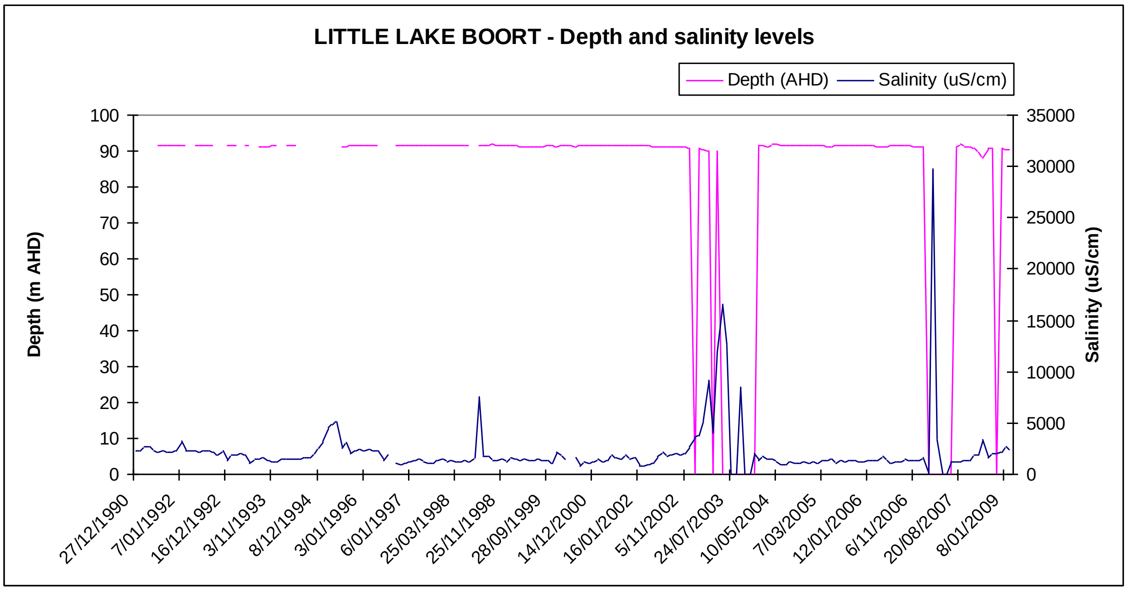
Table 4: Little Lake Boort wetting/drying calendar (Source: NCCMA 2008, pers. comm. Ed Thomas [GMW] September 2014)

93/94	94/95	95/96	96/97	97/98	98/99	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/d	d/w	w	w	w	w	w	w

09/10	10/11	11/12	12/13	13/14
w	w	w	w	w

A flushing channel was constructed between Little Lake Boort and Lake Boort in 1995 (DNRE 2002a). The purpose of this channel was to flush flows from Little Lake Boort to Lake Boort while also allowing inflows from no. 3 Channel. The aim was to improve water quality by maintaining low salinity levels within Little Lake Boort and is only used when Lake Boort is inundated or during a flood event (Appendix B).

A flushing pump was also installed in 2003 near the caravan park to allow water to be lifted from Little Lake Boort and returned to the irrigation supply system. This pump is used to return parked and borrowed water (defined below) to the channel system for consumptive uses and allows the water levels and quality to be maintained in the channel system (Appendix B).



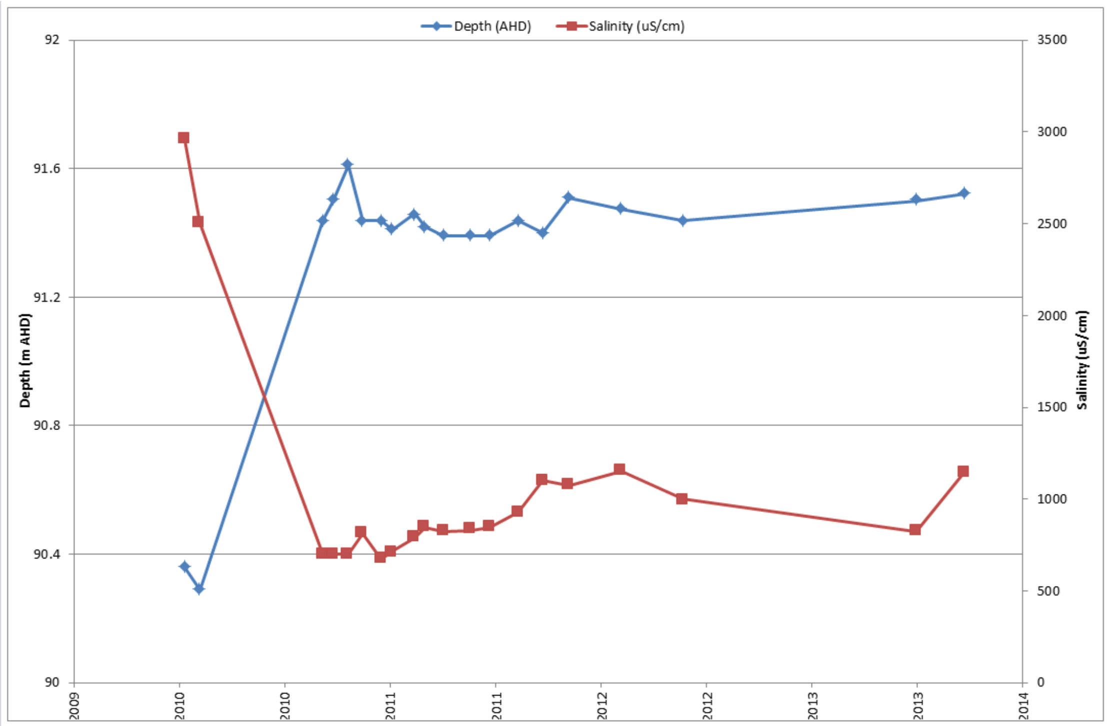


Figure 5: Depth and salinity levels as recorded by DPI between 1990 and 2014. *Note: Little Lake Boort did not dry out in 2006, 2007 or 2008; however levels were very low.*

Little Lake Boort has been maintained as a permanent lake with water supplied via a number of sources:

- Operational outfalls (160 ML 1997/98 to 2007/08 average);
- Water right owned by the Loddon Shire (290 ML/year);
- Borrowed water from GMW (up to 300 ML/year);
- Channel drainage water (up to 100 ML/year);
- Parked water from GMW (up to 200 ML/year); and
- Purchasing additional water on the GMW temporary trade market (delivered)
- Opportunities exist to harvest Loddon River floodwater (approximately 170 ML/day) via the no. 3 channel. Refer to GHD (2006) and Appendix B.

Limited information is available on the additional water sources above; however a brief discussion on those for which information is available is provided below.

Water right (delivered): equates to 290 ML and is owned by the Loddon Shire. The water right is subject to allocation which can be accessed any time during the irrigation season. The CoM contacts GMW and can have water delivered within a matter of days with an annual cost per ML (pers. comm. Barry Kennedy [CoM] 31 March 2010). Water delivered to the lake should not exceed 700 EC (DNRE 2002a).

Borrowed/loaned water: water is delivered to Little Lake Boort in December and returned in full to the irrigation system using the pump in March. In 2002 the Little Lake Boort Flushing Strategy (DNRE 2002a) stated that borrowed water generally did not exceed 100 ML/year; however it appears as though borrowed water could be as much as 300 ML/year (pers. comm. Barry Kennedy [CoM] 2 March 2010). Refer to Figure 6.

Channel drainage water: end-of season drainage water from GMW channels delivered to Little Lake Boort in mid to late May. This generally does not exceed 100 ML/year (DNRE 2002a; Figure 6). Drainage water delivered to the lake should not exceed 700 EC (DNRE 2002a).

Parked water: excess water that cannot be harvested after rain events and is re-directed to Little Lake Boort for temporary storage. Up to 100 ML is considered parked water, any water beyond this volume is converted to outfall water and is not returned to the GMW irrigation system (pers. comm. Barry Kennedy [CoM] 1 April 2010). Between 80% and 100% of the water parked in Little Lake Boort is returned to the GMW irrigation system using the pump, depending on storage duration (DNRE 2002a).

Since the late 1990s, channel outfalls have reduced dramatically and there was a requirement to utilise environmental water to maintain water levels in order to provide drought refuge, particularly for waterbirds. In 2009/10, 300 ML was delivered to Little Lake Boort having been secured from Loddon Wetland Entitlement and the associated Loddon System Withheld Flows Account (Figure 6).

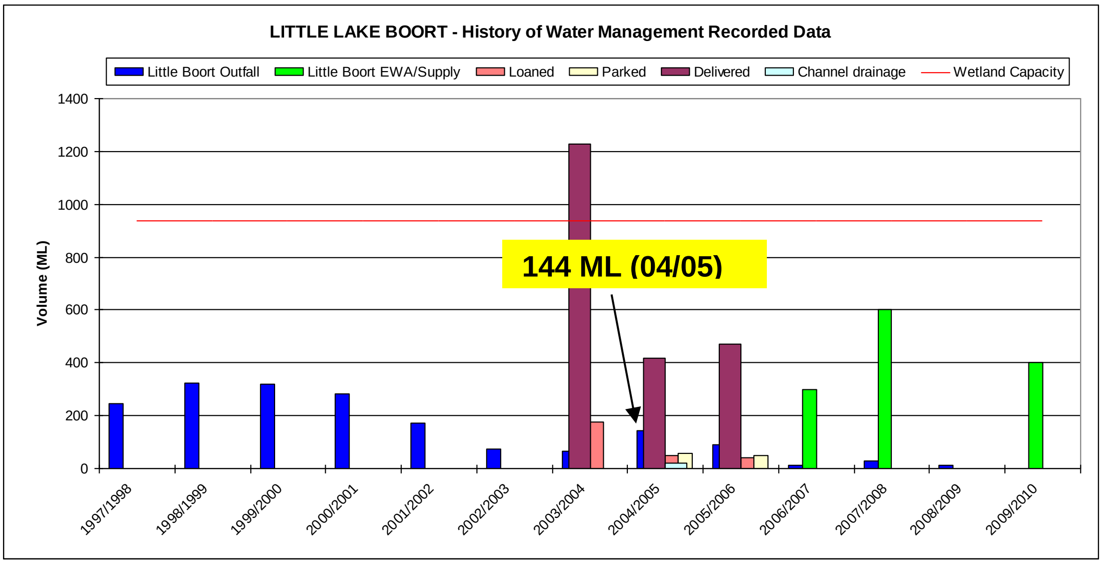


Figure 6: Recorded volumes received by Little Lake Boort from outfalls, environmental allocations and a variety of other sources *Note: outfalls recorded from 1997/1998 onwards.*

4.2.1. Recorded outfalls and GMW Connections Project

Outfall data for Little Lake Boort has been recorded by GMW since 1997/98 (Figure 6). Records indicate that outfall volumes have decreased significantly between 1997/98 (246 ML) and 2007/08 (28 ML).

The baseline water year, 2004-2005, has been selected to quantify the savings as part of water savings projects (DSE 2009e). 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 2008). 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.

Little Lake Boort received a total of 144 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.

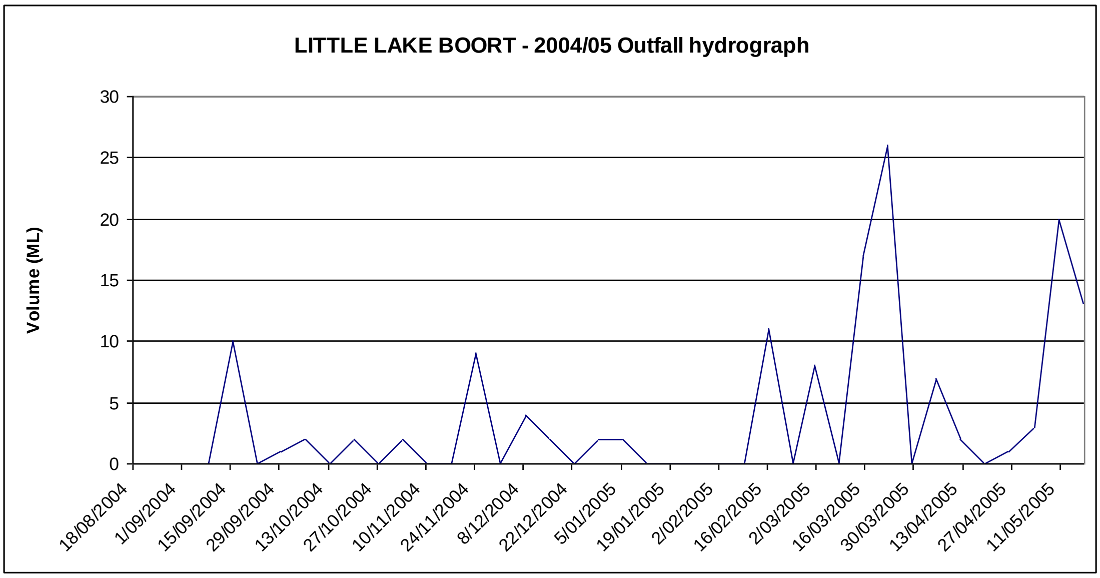


Figure 7: Little Lake Boort outfall hydrograph

4.3. Surface water/groundwater interactions

Little Lake Boort is situated on the Loddon River floodplain on upper floodplain alluvial sediments. It is approximately 10 km west of the Loddon River. The alluvial/Shepparton Formation sediments comprise silty clay and clay and are approximately 5 m thick at the site, overlying Parilla Sand sediments. Groundwater movement beneath the floodplain west of the Loddon River is from the south and southeast toward the north and northwest. Macumber (1973, cited in Bartley Consulting 2010) reported a possible hydrogeological connection between Little Lake Boort and West End Swamp (to the northwest) due to its higher elevation and the potential for groundwater to move through the lunette bordering West End Swamp. Nearby West End Swamp is a groundwater discharge zone which is currently characterised as a dry saline wetland.

Groundwater monitoring within the vicinity of Little Lake Boort has been conducted by DEDJTR since 1990; however no groundwater monitoring bores are located at the wetland itself. DEDJTR collect groundwater data from regional bores in the State Observation Bore Network as well as from other bores within the vicinity. Regular monitoring of surface water and electrical conductivity (EC) commenced in 1990 and is also undertaken by DEDJTR.

Regional groundwater levels declined from the 1990s until 2010 in response to a period of below average rainfall. Extensive flooding in 2010/11 led to sharp rises in groundwater levels. Figure 8 illustrates groundwater behaviour from within the vicinity of Little Lake Boort and shows the regional decline in groundwater levels. In the past, when the regional watertable level was highest, it would have been in close proximity to the bed of the wetland. However, as it has been maintained as a permanent wetland, groundwater movement into Little Lake Boort could not have occurred at those times.

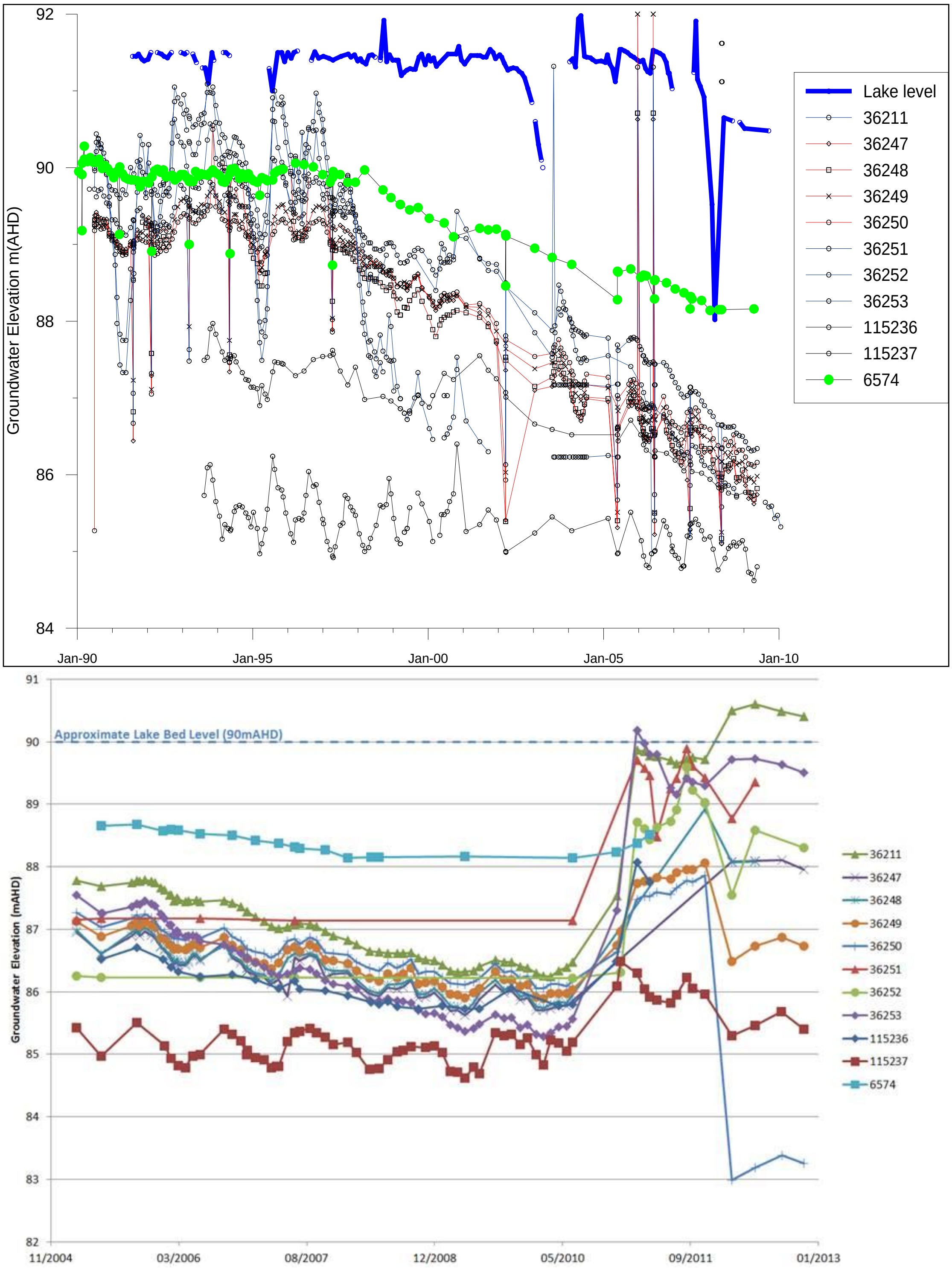


Figure 8: Groundwater levels from bores within the vicinity of Little Lake Boort (Source: Victorian Water Measurement Information System)

Groundwater levels in the vicinity of the Little Lake Boort have fluctuated over time (Figure 8). Bores 36211, 36251, 36252 and 36253 are located 800 m east of Little Lake Boort on the northern edge of Lake Boort. Bores 115236 and 115237 are on the west and east side of West End Swamp situated to the west of the Boort township. The figure shows major fluctuations of a shallow watertable until around 1998 when groundwater levels start to decline (Figure 8) in response to the regional drought conditions. Groundwater levels began to rise again between 2010 and 2011, after widespread flooding (Figure 8), then dropped in the summer of 2012 and have stabilised since then.

There are no groundwater bores at Little Lake Boort; therefore it is not possible to determine the groundwater level at the wetland. There is no lunette bordering the wetland which indicates that the bed level has been higher than historic periods of shallow groundwater levels. Currently, there is no evidence of groundwater discharge into the wetland. The groundwater levels within 800 m of Little Lake Boort are currently around 1-2 m below the bed level. Therefore, it is expected that groundwater levels at Little Lake Boort are also below bed level.

Data from bores within the vicinity of Little Lake Boort show fluctuating EC levels (Table 5). In particular, groundwater EC levels are significantly lower to the south of Little Lake Boort (Bore 6574) with extremely high EC levels i.e. greater than 30,000 EC, to the west of the Boort township (Bores 50976 and 50977). High EC levels are also reported in many other bores within the vicinity of Little Lake Boort. Hydrotechnology (2004, cited in Bartley Consulting 2010), inferred the groundwater EC levels beneath Little Lake Boort to be < 14,000 uS/cm.

Table 5: Analysis results of monitoring bores within the vicinity of Little Lake Boort (Source: Bartley Consulting 2010)

Bore	Location	Drilled depth (m)	Screen top (m)	Screen bottom (m)	Electrical Conductivity (uS/cm)			
					Min	Max	Mean	Readings
6545	1.6 km northwest	3.05			5250	40698	21293	25
6573	2.7 km southwest, adj. channel	26.00			14875	22317	20159	16
6574	1.4 km south	9.00			645	4484	1772	15
6597	3.0 km south	50.00			475	14061	8116	13
36211	200m east, north end Lake Boort	41.00	38.91	40.91	1003	33200	20358	16
36251		5.50	2.53	4.53	1795	9500	7691	8
36252		5.58	3.58	5.58	10179	16585	13326	8
36253		7.13	2.00	5.13	35340	39564	37273	3
36247	2 km east, east side Lake Boort	9.00	6.58	8.58	2600	29800	17180	15
36248		9.00	6.55	8.55	2220	29000	16752	15
36249		10.09	8.06	10.09	24687	32300	28756	16
36250		12.00	9.76	11.76	29200	32300	31090	16
50976	3.8 km northwest	76.00	42.95	49.01	29000	45000	36750	4
50977		18.00	4.00	16.00	37000	37000	37000	2
115236	1.8 km west	11.50	8.50	10.50	18520	21168	20380	10
115237	800 m west	6.00	3.00	5.00	36952	42300	38974	9

Similarly, surface water EC levels have fluctuated over time from 800 uS/cm to 29,700 uS/cm, with a median of 1,519 uS/cm (184 readings). The data suggests that as the water levels decline in Little Lake Boort salinity increases through evaporation (Figure 5 above). The monitoring record indicates that the surface water level within Little Lake Boort has consistently been above the groundwater level. It could therefore be a source of groundwater recharge.

Based on the analysis of 2009 groundwater levels within the vicinity of Little Lake Boort:

- The lake surrounds show little evidence of adverse impacts due to the maintenance of water in Little Lake Boort. This is likely to be reflective of the relatively higher elevation of the site compared with surrounding areas.
- However, the greatest risk of watertable rise to within the capillary fringe in surrounding areas is when there is high water level in the lake combined with high regional groundwater levels. A permanently maintained surface water body can be a continual source to groundwater, with watertable mounding and an increased risk of discharge through evapotranspiration to low lying areas on neighbouring land.
- Putting water into Little Lake Boort when regional groundwater levels are low increases the opportunity for salts to move down the profile and into the groundwater.
- It is noted that a study of the site hydrology assumed negligible seepage to groundwater, and this is supported by the apparent increase in salt load in the Lake, shown by increasing EC (Bartley Consulting 2010).

4.4. Surface water balance

A daily surface water balance has been modelled in order to identify the hydrological attributes of Little Lake Boort. 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 Little Lake Boort 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 wetland to the targeted supply level, i.e. Little Lake Boort filled to FSL (91.5 m AHD), is 935 ML (Archards Irrigation 2010).
- **Infiltration:** volume required to fill the underlying soil profile. Calculation of this volume has been adapted from measurements undertaken by GMW (GMW 2008a). The following assumptions were included in the application of the SWET model for Little Lake Boort (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 generally considered negligible due to the low permeability of the underlying soil (GMW 2008b)
- **Rainfall/runoff:** this includes rainfall directly falling onto the wetland 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). Little Lake Boort has virtually no local catchment area, therefore 0.1 hectares was used. 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 wetland 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 modelling does not consider water diversion/extraction from Little Lake Boort as part of the overall surface water balance.*
- *The model has been set up to model water levels at a single target level (91.5 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 wetland in accordance with the optimal regime specified in Section 5.3. The modelling results for Little Lake Boort are presented in Section 5.3 and Appendix G.

4.5. Operational uses

Little Lake Boort is used as an operational outfall, although the onset of drought initiatives and efficiency programs has considerably reduced outfall volumes. GMW parked and borrowed water is currently flushed through the wetland using a pump installed at the northern end of

Little Lake Boort (Figure 4). Operational Guidelines for the Pump and Little Lake Boort were developed by GMW in 2001. A flushing channel also connects Little Lake Boort and Lake Boort and is able to be used to flush water into the larger lake when inundated. The Little Lake Boort Flushing Strategy was prepared by the Department of Natural Resources and Environment in 2002.

Currently, two users have existing diversion licences from Little Lake Boort. The Boort Lawn Tennis Club and Boort Bowling Club have diversion licences permitting the extraction of 2.5 ML and 2 ML, respectively, from the wetland. However, these licences have not been used for some time as they have an alternative supply through the Loddon Shire piped supply from the Boort no.3 channel that also services Nolan's Park & the Caravan Park (pers. comm. Lawrence Cameron [GMW] 19 February 2010).

4.5.1. Flood mitigation

Little Lake Boort can receive harvested floodwater (approximately 170 ML/day) via the no. 3 channel. Refer to GHD (2006) and Appendix B.

5. Management objectives

Previous management recommendations for Little Lake Boort relate to maintaining salinity levels and recreational values. In particular, the following management targets were identified by DNRE (2002a):

- No net accumulation of salt over the modelling period
- An average salinity of approximately 1500 EC over the modelling period
- A maximum period during summer with levels above minimum summer level
- A minimum number of years with levels below minimum winter level
- No lake levels above the maximum water level.

Table 6 provides an outline of information and management recommendations from the Little Lake Boort Flushing Strategy (DNRE 2002a).

Table 6: Previous management recommendations

Source	Objectives	Duration	Timing	Frequency
DNRE (2002a)	• Maintain salinity levels and recreational values • Maintain recreational values Measures ○ Secure a 300 ML (minimum) water entitlement for Little Lake Boort, as part of the Loddon Bulk Entitlement process. ○ Adopt GMW's draft guidelines (GMW 2001) for the operation of the proposed Little Lake Boort pump ○ Adopt a pumping regime that maximises opportunities for returnable channel outfalls (and therefore salt) to be removed from the lake. ○ Locate the pump at the site adjacent to the caravan park residence. ○ Do not use the existing flushing channel until a water entitlement for the lake is approved. ○ If agreement can be reached with GMW, undertake opportunistic pumping from the lake at times of moderate to high channel flow, with immediate return to the lake following the cessation of pumping.	Permanent		

5.1. Water management goal

The water management goal for Little Lake Boort 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).

The proposed management goal is based on the environmental values the wetland supports, the current wetland condition and potential risks that need to be managed. It is recognised that this recommendation contradicts previous management of Little Lake Boort as a permanent open freshwater lake and associated recommendations (Table 6), and that there are likely to be conflicting views to reinstating an infrequent dry phase.

Little Lake Boort water management goal:
Maintain Little Lake Boort as a deep freshwater marsh[3], experiencing an infrequent dry phase, characterised by open water, associated mudflats and fringing aquatic vegetation as these provide habitat for waterbirds, reptiles, amphibians and fish.

Restoring an infrequent dry phase has been recommended to promote the growth of fringing aquatic vegetation to establish waterbird breeding opportunities and to maintain biological and chemical processes within the wetland (Tucker *et al.* 2002; Boulton and Brock 1999). The following provide examples of the biological responses of wetland biota upon drying:

- Encourages:
    - germination of emergent species across greater elevations therefore enhancing the structural complexity of the wetland
    - germination of a range of dry wetland bed plants that provide habitat and release nutrients into the wetland upon filling. Dry bed plants may also take up nutrients re-released upon filling
- Sediment consolidation minimising potential turbidity upon filling
- Nutrients are locked within the soil profile
- A seed bank of aquatic submerged and amphibious plants is stored enabling recolonisation following inundation
- An egg bank of zooplankton and benthic invertebrates is stored enabling recolonisation following inundation
- Minimise the threat of exotic fauna species such as Common Carp (*Cyprinus carpio*).

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 Little Lake Boort (Table 7). The process for identifying ecological and hydrological objectives closely follows that recommended in FLOWs: a method for determining environmental flow requirements in Victoria (DNRE 2002b). 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 attract 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 are 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 2002b). All values identified have stages in their life-cycle or process that are dependent on particular water regimes for success e.g. colonially

[3] Deep freshwater marshes are less than 2 m deep and are inundated for longer than 8 months of the year or can be permanently inundated (DCFL 1989)

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[4] were identified and described for all of the ecological values (Campbell, Cooling & Hogan 2005).

The ecological objectives and hydrological requirements for Little Lake Boort 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 identified that there are significant data gaps required to assess the achievement of the ecological objectives. However, based on the limited data available, the review found that the ecological objectives and hydrological requirements were still appropriate for Little Lake Boort and recommended that more survey effort be directed towards vegetation, frogs and invertebrates to more accurately assess progress towards the ecological objectives (GMW 2015).

Table 7: Little Lake Boort proposed ecological objectives and associated hydrological objectives

Ecological Objective	Justification	Hydrological Requirement
1. Habitat Objectives		
1.1 Maintain open water and restore submerged aquatic macrophyte habitat in the deeper sections of the wetland	Provides open water habitat for diving waterbirds, reptiles, fish, invertebrates and frogs (e.g. Growling Grass Frog, Barking Marsh Frog)	Maintain inundation of 50 cm - 1.7 m[5] (FSL) four in six years. Restore infrequent periods of drying.
1.2 Restore Tall Marsh (EVC 821) habitat	Provides habitat for waterbirds, frogs and invertebrates e.g. Clamorous Reed Warbler, Australasian Shoveler, Intermediate Egret, Musk Duck, Whiskered Tern, Growling Grass Frog, Barking Marsh Frog	Keep the wetland predominantly wet with infrequent periods of drying
2. Species/Community Objectives		
2.1 Restore feeding and breeding opportunities for waterbirds, frogs (e.g. Growling Grass Frog) and invertebrates	Linked to habitat objectives. Providing a variety of habitat types and high productivity of micro and macro-invertebrates and plant species through a wetting and drying cycle should enable breeding opportunities.	Fill in spring and keeping wet for at least seven to ten months.
2.2 Maintain a viable seed and egg bank	Seed and egg banks provide a source of survival for invertebrates and macrophytes in temporary wetlands during dry periods. These habitats and food sources in turn support higher order consumers such as waterbirds, frogs and fish.	Maintaining inundation with fluctuating water levels four in six years therefore restoring infrequent periods of drying.
3. Process Objectives		
3.1 Restore ecological[6] processes associated with a dry phase.	A variety of biological and chemical processes will be restored by infrequently drying the wetland out e.g. germination of emergent and dry wetland bed vegetation, sediment consolidation, maintaining a viable seed and egg bank	Restore infrequent periods of drying (minimum 12 months) with the draw-down and dry phase potentially lasting 18 to 24 months.

[4] Timing, frequency and duration
[5] Refer to Appendix K: for comparison of bathymetric information and vegetation mapping.
6 Chemical and biological processes

Ecological Objective	Justification	Hydrological Requirement
3.2 Restore connectivity between river, floodplain and wetland	Connectivity facilitates dispersal and movements of plant propagules, micro and macro-invertebrates and fish, as well as nutrient, salinity and carbon cycling	In times of natural high flow restore connectivity to Lake Boort and Kinypanial Creek (flushing channel etc)

5.3. Desired water regime

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

Past water regimes of Little Lake Boort aimed at providing social, economic and environmental benefits. This involved maintaining the wetland as a permanent open freshwater lake that received regular tops ups and was occasionally flushed.

The desired water regime is designed to meet only the ecological objectives described in Table 7 recognising that this may be sub-optimal for social and economic values. The desired water regime will encourage growth of fringing aquatic vegetation, increasing the wetland's diversity by reinstating more natural, fluctuating water levels. The partial exposure of the littoral zone by fluctuating water levels and the complete drying of the bed is crucial in maintain important ecological processes. However, it is recognised that there may be conflicting views around drying the wetland out.

Figure 9 below illustrates the various habitats in the wetland (e.g. open water and associated mudflats, submerged aquatic macrophytes, fringing emergent vegetation) that are being targeted by the water regime.

Timing: Maintain inundation four in six years with a dry period of at least 12 months (drawdown and dry period may take longer i.e. 18 months). Increase water depth in late winter/spring to limit growth of Cumbungi.

Frequency of wetting: Optimum: four in six years

Maximum: five in six years

Duration: Maintain inundation for 48 months; drawdown and dry for maximum of 24 months.

Extent and depth: Variable

- Allow depth to fluctuate over the period of inundation (48 months) between approximately 50 cm to 1.7 m (FSL) every year except in the dry phase
- Increase water depth during the wet phase in spring to limit growth of Cumbungi.

Variability: High. Allow the height of the wetland to fluctuate.

Wetland water regime:
Fill Little Lake Boort to FSL (91.5 m AHD) and maintain inundation for four in six years. Allow water level to fluctuate between 0.5m and 1.7m by evaporation or as a result of operational management. Allow the lake to be completely dry for at least 12 months (excluding draw down).

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

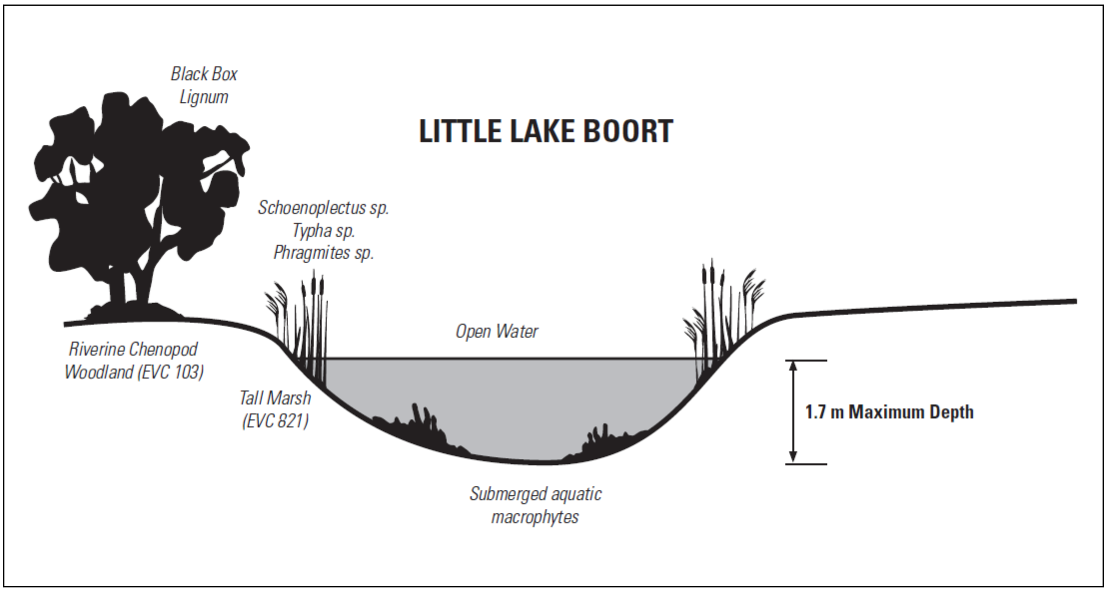


Figure 9: Schematic of wetland areas to be targeted (not to scale)

The volumes of water required to provide the desired water regime for Little Lake Boort are presented in Table 8. These volumes reflect the results from the SWET modelling (model described in Section 4.4 and results presented in Appendix G). These calculations were prepared with the model set at 91.5 m AHD. As noted above, it is not possible to calculate the volumes required to reach a range of target levels in order to test various management scenarios.

Table 8: Volumes required in providing the desired water regime for Little Lake Boort (SWET modelling output)

Result	
Mean long-term (LT) annual controlled inflow requirement	645 ML/year
95th percentile of mean LT annual controlled inflow requirement	1,778 ML/year
Average LT controlled inflow requirement for filling period	3,878 ML
Record length	118
No. of periods	20
Years with no inflow	40 in 118
No. of draw downs over record	20
No. of draw downs not fully drawn down	1
% of draw downs not fully drawn down	5
95th percentile duration of full period (months)	38.8
50th percentile duration of full period (months)	38.1

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 wetland 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, which may include years with zero water required (i.e. two out of six years). A mean long-term annual volume of 645 ML would be required to fill and maintain levels at 91.5 m AHD[7].
- **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 (1,778 ML).
- **Average long-term controlled inflow requirement for filling period**: the total amount of water to be put into the wetland in a controlled fashion to achieve the desired water level regime for the recommended period (i.e. six years). This excludes natural inflows from rainfall and local catchment runoff. Therefore, over an inundation period of approximately four years (allowing for a maximum dry phase of 24 months

[7] 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.

where no controlled inflows are provided), the maximum volume required to fill Little Lake Boort and maintain levels at 91.5 m AHD would be approximately 3,878 ML.

Refer to Appendix G for greater detail.

Please note: due to the variability of inflows to the wetland, 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 to Little Lake Boort 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 Connection Project considered in the Little Lake Boort EWP is related mainly to a reduction in outfalls. Other potential impacts to the wetland will be managed through 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
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 are less than what is required to support all water-dependent environmental values of a particular wetland. Therefore, the outfall water only forms part of the overall volume required to provide the water regime of the wetland. The water regime supports processes and systems which in turn provide suitable conditions for defined ecological values (e.g. breeding of waterbirds).

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

Step 1: Describe the desired water or flow regime

Step 2: Determine the baseline year incidental water contribution

Step 3: Assess dependency on baseline incidental water contribution

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. Little Lake Boort mitigation water

Step 1: Describe the desired water or flow regime

The desired water regime for Little Lake Boort is to maintain inundation for four in six years. Further detail is provided in Section 5.3. The total average volume required to fill and maintain levels over approximately 4 years is 3,878 ML.

Step 2: Determine the baseline year incidental water contribution[8]

[8] 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.

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 Little Lake Boort from leakage and seepage from the no. 3 channel 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 7 ML/year to 27 ML/year may be received by Little Lake Boort (Appendix H). However, if future GMW Connections Project actions are likely to impact the potential for leakage and seepage to reach Little Lake Boort (i.e. lining the main supply channel or decommissioning any channels within 200 m of the wetland), an analysis will be triggered in accordance with the Water Change Management Framework.

Therefore, only one hydrological connection (outfalls) is included in 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 144 ML, refer to Section 4.1. A channel less than 100 m in length delivers water from the regulating structure to the wetland. Therefore, losses associated with leakage or seepage from the delivery channel are considered negligible at Little Lake Boort and 100% (or 144 ML) of this outfall volume is considered to have contributed to the wetland's water balance in 2004-05.

The determination of the baseline year incidental water contribution is summarised in Table 9.

Table 9: 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 the origin (irrigation system) and wetland (for baseline year) (ML)	Baseline year incidental water contribution at the wetland (Net) (ML)
Outfall #ST008516	144	0	144

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 Little Lake Boort with the results presented in Table 10.

Table 10: 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 (< 100 m in length) delivers outfall water to Little Lake Boort from the automated 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 (< 100 m in length). There are no impediments or diversions restricting outfalls being delivered to Little Lake Boort. 100% of the outfall water (144 ML) is estimated to have reached Little Lake Boort 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)	In the years that qualify for mitigation water (i.e. four out of six), the wetland does not have more water than is required to support the desired state of the environmental values.
2.2 That occurs at a time that is detrimental to the environmental values	In 04/05, losses occurred between September and May (Figure 7). Little Lake Boort is proposed to be managed as a deep freshwater marsh and losses are not considered to have detrimental impacts to the high environmental values at the wetland.
2.3 That is of poor quality (or results in	Losses (irrigation outfalls) are of acceptable water

Criteria by which mitigation water may be assessed as not required	Link between incidental water (losses) and environmental values
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	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 wetland and maintain water levels within Little Lake Boort.
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 wetland and contribute to maintaining open water habitat for waterbirds, fish, reptiles and amphibians and aquatic plant species.
4.2 Diminish the benefits of deploying any environmental water allocations (over and above the contribution from the irrigation system).	If outfall volumes were removed or reduced, additional water would need to be secured for providing freshwater inflows to maintain water levels and to contribute to providing drought refuge for a range of species at Little Lake Boort.

The assessment of the requirement for mitigation water for Little Lake Boort demonstrates that the **outfall water provides benefit to the wetland and that the provision of mitigation water is warranted if it is managed for environmental purposes**. In particular, the outfall water received by the wetland contributes to providing open water habitat for a variety of flora and fauna species. If the volume of outfall water was to be reduced or removed, additional water would need to be secured to maintain the wetland's environmental values either by filling following a dry phase or in maintaining inundation. Mitigation water is required four in six years.

It is recognised that Little Lake Boort is recommended to be classified as a recreation reserve under the recent VEAC recommendations for public land management (Section 2.3). Recreation areas will be managed for recreation, parks and gardens, with facilities provided for community purposes and education. Features of cultural significance, natural surroundings and the local character and quality of the landscape will be maintained or restored where relevant and compatible with the primary purpose (VEAC 2008; DSE 2009c). If the management of Little Lake Boort for recreational purposes in accordance with the VEAC recommendations does not allow for the maintenance of environmental values, the achievement of objectives, or if management actions have deleterious impacts on environmental values, mitigation water is not considered to directly benefit high environmental values and therefore may not be justified.

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.

As there is no other more efficient infrastructure options for delivering mitigation water, BMW will be calculated at Outfall #ST008516 (gross).

Gross BMW

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

= 144 ML / 1.5 (four in six years)

= 96 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 2009e) and will become available in any following year.

MWC (%)	=	$\frac{\text{Gross BMW}_{\text{(Little Lake Boort 2004/05)}} \text{ (Step 4)}}{\text{Baseline incidental water contributions at origin}_{\text{(Gross)}} \text{ (Step 2)}}$
		= (96/144) x 100
		= 67%

The overall MWC for Little Lake Boort is 67%.

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 DELWP. 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 15% of the annual long-term volume of water required in order to provide the desired water regime (645 ML/year). 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 wetland if they are supporting significant environmental values. As such, it is important that the environmental water holder secures additional sources of water to maintain Little Lake Boort as a deep freshwater marsh supporting a range of environmental values. The most likely additional sources of environmental water will be existing and future environmental entitlements.

Discussion of potential sources of environmental water to provide the desired water regime in order to support high environmental values at Little Lake Boort follows. There are also a variety of other avenues currently used to secure water for the wetland and maintain a variety of values (environmental, social and economic).

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).

5.5.2. 75 GL environmental entitlement

Water savings generated by Stage 1 of the GMW Connections Project will provide up to 75 GL to be vested in the Minister for Environment and Climate Change 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 (GMW 2013).

In addition, Stage 2 of GMW Connections Project will generate up to 204 GL of water savings, which will be allocated to the environment. This water will be vested in the Commonwealth Environmental Water Holder.

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 Little Lake Boort is not a wetland of international importance, it is a refuge for species listed under other international conventions. The *EPBC Act* listed Growling Grass Frog and Swift Parrot (*Lathamus discolor*) have also been recorded within the vicinity of Little Lake Boort. Therefore, a case for the receipt of Commonwealth environmental water could be made.

5.5.4. Recreational water

The Little Lake Boort Committee of Management has taken over as water managers through an amendment of the bulk entitlement and have purchased an additional 100ML of water specifically for recreational use at the lake.

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 mitigation water volume represents 15% of the mean long-term annual volume required (645 ML/year). Awareness of the potential risks and impacts will influence future intervention and long-term condition monitoring undertaken at Little Lake Boort, will inform the adaptive management of the watering regime and the provision of mitigation water (Section 8).

Table 11 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 Little Lake Boort. 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 11: Potential risks, impacts and mitigation measures associated with the provision of mitigation water to Little Lake Boort

Risks/limiting factors	Impacts	Mitigation measures
Uncertain objectives for future management at Little Lake Boort (e.g. potential for conflicting management objectives)	Inability to manage Little Lake Boort in accordance with the desired water regime Failure to achieve identified objectives and water management goal	Negotiate the introduction of the desired water regime with the CoM.
Ineffective delivery	Inability to deliver water in order to achieve objectives and water management goal	Ensure that the delivery capacity is sufficient to facilitate delivery of required volumes at critical times (e.g. delivery share).
Future GMW Connections Project actions inhibit significant leakage and seepage loss contributions	Loss of high environmental values. Failure to achieve identified objectives and water management goal	If future actions are likely to impact seepage and leakage loss contributions (i.e. lining or decommissioning any channels within 200 m of the wetland) detailed analysis of the loss contributions is required and incorporated into the mitigation water recommendations.
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
Opportunistic diversion licences	Using environmental and mitigation water for consumptive use.	Continue providing alternative supply.

7. Water delivery arrangements

Little Lake Boort receives outfalls from the no. 3 channel via a fully automated regulator and a short delivery channel <100 m in length (Figure 10). The reported capacity of the no. 3 channel and siphon upstream of the outfall structure is 100 ML/day. The outfall structure has a maximum capacity of 80 ML/day, therefore restricting inflows by a possible 20 ML/day.

At present, Little Lake Boort is flushed by returning parked and borrowed water to the channel system via a 600 mm diameter pump located on the northern margin. As mentioned earlier, a flushing channel also connects Little Lake Boort and Lake Boort and can be used to flush water into Lake Boort when it is full.

At a rate of 80 ML/day, Little Lake Boort can be filled in approximately 12 days (assuming no losses and adequate capacity is available in the no. 3 channel). However, recent delivery of environmental water to top-up the wetland occurred at a rate of 20 ML/day (pers. comm. Bridie Velik-Lord [NCCMA] 24 February 2010).

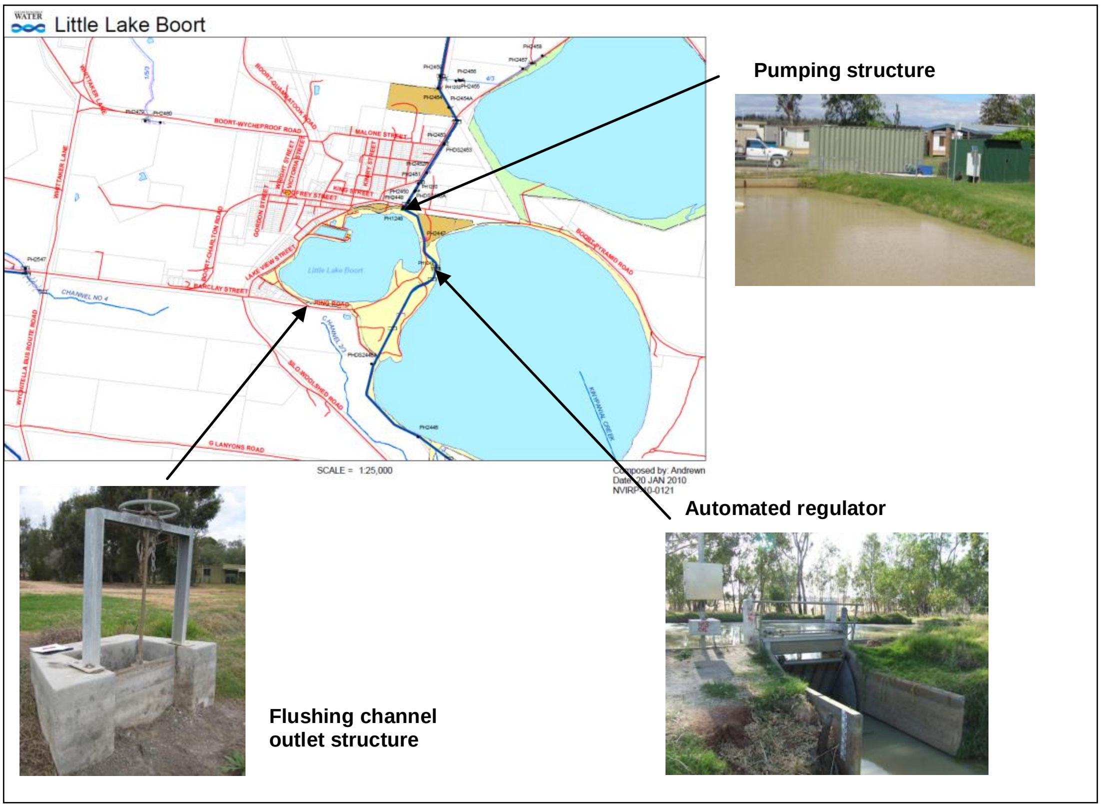


Figure 10: Little Lake Boort Infrastructure

7.1. GMW Connections Project works program – No. 3 channel

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.

The Pyramid-Boort no. 3 channel, on which the Little Lake Boort outfall structure is located, is the backbone within the vicinity of Little Lake Boort. It will not be rationalised from the irrigation water supply system as part of the GMW Connections Project and connection to Little Lake Boort will remain.

7.2. Infrastructure requirements

At present, Little Lake Boort is maintained as a permanent open freshwater lake, with top-ups provided via the irrigation system at a rate of 20 ML/day. The capacity of the existing infrastructure is limited to 80 ML/day at the automated regulator which, if operating at full capacity, would allow the wetland to be filled in approximately 12 days (assuming no losses and adequate capacity is available in the no. 3 channel). The current delivery infrastructure is considered adequate to deliver the desired water regime and no infrastructure upgrades are recommended as part of GMW Connections Project.

8. Adaptive management framework

A key GMW Connections Project principle is that an adaptive management approach is adopted to ensure an appropriate application of the scientific method to management (Section 9.4, GMW 2013).

Adaptive management is a continuous management cycle of assessment and design, implementation, monitoring, review and adjustment. Table 12 shows how the adaptive management approach will be applied in the context of this EWP.

Table 12: Adaptive management framework

Adaptive management phase	Application to this EWP (Responsible agency)	When (Sections 15 and 19, GMW 2013)
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 mitigation water contribution to achieving the water management goal by monitoring individual ecological 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 Connections 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 wetland.

8.2. Review

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

As per the requirement of the WCMF, it is expected this EWP will be reviewed in 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 review 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 13 (GMW 2013). The table outlines the roles and responsibilities before and during the implementation of GMW Connections Project in the modified GMID.

Table 13: 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 GMW irrigation delivery system. • Report on environmental outcomes (e.g. wetland or waterway condition) from the delivery of the water, in the course of normal reporting on catchment condition. • 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, currently the Committee of Management)	• Identify and inform GMW Connections Project of opportunities for best practice. • Participate in the Environmental Technical Advisory Committee. • Agree to implement relevant components of Environmental Watering Plans. • Agree to implement other relevant regional management and mitigation measures required due to the implementation of GMW Connections Project.	• Implement the relevant components of Environmental Watering Plans. • Operate, maintain and replace, as agreed, the infrastructure required for delivery of mitigation water, where the infrastructure is not part of the GMW irrigation delivery system. • Where agreed, participate in the periodic review of relevant EWPs. • Manage and report on other relevant catchment management and mitigation measures required due to the implementation of GMW Connections Project.
System Operator	• Identify and inform GMW Connections Project of opportunities for best practice. • Participate in the Environmental Technical Advisory Committee. • Agree to implement relevant components of Environmental Watering Plans.	• Implement the relevant components of Environmental Watering Plans, namely delivery of mitigation water. • Operate, maintain and replace, as needed, the infrastructure required for delivery of mitigation, or other, water, where the infrastructure is part of the GMW irrigation delivery system. • May negotiate transfer of ownership of infrastructure to the environmental water/land manager for provision of mitigation water if it is no longer required for the public distribution system, in accordance with the principles set out in the WCMF. • 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 GMW. This arrangement is legally binding and reflects the commitments of GMW Connections Project to provide water to mitigate potential impacts to high value environmental assets. The arrangements require GMW to set aside water in the Goulburn and Murray Systems to meet the mitigation water needs, calculated in accordance with the methods in the Water Change Management Framework, for future use at wetlands and waterways that have an approved environmental watering plan.

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 Little Lake Boort 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 11. This has been developed to describe the decision-making process required to coordinate implementation of the desired water regime for Little Lake Boort. 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.

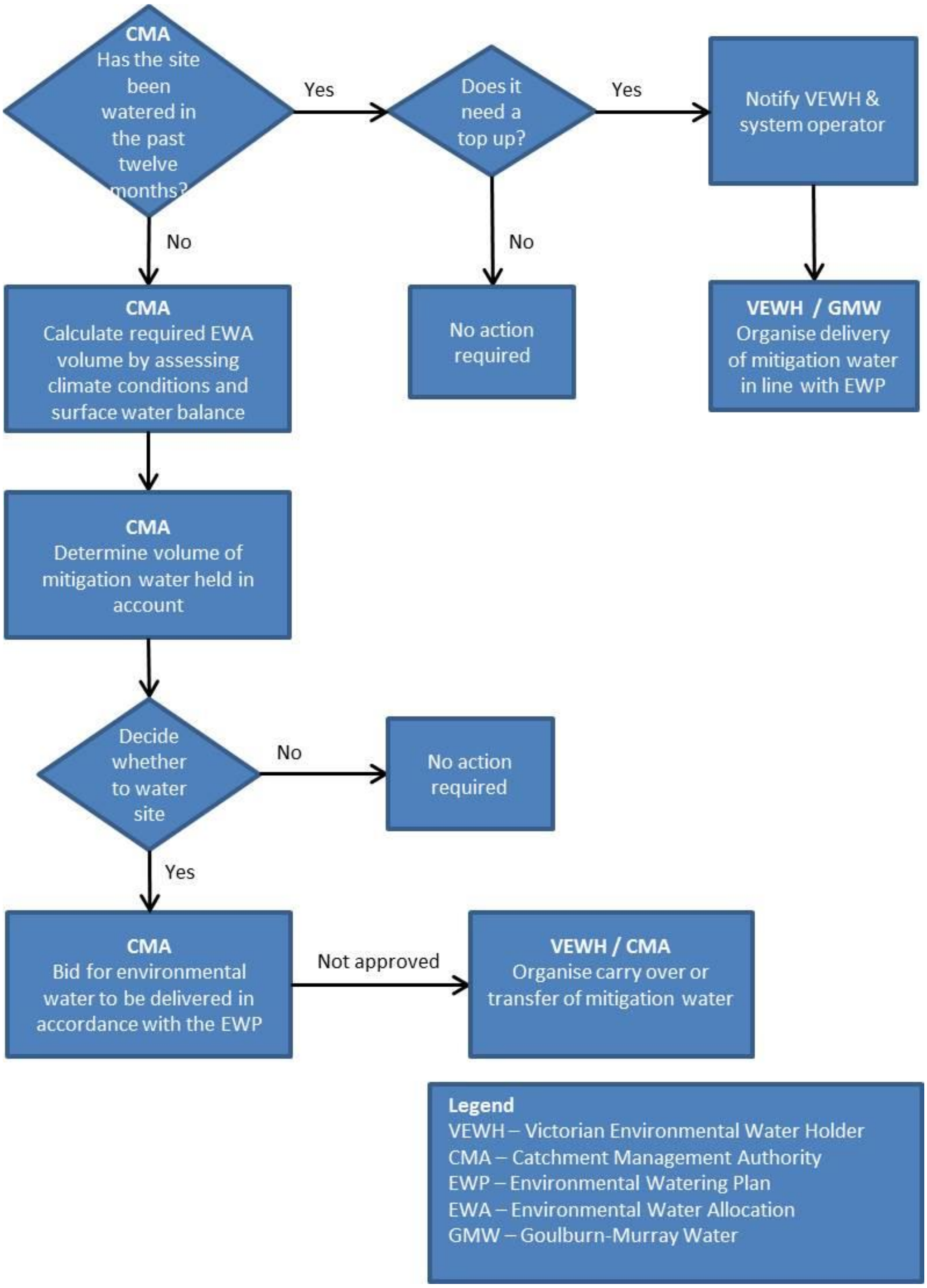


Figure 11: Operational management framework

10. Knowledge gaps

The Little Lake Boort 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. Little Lake Boort

- Further clarification on the intended future management of Little Lake Boort is required, i.e. primarily for environmental or social values, and this must inform the adaptive management of 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).
- 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).

10.2. Roles and responsibilities

- GMW Connection Project and North Central CMA are jointly responsible for addressing knowledge gaps associated with the intended future management of Little Lake Boort.
- North Central CMA in its capacity as environmental water manager is responsible for addressing the remaining knowledge gaps listed under Section 10.1.

11. References

Archards Irrigation (2010). *Little Lake Boort Contour Plan and Capacity Table*. Archards Irrigation, Cohuna, Victoria

Baldwin, D. S., Nielsen, D. L., Bowen, P. M. and Williams, J. (2005). *Recommended Methods for Monitoring Floodplains and Wetlands*, MDBC Publication No. 72/04, Murray-Darling Basin Commission, Canberra, Australian Capital Territory

Bartley Consulting (2010) *Hydrogeological Overview – Little Lake Boort.* Prepared for the North Central Catchment Management Authority by Bartley Consulting, Heidelberg, Victoria

Boulton, A., and Brock, M. (1999). *Australian Freshwater Ecology: Processes and Management*, Gleneagles Publishing, Adelaide.

Bureau of Meteorology (2009). *Climate Statistics for Boort*, Australian Government [online] available: http://www.bom.gov.au/climate/averages/tables/cw_080002.shtml [accessed: November 2009], Canberra

Campbell, E., Cooling, M. and Hogan, R. (2005). *Ecological accountability in Gunbower Forest*. Paper for International River Symposium, Brisbane.

Campbell, C. J., Johns, C. V. and Reid, C. J. (2009). *NVIRP Technical Report: Wetland and Waterway Watering Requirements*. Report prepared for the North Central Catchment Management Authority by The Murray-Darling Freshwater Research Centre, November, 118pp

DCFL (1989) Report *No. 1: Conservation value of the wetlands in the Kerang Lakes Area*, Report to Kerang Lakes Area Working Group, Department of Conservation Forests & Lands, Kerang Lakes Assessment Group, Bendigo.

DEPI (2013). *Advisory List of Threatened Vertebrate Fauna in Victoria,* The Department of Environment and Primary Industries, Melbourne.

DEPI (2014). *Flora and Fauna Guarantee Act 1988 Protected Flora List* May 2014, The Department of Environment and Primary Industries, Melbourne.

DEWHA (2009). *Environment Protection and Biodiversity Conservation Act*, Department of the Environment, Water, Heritage and the Arts, Canberra, Australian Capital Territory, Available at: www.environment.gov.au, Accessed: November 2009

DEWHA (2008). *Water Requirements of Important Wetlands in the Murray-Darling Basin – Initial Overview Assessment,* Final Report, Compiled by Fluvial Systems and Lloyd Environmental, Canberra.

DNRE (2002a). *Little Lake Boort Flushing Strategy*. Department of Natural Resources and Environment, Bendigo, Victoria

DNRE (2002b). *FLOWS – a method for determining environmental water requirements in Victoria*, Department of Natural Resources and Environment, Melbourne, Victoria.

DNRE (1997). *Victoria's Biodiversity Directions in Management,* Department of Natural Resources and Environment, Melbourne.

DPCD (2009). *Environment Assessment Referrals from July 2008 - June 2009*. Available at: http://www.dse.vic.gov.au/DSE/nrenpl.nsf/LinkView/E6DAFE581144D1FFCA25757B0008A28314CD70100E11BFB5CA2572DA007FAA9C, Accessed: November 2009

DPCD (2007). *General Practice Note The Aboriginal Heritage Act 2006 and the Planning Permit Process* July 2007 (Revised October 2007), the Department of Planning and Community Development, Melbourne.

DPI and HydroEnvironmental (2007). *Irrigation Drainage Memorandum of Understanding Decision Support System: Assumptions for Management Actions – North Central Catchment,* Prepared by Brian Holmes, Department of Primary Industries, Kerang.

DSE (2009a). *Biodiversity Interactive Map*. Department of Sustainability and Environment http://mapshare2.dse.vic.gov.au/MapShare2EXT/imf.jsp?site=bim (Accessed November 2009)

DSE (2009b). Data Source: 'WETLAND_1788', © The State of Victoria, Department of Sustainability and Environment. The contribution of the Royal Botanical Gardens Melbourne to the data is acknowledged. Accessed: January 2009.

DSE (2009c). *Victorian Government Response to: Victorian Environmental Assessment Council's River Red Gum Forests Investigation*, Final Report, Victorian Government, March, Melbourne

DSE (2009d). Data Source: 'WETLAND_1994', © The State of Victoria, Department of Sustainability and Environment. The contribution of the Royal Botanical Gardens Melbourne to the data is acknowledged. Accessed: January 2009.

DSE (2009e). *Water Savings Protocol Technical Manual for the Quantification of Water Savings Final Version 1.0,* Department of Sustainability and Environment, Melbourne Victoria

DSE (2008) *Northern Victoria Irrigation Renewal Project – Suggested principles & processes for compliance with environmental obligations,* Compiled by Andrea Ballinger, Department of Sustainability and Environment, Melbourne.

DSE (2008b) *Northern Region: Sustainable Water Strategy.* Department of Sustainability and Environment, Melbourne.

DSE (2007). *Native Vegetation Information: Overview of Native Vegetation Spatial Datasets Information Sheet No. 1*. Department of Sustainability and Environment, East Melbourne, Victoria.

DSE (2006). *Murray Flora and Fauna Entitlement: Annual Distribution Program 2006/2007*, Compiled by Andrea Joyce, Department of Sustainability and Environment, October, Melbourne.

DSE (2005a). *Advisory List of Rare or Threatened Plants in Victoria,* Department of Sustainability and Environment, Melbourne, Victoria

DSE (2005b). *Index of Wetland Condition: Conceptual Framework and Selection of Measures*. Department of Sustainability and Environment, Victoria. Hillemacher, M. and Ivezich, M. (2008). *Boort District Wetlands Environmental Water Delivery Options Assessment.* Report P108022_R01 by Alluvium for North Central CMA

Feehan Consulting (2009). *Northern Victorian Irrigation Renewal Project. Waterway Short-listing Report.* Report prepared for Northern Victorian Irrigation Renewal Project.

GHD (2006). *Serpentine to Boort Floodplain Management Plan, Final Plan.* Prepared for North Central Catchment Management Authority, GHD, Victoria

Gippel, C.G. (2010). *Comments on Application of SWET Water Balance Model to Terminal Wetlands_V1.* Prepared by Dr. Chris Gippel, Fluvial Systems Pty Ltd, Stockton, NSW

Gippel, C. J. (2005a). *Operational procedure to calculate water recovery from wetlands and lakes at the source (individual wetlands).* Fluvial Systems Pty Ltd, Stockton, NSW. The Living Murray, Murray-Darling Basin Commission, Canberra, Australian Capital Territory.

Gippel, C. J. (2005b). *Model to calculate water recovery from wetlands and lakes at the source (individual wetlands) – Example application to Euston Lakes and Edward Gulpa wetlands.* Fluvial Systems Pty Ltd, Stockton, NSW. The Living Murray, Murray-Darling Basin Commission, Canberra, Australian Capital Territory.

Gippel, C. J. (2005c). *SWET (Savings at Wetlands from Evapotranspiration daily Time-Series)*. *A model to calculate water recovery from wetlands and lakes at the source (individual wetlands). Model Manual.* Fluvial Systems Pty Ltd, Stockton, NSW. The Living Murray, Murray-Darling Basin Commission, Canberra, Australian Capital Territory.

GMW (2001). *Operational guidelines for the Pump and Little Lake Boort.* Goulburn-Murray Water, Victoria

GMW (2008a). *G-MW Murray Strategic Monitoring Project*, Goulburn-Murray Water, Shepparton.

GMW (2008b). *Environmental Water Allocations - Calculations for the SIRTEC*, Agenda Paper Compiled by Sam Green and Mary Shi, Tatura

GMW (2013). *Water Change Management Framework*, Version 3, Goulburn-Murray Water Connections Project, Tatura, Victoria

GMW (2015). *Environmental Watering Plan Review 2015. Comparison of Monitoring Data to Ecological Objectives.* Goulburn-Murray Water, Tatura.

Hydro Environmental (2009). *Northern Victoria Irrigation Renewal Project. Wetland Short-listing Report*. Report prepared for Northern Victoria Irrigation Renewal Project.

Hillemacher, M. and Ivezich, M. (2008). *Boort District Wetlands Environmental Water Delivery Options Assessment.* Report P108022_R01 by Alluvium for North Central CMA

HydroEnvironmental (2008). *Northern Victoria Irrigation Renewal Project: Priority Wetland Assessment.* Report Prepared for NVIRP, 28th January, Victoria.

LCC (1988). *Statewide Assessment of Public Land Use*, Land Conservation Council, July, Melbourne, Victoria

McJannet, D.L., Webster, I.T., Stenson, M.P. and Sherman, B.S. (2008). *Estimating Open Water evaporation for the Murray Darling Basin.* A Report to the Australian Government from the CSIRO Murray-Darling Basin Sustainable Yields Project. CSIRO, Australia. Available at: www.clw.csiro.au

NCCMA (2008). *2008/2009 Annual Watering Plan: Bulk Entitlement*, (Loddon River Environmental Reserve) Order 2005. Final Draft. NCCMA, Huntly, Victoria.

NCCMA (2005). *Wetlands Background Paper,* North Central Catchment Management Authority, Huntly.

NVIRP (2010). *Water Change Management Framework*, Version 2, Northern Victoria Irrigation Renewal Project, May 2010, Shepparton, Victoria

O'Brien, R. and Joyce, A. (2002). *Loddon Wetland Water Supply Issues Paper Meeting No. 5 20th February 2002,* prepared for the Loddon Bulk Entitlement Project Group by the Department of Primary Industries and Department of Sustainability and Environment, Victoria.

Saddlier, S., O'Connor, J., Brown, G. and Loyn, R. (2009). *Northern Victorian Irrigation Renewal Project Threatened Species – Expert Comment*, prepared by Arthur Rylah Institute for Environmental Research, Department of Sustainability and Environment, Victoria.

SKM (2008). *Food Bowl Modernisation Project – Environmental Referrals*, Document prepared for the Department of Sustainability and Environment, 13th November, Melbourne.

Tucker, P., Harper, M., Dominelli, S., van der Wielen, M., Siebentritt, M. (2002). *Your Wetland: Hydrology Guidelines,* Australian Landscape Trust, Renmark, South Australia

VEAC (2008). *River Red Gum Forests Investigation*, Final report, Victorian Environmental Assessment Council, July, Melbourne.

Appendix A: NVIRP TAC and 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
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	R & D 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	Executive Manager – MCAR 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 NVIRP. 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 GMW 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

Input provided from the members of the Little Lake Boort Committee of Management.

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:

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

- Little Lake Boort was part of the larger wetland system (Lake Boort & Lake Lyndger) that were part of the creek line and wetland system that filled and flushed during a Loddon River flood events.
- The Loddon River floodplain and its wetlands experienced highly variable rainfall and flooding conditions.
- Little Lake Boort was originally part of Lake Boort and is a slightly more elevated section on the northwestern side.
- The Kinypanial Creek is the main watercourse that delivered Loddon River floodwater into Lake Boort.
- The floodwater traveling along the Kinypanial Creek could spread out over 1 km in width.
- During wet periods the Kinypanial Creek would also receive water from the Borung Hills to the south. In more significant floods the overflow from Woolshed Swamp also reached Lake Boort.
- Little Lake Boort is the slightly elevated section of the larger wetland and supported Red Gums on the wetland floor and Black Box communities at slightly higher elevations.
- There is a well-formed lunette on the eastern side of Lake Boort and this section of the wetland would have held water for up to 12 months after a large flood event, but still regularly drying out.
- Little Lake Boort, Lake Boort and Lake Lyndger were highly productive wetlands and were important recourses to Aboriginal people.

Changed Management

- The Boort wetlands would have contained a greater diversity of native plants, insects and animals than what is present today.
- Little Lake Boort and the broader floodplain area were impacted dramatically as part of European Settlement.
- Grazing of hard hoofed domestic livestock put significant pressure on the native plants, altered the soil conditions and displaced native fauna.
- Heavy grazing of livestock diminished native plant cover and extinction of the more palatable species was likely in the mid 1800's.
- The Loddon River floods were manipulated to suit European settlers and this changed water regime altering the districts waterways and wetlands.
- Some of the large River Red Gums on the wetland floor may have initially died from excessive flooding in the 1860's and onwards. The influence of "Black Fellows Cutting" at Fernihurst was significant in pushing additional floodwater through the Boort wetlands.
- Dead tree stumps were removed from Little Lake Boort and the northwestern side of Lake Boort in 1962.
- Levees constructed on the floodplain channel the water through the creek lines and waterways and prevented the natural spread or sheet flooding of the area.
- The GMW channel was constructed in the 1920's/30's, which split Little Lake Boort from Lake Boort.
- Little Lake Boort has been managed as mostly a permanent lake since the development of the irrigation supply system (80 yrs).
- Poor quality, slightly saline Loddon River floodwater was delivered into the GMW channel system at the commencement of a flood and outfalled into Lake Boort, in the flood years of 1970's/80's, to reduce the salinity impact on Kerang's water supply.
- Various methods of opportunistic pumping to lift floodwater from Lake Boort into Little Lake Boort have been used to ensure the lake receives adequate water.
- There has been a need to flush Little Lake Boort to improve the water quality.
- The Little Lake Boort Flushing Channel was constructed in the mid 1990's to allow water and salt to be flushed out of the lake and into Lake Boort. Estimated capacity of 80 ML.
- Parks Victoria has raised environmental concerns over the intentional flushing of Little Lake Boort into Lake Boort via the flushing channel. Recent flushing events have been photographed and monitored by Little Lake Boort CoM members to ensure no negative impact on Lake Boort.
- Parks Victoria has a preference that any water flushed from Little Lake Boort into Lake Boort is done during a flood event.
- Little Lake Boort is an attractive recreational lake and provides opportunities for water skiing, boating, swimming, camping and site seeing.
- If the water levels in Little Lake Boort fall 250 mm below full supply level then the lake is considered unsafe for water skiing. This is the fourth season that they haven't been able to ski on the lake.
- Loddon River floodwater has also been delivered into Little Lake Boort, and Lake Boort via the GMW main channel. The CoM receives four days notice from GMW if there is opportunity to harvest Loddon River floodwater.
- Little Lake Boort will only receive water from the GMW channel system after all the irrigator's needs are met.
- Channel outfalls have significantly been reduced, particularly over the past 10 to 15 years and are currently insignificant.
- The outfalls into the wetlands will reduce as the channel system becomes automated.
- The groundwater levels under Lake Boort have fallen dramatically over the past 10 years and aren't seen to pose a salinity effect. They are estimated to be greater than 5 m below the bed of the wetland.

- At least 5 aquatic plants have proliferated in Little Lake Boort and there has been a need to cut and remove large areas to allow for boating access.
- The Shire developed a boat "Weed Willy" to mow and remove aquatic weeds to provide boating access, when the lake was maintained full.
- Drying the lake slightly reduced the dominance of water plants.
- Sago Pondweed has been one of the most prolific aquatic plants that needed to be harvested to allow for boating access.
- Cumbungi has the potential to spread across sections of Little Lake Boort when water levels are reduced. Currently it has invaded the inlet area of the wetland.
- A flushing pump was installed near the caravan park to allow water to be lifted from Little Lake Boort and returned back into the irrigation supply system.
- GMW has been very cooperative in working out suitable water delivery options for Little Lake Boort.
- The "Little Lake Boort Flushing Strategy" sets out rules and describes several cooperative opportunities, which allows water to be delivered into Little Lake Boort and returned to the GMW channel system for consumptive use.
- The use of the flushing pump allows the water levels in Little Lake Boort to be maintained for active recreational use and also assists keeping the wetland fresh, without disadvantaging local irrigators.
- The Loddon Shire has access to a water allocation that can be delivered into Little Lake Boort.
- The local community has generously donated money to ensure water is purchased to maintain Little Lake Boort.
- Currently there is a local community petition with 500 signatures requesting that Little Lake Boort be maintained.
- The Loddon Shire can approve on ground works around the area the CoM have responsibility for.
- There are two regulated users that divert water from Little Lake Boort however they both have access to alternate channel supply.

Environmental & Other Values

- Little Lake Boort supported a range of frogs when kept full, including the Barking Marsh Frog. Frog numbers are suspected to have dropped in response to the presence of Carp.
- Lots of Ribbon weed, yabbies, leeches, etc
- Heaps of waterbirds were present across all of the districts wetlands during the flood years of the 1950's, including Little Lake Boort.
- Consistently high numbers of waterbirds used the wetland over a long period of time, despite the lake experiencing high recreational use. Bats are also known to occur at the lake.
- Heaps of ducks use Little Lake Boort. Swans and pelicans are currently very common. Swans nest prolifically but cygnets are often taken by foxes.
- Birds return to the lake in the evening to feed and roost.
- Environmental water has been delivered into Lake Boort in recent years and the wetland has been considered a drought refuge for waterbirds and other water dependant species.
- The CoM is grateful that environmental water has been utilized to maintain some water in Little Lake Boort in recent years.
- Regular bird counts have been record at Little Lake Boort with impressive numbers and diversity. Different waterbirds use the wetland at different times and different water levels.
- Simon Starr, a keen local bird watcher, regularly brings visitors to Little Lake Boort.
- Historically Little Lake Boort is closed to duck hunting and acts as a wildlife refuge.
- Terrestrial birds like Fairy Martins are often present at very high numbers.

- An intact Black Box plant community abuts the southeastern side of the wetland. Goannas, carpet snakes and wallabies are regular visitors or residents in the surrounds.
- Little Lake Boort supported a good fishery, including lots of Red Fin and Catfish. Fish stocking has also been undertaken at Little Lake Boort (Cod, Trout, Yellow Belly).
- Water rats and tortoises where common although lost when lake levels drop.
- Carp traps were installed in the inlet channel to the lake and used over the past 2 seasons. When water is injected into Little Lake Boort, Carp swim upstream against the flow, through the road culvert at the “Ring Road” towards the GMW outfall channel. Fourteen tons of Carp have been captured and removed from Little Lake Boort.
- The fish trap has flexible fins placed on the end of the tunnel and this only permits fish that push against them to enter the containment area. Native fish aren’t known to push through the trap and no native fish have been harmed or disadvantaged.
- Geoff Sainty an aquatic plant specialist supports the targeted removal of carp at Little Lake Boort and there appears to be an improvement in the clarity of the water since large quantities of carp have been removed.
- Several environmental improvement projects have been undertaken at Little Lake Boort, including planting of emerged aquatics (Club Rush) for habitat and to protect the shore from erosion.
- Revegetation and restoration projects have also been undertaken around Little Lake Boort.
- Fluctuating the water levels in Little Lake Boort is preferable to maintaining a constant high water level.
- The walking track and the sealed ring road receive high usage from visitors who enjoy the aesthetics of the lake.
- The local community is part of the environment and their health needs to be considered as part of overall water management of Little Lake Boort.
- Many of the town’s recreational pursuits are located on the shore of Little Lake Boort, which makes them more aesthetically pleasing.
- The isolated rural communities in Boort area are dependent upon Little Lake Boort functioning for the social, recreational and economic reasons.
- There are massive economic benefits to the community with Little Lake Boort functioning as a permanent freshwater lake. The calculated benefit is around $500,000/yr.
- Increased visitation to Lake Boort (duck shooting) and Little Lake Boort (swimming, water skiing and boating) does not result in increased crime or social problems within the community, as the community amenities are valued.
- There is an increase of 3% to 4% of people when Little Lake Boort is maintained.
- Huge community support for maintaining Little Lake Boort and there is increased community interest in environmental protection.
- Currently there is an environmental loss due to very low/almost dry lake levels.

Suggested Future Management

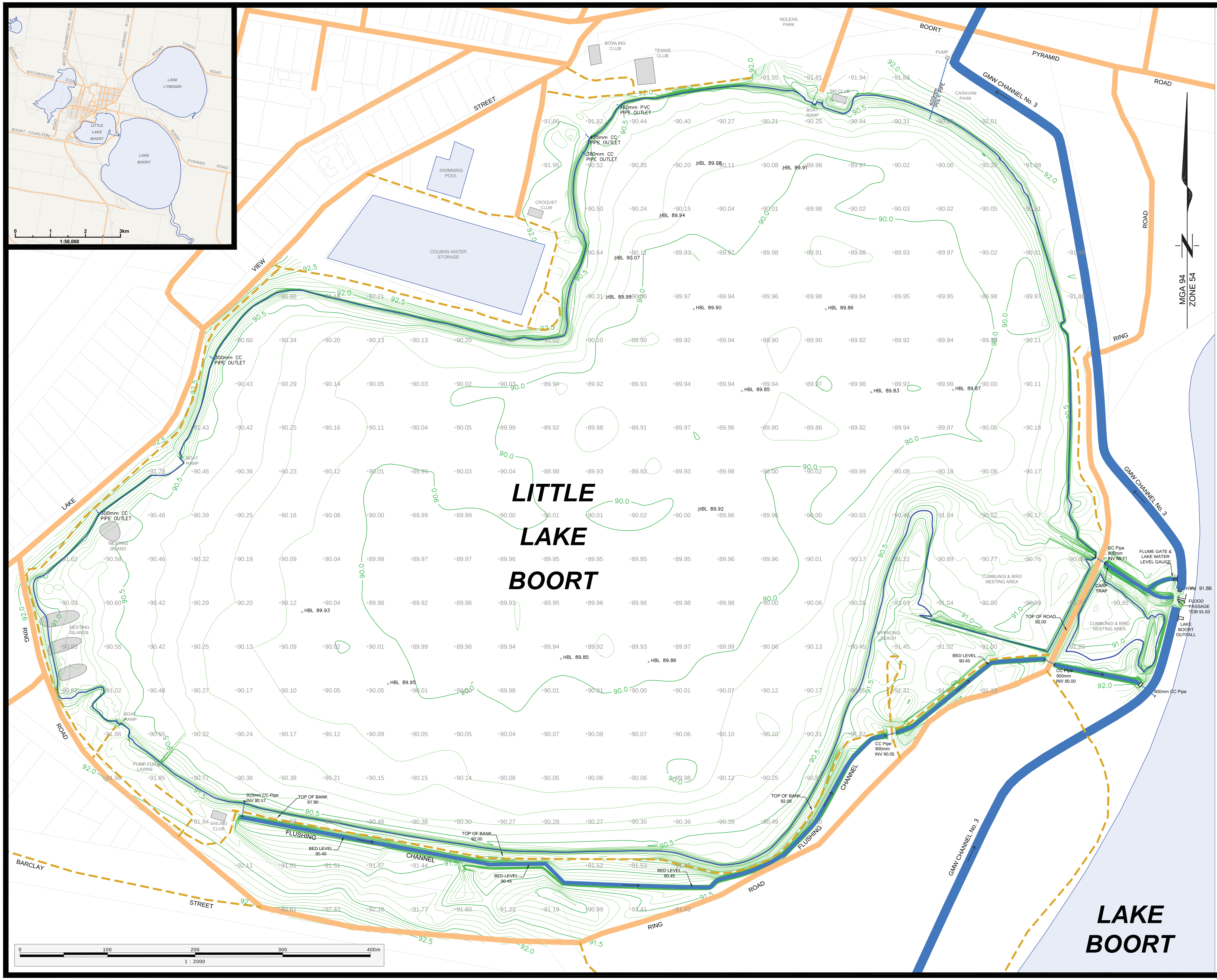
- The long-term water management of Little Lake Boort needs to consider the environment of the lake along with the social, recreational and economic benefits to the community. A cooperative approach would give multiple benefits.
- A permanent water regime is the preferred water regime as it does not disadvantage the other important values that the wetland provides (social, recreational and economic).
- The occasional flushing of the lake, either via the flushing channel or the return pump to the GMW channel is required periodically to prevent salt accumulation within the wetland and maintaining the water quality below 1500 EC.

- It's very important to advertise and explain the purpose and use of the environmental water allocation. More media explanation, face-to-face presentations and articles and stories are recommended.
- More agency interaction with the CoM and local community in the area in recommended as continual staff changes deduces the partnerships that can be developed.

Key Points

- Little Lake Boort was originally a high value ephemeral, Red Gum/Black Box swamp that received highly variable Loddon River flood flows. These wetlands were well connected to each other and a series of shallow meandering, vegetated creek lines.
- Wetland has been dramatically altered over time since European Settlement and been managed as a permanent freshwater lake since the 1920's developing new environmental values.
- The lake has supported an impressive number and range of water dependant species while still providing for active recreational activities.
- In more recent times the wetland has provided an important drought refuge and received environmental water delivery.
- The management of Lake Boort needs to consider the environmental values and also the important social, recreational and economic values.

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



Lake Capacity Table

Elevation m (AHD)	Capacity ML	Surface Area Ha
89.80	0.0	0.0
89.90	0.2	1.1
90.00	10.5	23.7
90.10	43.1	39.4
90.20	87.1	48.2
90.30	137.9	53.1
90.40	193.1	57.3
90.50	252.6	61.6
90.60	315.4	63.8
90.70	379.9	65.1
90.80	445.7	66.6
90.90	513.1	68.1
91.00	581.7	69.2
91.10	651.2	69.8
91.20	721.3	70.4
91.30	792.0	71.1
91.40	863.4	71.7
*91.50	935.4	72.3
**91.60	1,008.1	73.1
91.70	1,081.6	74.0
91.80	1,156.1	75.1

*Operating Full Supply Level
**Maximum Water Level

LEGEND

- HBL 65.08 — HARD BED LEVEL
- H/W 65.08 — TOP OF HEADWALL
- INV 65.08 — PIPE INVERT LEVEL
- HWM 65.08 — HIGH WATER MARK
- CONCRETE HEADWALL / STRUCTURE
- 65.08 — EXISTING SURFACE LEVEL
- LOT BOUNDARIES (APPROX.)
- TRACK
- ROAD
- CHANNEL
- MAJOR CONTOUR (1.0m INTERVAL)
- MINOR CONTOUR (0.20m INTERVAL)
- PIPE
- PERIMETER / FULL SUPPLY LEVEL
- DAM / LAKE

ARCHARDS IRRIGATION PTY LTD
A RURALCO BUSINESS
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LEITCHVILLE ROAD
COHUNA 3568
PH: 03 5453 2664
FAX: 03 5456 3226
www.archards.com.au
survey@archards.com.au

PROJECT NUMBER: 3817
CLIENT: NCCMA
PROJECT: LITTLE LAKE BOORT
PLAN TITLE: CONTOUR PLAN & CAPACITY TABLE
SITE LOCATION: BOORT VIC 3537

PROJECTION: MGA 94 ZONE 54
HORIZONTAL DATUM: GDA 94
HEIGHT DATUM: AHD
SURVEY BY: DC
SURVEY DATE: 30/01/2010

SHEET SIZE: A0
SCALE: 1:2000
DRAWN BY: DC
LAST AMENDED: 02/03/2010

FILENAME:
3718 Little Boort Lake.dwg

Appendix D: Wetland characteristics

Characteristics	Description
Wetland Name	Little Lake Boort
Wetland ID	7625 450990
Wetland Area	72 ha at 91.5 m AHD, 595 ha reserve
Conservation Status	Bioregionally Important Wetland
Land Manager	Little Lake Boort Committee of Management
Surrounding Land Use	Residential and recreational facilities
Water Supply	Natural: Kinypanial Creek Current: Channel outfalls (no. 3) • Channel capacity: 100 ML/day, • Siphon capacity: 100 ML/day • Regulator capacity: 80 ML/day (approx. 12 days) • Recent delivery rate: 20 – 30 ML/day
1788 Wetland Classification	Category: Permanent Open Freshwater
1994 Wetland Classification	Category: Deep Freshwater Marsh Subcategories: open water
Wetland Capacity	935 ML, *FSL 91.5 m AHD* (Archards Irrigation 2010)
Outfall Volumes	144 ML (04/05) 160ML (97/98 to 07/08 average)

Appendix E: Flora and fauna species list

Compiled: September 2009

Sources:

Campbell *et al*. (2009)

DSE (2009a)

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: January 2015

Sources:

eBird Website (2014)

North Central Catchment Management Authority bird monitoring records (2014).

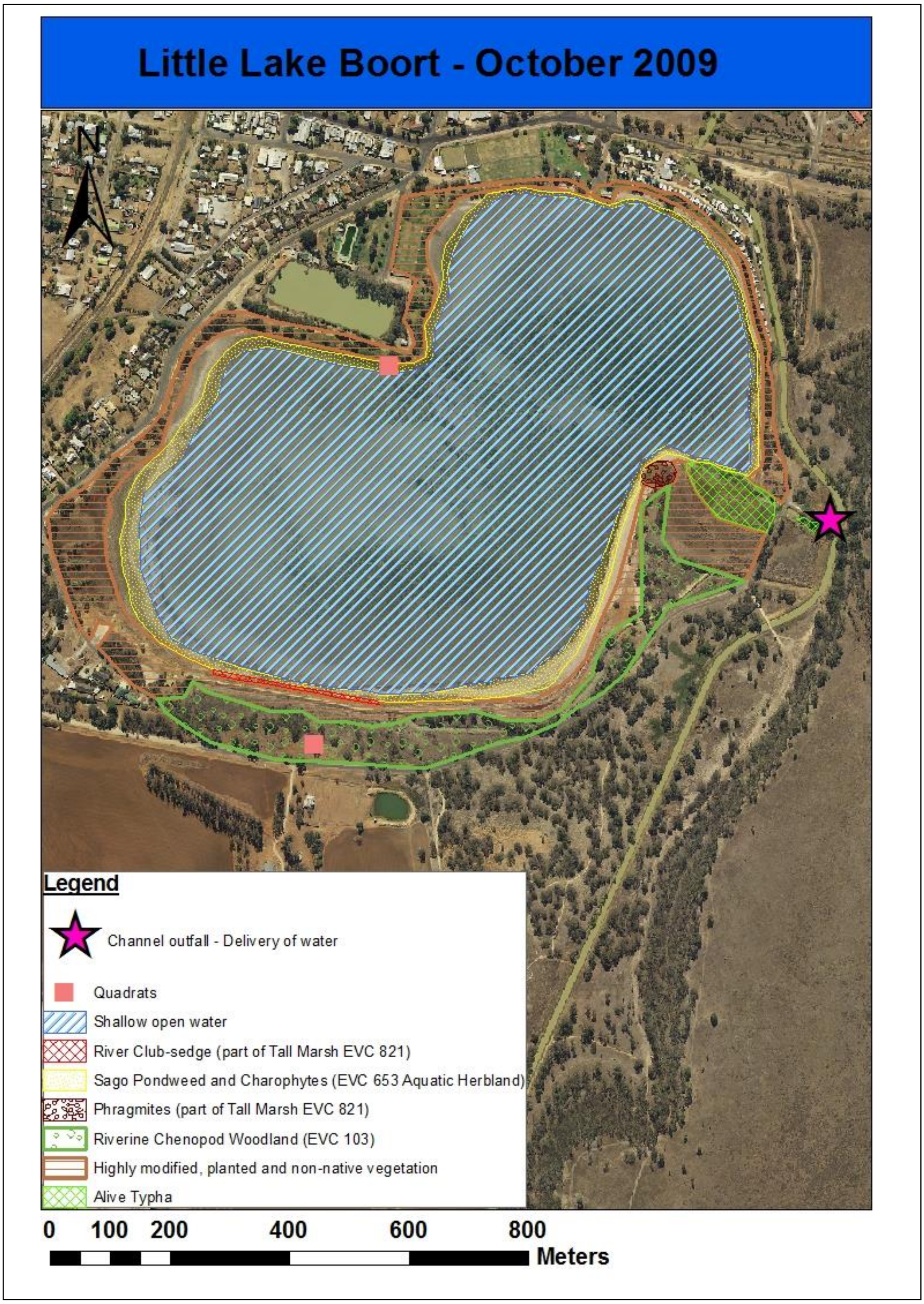
Common Name	Scientific Name
Fauna - native	
Australasian Grebe	*Tachybaptus novaehollandiae*
Australasian Shoveler	*Anas rhynchotis*
Australian Hobby	*Falco longipennis*
Australian Magpie	*Gymnorhina tibicen*
Australian Pelican	*Pelecanus conspicillatus*
Australian Raven	*Corvus coronoides*
Australian Reed-warbler	*Acrocephalus australis*
Australian Shelduck	*Tadorna tadornoides*
Australian Smelt	*Retropinna semoni*
Australian White Ibis	*Threskiornis molucca*
Australian Wood Duck	*Chenonetta jubata*
Baillon's Crake	*Porzana pusilla*
Barking Marsh Frog	*Lymnodynastes fletcheri*
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-faced Honeyeater	*Entomyzon cyanotis*
Bony Herring	*Nematalosa erebi*
Brown Falcon	*Falco berigora*
Brown Goshawk	*Accipiter fasciatus*
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*
Brown Quail	*Coturnix ypsilophora*
Buff-banded Rail	*Gallirallus philippensis*
Caspian Tern	*Hydroprogne caspia*
Chestnut Teal	*Anas castanea*
Clamorous Reed Warbler	*Acrocephalus stentoreus*
Collared Sparrowhawk	*Accipiter cirrhocephalus*
Common Brushtail Possum	*Trichosurus vulpecula*
Common Froglet	*Crinia signifera*
Crested Pigeon	*Ocyphaps lophotes*
Darter	*Anhinga novaehollandiae*
Dusky Moorhen	*Gallinula tenebrosa*
Eastern Brown Snake	*Pseudonaja textilis*

Common Name	Scientific Name
Eastern Great Egret	*Ardea modesta*
Eastern Rosella	*Platycercus eximius*
Eurasian Coot	*Fulica atra*
Fairy Martin	*Hirundo ariel*
Flat-headed Gudgeon	*Philypnodon grandiceps*
Freckled Duck	*Stictonetta naevosa*
Freshwater catfish	*Tandanus tandanus*
Galah	*Eolophus roseicapilla*
Glossy Ibis	*Plegadis falcinellus*
Golden Perch	*Macquaria ambigua*
Great Cormorant	*Phalacrocorax carbo*
Great Crested Grebe	*Podiceps cristatus*
Greenshank	*Tringa nebularia*
Grey Shrike-thrush	*Colluricincla harmonica*
Grey Teal	*Anas gracilis*
Grey-crowned Babbler	*Pomatostomus temporalis*
Growling Grass Frog	*Litoria raniformis*
Hardhead	*Aythya australis*
Hoary-headed Grebe	*Poliocephalus poliocephalus*
Intermediate Egret	*Ardea intermedia*
Latham's Snipe	*Gallinago hardwickii*
Laughing Kookaburra	*Dacelo novaeguineae*
Little Black Cormorant	*Phalacrocorax sulcirostris*
Little Eagle	*Hieraaetus morphnoides*
Little Grassbird	*Megalurus gramineus*
Little Pied Cormorant	*Microcarbo melanoleucos*
Long-billed Corella	*Cacatua tenuirostris*
Magpie-lark	*Grallina cyanoleuca*
Masked Lapwing	*Vanellus miles*
Musk Duck	*Biziura lobata*
Musk Lorikeet	*Glossopsitta concinna*
Nankeen Kestrel	*Falco cenchroides*
Nankeen Night Heron	*Nycticorax caledonicus*
Noisy Miner	*Manorina melanocephala*
Pacific Black Duck	*Anas superciliosa*
Pacific Swift	*Apus pacificus*
Peaceful Dove	*Geopelia striata*
Pied Butcherbird	*Cracticus nigrogularis*
Pied Cormorant	*Phalacrocorax varius*
Pink-eared Duck	*Malacorhynchus membranaceus*
Plumed Whistling Duck	*Dendrocygna eytoni*
Purple Swamphen	*Porphyrio porphyrio*
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*
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*
Restless Flycatcher	*Myiagra inquieta*
Royal Spoonbill	*Platalea regia*
Sacred Kingfisher	*Todiramphus sanctus*
Silver Gull	*Chroicocephalus novaehollandiae*
Spotted Crake	*Porzana porzana*
Straw-necked Ibis	*Threskiornis spinicollis*
Striated Pardalote	*Pardalotus striatus*
Superb Fairy-wren	*Malurus cyaneus*

Common Name	Scientific Name
Swamp Harrier	*Circus approximans*
Swift Parrot	*Lathamus discolor*
Tree Martin	*Hirundo nigricans*
Wedge-tailed Eagle	*Aquila audax*
Welcome Swallow	*Hirundo neoxena*
Whiskered Tern Whistling Duck	*Chlidonias hybridus* *Dendrocygna eytoni*
Whistling Kite	*Haliastur sphenurus*
White Faced Heron	*Egretta novaehollandiae*
White bellied Sea-Eagle	*Haliaeetus leucogaster*
White-breasted Woodswallow	*Artamus leucorynchus*
White-browed Woodswallow	*Artamus superciliosus*
White-faced Heron	*Egretta novaehollandiae*
White-necked Heron	*Ardea pacifica*
White-plumed Honeyeater	*Lichenostomus penicillatus*
Willie Wagtail	*Rhipidura leucophrys*
Yellow-billed Spoonbill	*Platalea flavipes*
Fauna - exotic	
Black Rat	*Rattus rattus*
Carp	*Cyprinus carpio*
Common Starling	*Sturnus vulgaris*
European Goldfinch	*Carduelis carduelis*
Goldfish	*Carassius auratus*
House Sparrow	*Passer domesticus*
Mallard	*Anas platyrhynchos*
Redfin Perch	*Perca fluviatilis*
Tench	*Tinca tinca*
Flora - native	
Black Box	*Eucalyptus largiflorens*
Charophyte	*Charophyte*
Chenopod	*Chenopodium sp*
Common Reed	*Phragmites australis*
Cumbungi	*Typha sp.*
Fennel Pondweed	*Potamogeton pectinatus*
Pale Spike-sedge	*Eleocharis pallens*
River Club-sedge	*Schoenoplectus tabernaemontani*
Rush	*(#185) Juncus sp.*
Rush	*(#192) Juncus sp.*
Spiny Flat-sedge	*Cyperus gymnocaulos*
Flora - exotic	
Aster-weed	*Aster subulatus*
Barley Grass	*Hordeum sp.*
Buck's-horn Plantain	*Plantago coronopus ssp. coronopus*
Celery Buttercup	*Ranunculus scleratus ssp. scleratus*
Gazania	*Gazania sp.*
Giant Honey-myrtle	*Melaleuca armillaris ssp. armillaris*
Kikuyu	*Pennisetum clandestinum*
Little Medic	*Medicago minima*
Ox-tongue	*Helminthotheca echioides*
Paradoxical Canary-grass	*Phalaris paradoxa*
Pepper Tree	*Schinus mollee*
Perennial Beard-grass	*Polypogon lutosus*
Rough Sow-thistle	*Sonchus asper s.l.*
Spear Thistle	*Cirsium vulgare*
Willow	*Salix sp.*

Appendix F: Vegetation composition map – 22 October 2009

Vegetation composition mapping 2009



Appendix G: Hydrology (SWET OUTPUT)

set	Wetland Name	Little Lake Boort							
		Degrees	Degrees	Minutes					
set	Latitude	-36.12216	-36.00	7.3297					
set	Longitude	143.72584	143.00	43.5505					
		Metres (AHD)							
	Altitude	91.8						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	383	0	0.052	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	20							
		mm/day							
adjust	Maximum artificial filling rate	20							

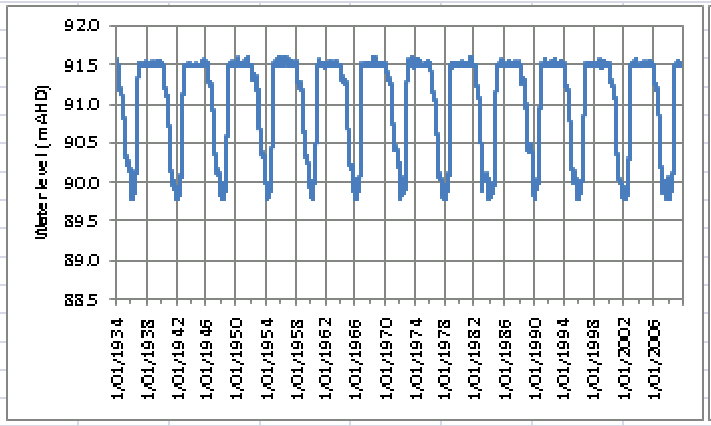
	Management parameters	Day	Month	Start day
adjust	Earliest start to fill	1	9	244
adjust	Latest start to fill	31	12	
adjust	Duration wet cycle - includes filling	1278	42	
adjust	Duration dry cycle - includes drawdown	913	30	
set	Start condition	Wet		Years
set	Maximum wet-dry cycle length			6

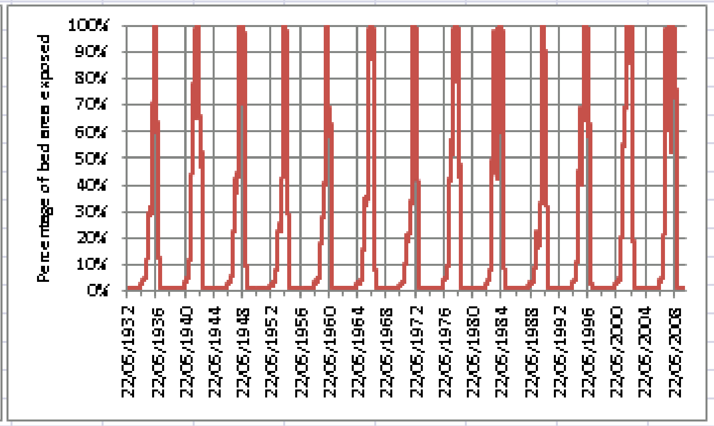
To operate the model
First fill in the required input data cells.
Calculation is set to Manual, so
when ready press Function9 (F9) key
It takes 20 seconds to re-calculate and plot

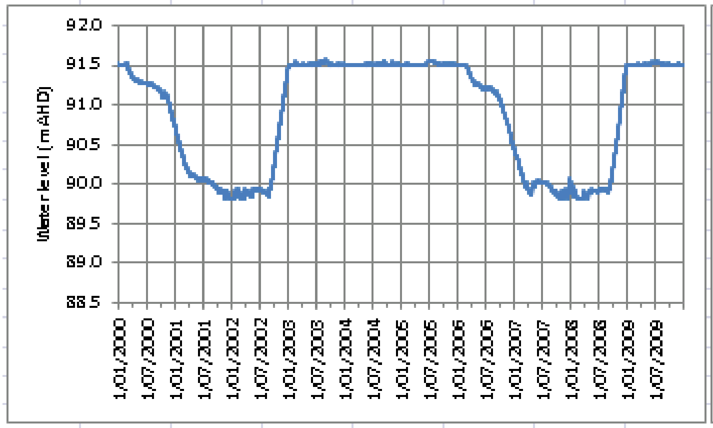
		Day	Month	
adjust	Irrigation year start	1	9	
		Elevation	Volume	Area
adjust	Target level	91.5	935400	723000
		Elevation	Volume	Area
set	Wetland spill level	91.6	1008100	731000
		Elevation	Tolerance for drawdown (m)	
adjust	Lowest wetland level	89.8	0.1	
			1 = Pan; 2 = Modelled	
choose	Factored Pan evaporation or modelled ET method?		2	

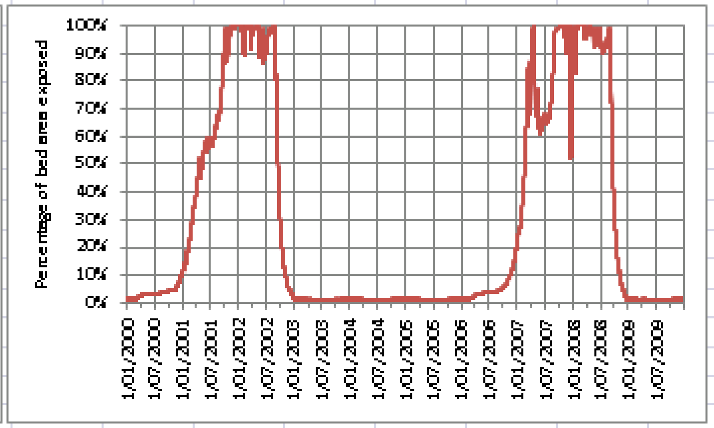
RESULT			
	ML/year	P95 (ML/yr)	Years with no inflow
Mean long-term annual artificial water inflows	645	1,778	40 in 118 years
	ML	No. Periods	Record length (years)
Average water inflows for filling periods	3,878	20	118
Drawdowns over record (number of)	20		
Drawdowns not fully drawn down (number of)	1		
Drawdowns not fully drawn down (percentage)	5%		
95th percentile duration of full period (months)	38.8		
50th percentile duration of full period (months)	38.1		

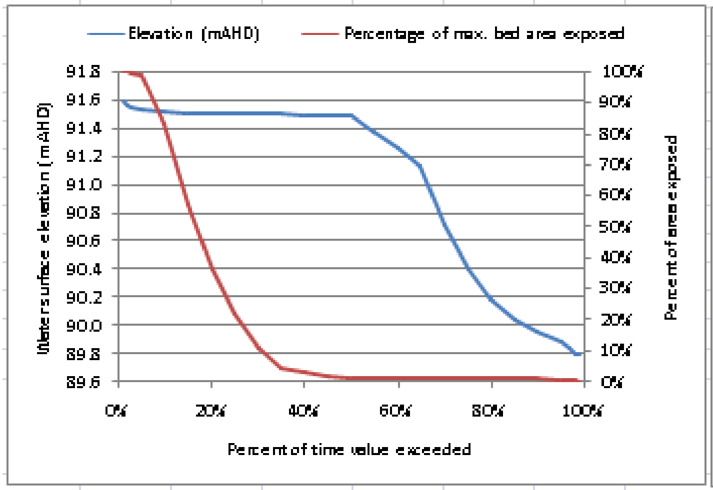
Fill cycle length (yr)	No. cycles
1	
2	
3	
4	
5	
6	20
7	
8	
9	
10	

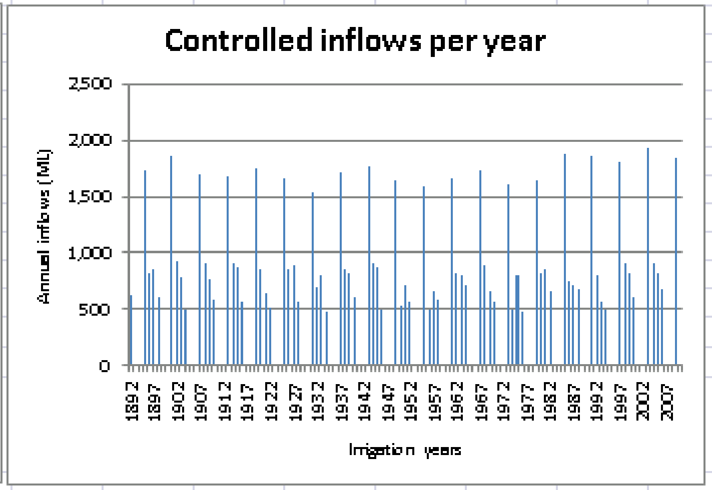












Appendix H: Preliminary leakage and seepage loss contribution calculations

Wetland	Wetland <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)
Little Lake Boort	Yes	1000	12	channel 3	10 m	7	14	20	27	7	27

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 ArcGIS

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		
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, fauna (waterbirds, fish and frogs), water quality and groundwater monitoring Adaptively manage watering regime and delivery. Re-model volumes required in light of changing climatic conditions, additional water sources and wetland phase.
Limited water availability (i.e. no environmental water allocation to provide the desired water regime)	Failure to achieve identified objectives and 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, other water sources 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 as above. Re-model volumes required in light of changing climatic conditions, other water sources and wetland phase.
Poor water quality (i.e. temperature fluctuations, blackwater events, high turbidity, salinity and nutrient levels)	Reduced primary production (turbid water), limiting food resources for aquatic invertebrates and waterbirds. Excessive algal growth	Monitoring of groundwater levels, salinity and nutrient inputs in conjunction with a regular water quality monitoring program. Continue using the flushing channel and pump in accordance with operational recommendations. Adaptively manage watering regime and delivery.
Ecological Response		
Unreliable supply of food/nesting sites	Limited occurrences of waterbirds	Seasonal water delivery, regular monitoring (spring assessments) and adaptive management of watering regime to ensure suitable habitat is provided throughout breeding events.
Lag time between wetland watering and bird breeding	No successful breeding events	Seasonal water delivery, regular monitoring (spring assessments) and adaptive management of watering regime Top-ups may be required complete bird breeding events
Proliferation of pest plants and animals (e.g. Common Carp)	Reduced habitat and resource availability Predation Limited establishment of native vegetation	Continue harvesting Common Carp during filling periods. • Consider installing a 'large bodied fish exclusion screen' in the no. 3 channel. Regular monitoring (e.g. IWC assessments)

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 Little Lake Boort. 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.

It is recommended that an environmental monitoring plan is developed for the wetland, to ensure planned analysis and reporting of the impacts of the adopted watering regime (Bartley Consulting 2010).

1. Long Term condition monitoring

Long term condition monitoring is recommended in order to evaluate any changes to wetland values (particularly vegetation and groundwater) 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 Little Lake Boort.

Vegetation Condition and Distribution

A number of photo points and objectives for long term vegetation monitoring need to be established for Little Lake Boort 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, on a yearly basis to capture vegetation condition and distribution. It is recommended that a database be compiled in order to store details of the monitoring photos captured.

It is also recommended that the condition and distribution of vegetation communities, including exotic species, throughout Little Lake Boort, are assessed every five years 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). It is recommended that an IWC assessment be completed for Little Lake Boort every 5 years. However, this may need to be undertaken sooner depending on the rate of response to watering (DSE 2005b) and 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 immediate vicinity of Little Lake Boort is currently conducted by DEDJTR and local volunteers (Section 4.3). 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.

It is recommended that the environmental monitoring plan to be prepared for the wetland 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.

Table J1 identifies additional recommendations for improving the long-term groundwater monitoring at Little Lake Boort and to enhance the quality of data being collected (Bartley Consulting 2010).

Table J1: Additional groundwater monitoring recommendations (Bartley Consulting 2010)

Target	Recommendation
Long-term groundwater monitoring	A review of the groundwater-related aspects of the site, including a re-assessment of environmental risks, is undertaken at least every seven years and sooner if data becomes available from newly installed bores, or the water regime is changed, or if regional groundwater levels rise.
	The impact of any water regime change is reviewed and assessed in accordance with the requirements of the environmental monitoring plan, and subject to the availability of suitable data should include an appraisal of the movement of the wetting front and salt, impacts on surrounding groundwater levels and neighbouring land, and a water budget that includes estimates of

Target	Recommendation
	accessions to groundwater.
Data quality	Installing data loggers in selected groundwater bores, to provide data before watering and throughout the wetting and drying cycle at the site
	Installing data loggers to record surface water level and salinity at the inlet, in the Lake, and at all discharge points, supported by manual readings
	Using volume rating tables to assist recording level and volume, to verify surface water data logger readings
Breadth of data collected	Identifying and monitoring neighbouring areas that are considered susceptible to salinisation or waterlogging
	Installation of shallow and deep groundwater monitoring bores, at three locations - on the western, northern and southeastern sides of the site
	Investigating the potential for seepage from Channel No.3 and possible impacts on a dry lake floor
	Assessing the watertable depth and soil and salinity profile beneath the site floor

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 wetland.

Vegetation

Following the provision of water 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. Monthly monitoring is recommended and snapshot assessments should incorporate the components outlined in Table J2. A database of any previous flora records has been compiled for Little Lake Boort and should be updated following regular monitoring.

Table J2: Components of vegetation intervention monitoring

Component	Target	Method	Objective
Vegetation distribution	Submerged aquatic macrophyte vegetation, Tall Marsh habitat	• Distribution mapping • Photo points	Habitat objectives, species/community objectives
Vegetation condition		• Photo points	Habitat objectives
Species diversity	Additional species with a focus on submerged aquatic macrophyte habitat	• Species list comparison	Habitat objectives

Waterbirds

The diversity and abundance of waterbirds at Little Lake Boort needs to be monitored following watering for the duration of the inundation period in order to assess the success of implementation and achievement of objectives. It is essential that commentary on abundance and breeding events informs the adaptive management of the delivered water regime.

Waterbird monitoring is currently undertaken by DELWP under a contract with North Central CMA. Monthly monitoring as water levels fluctuate will ensure changes in bird communities are captured (Baldwin et al. 2005). It is essential that spring surveys are conducted to adequately monitor breeding events and to inform the adaptive management of the water regime (i.e. providing top-ups to maintain water levels in order to complete breeding events). Numerous previous surveys and records are available to provide baseline data in order to evaluate the response of waterbirds to the provision of water. A database has been compiled of all recordings made at Little Lake Boort and should be updated regularly following monitoring. Table J3 outlines the recommended components of waterbird monitoring.

Table J3: Components of intervention monitoring of waterbirds

Component	Target	Method	Objective
Species	All species including those of	• Area searches (Baldwin et al.	Habitat

Component	Target	Method	Objective
diversity	conservation significance	2005)	objectives, 2.1
Waterbird abundance			Habitat objectives, 2.1
Habitat availability	Open water (including aquatic and amphibious species), mudflats, tall marsh vegetation, Riverine Chenopod Woodland	• Undertaken in conjunction with vegetation monitoring	Habitat objectives, 2.1
Breeding populations	e.g. Black Swan,	• Nest surveys (Baldwin et al. 2005)	Habitat objectives, 2.1

Fish, amphibians and macroinvertebrates

It is recommended that the response of fish, amphibians and macroinvertebrates is monitored following watering as they provide important food sources for several waterbirds. Growling Grass Frog, a federally listed species, has previously been recorded at Little Lake Boort. Continued monitoring of the species is recommended to inform the adaptive management of the water regime. In addition, Common Carp exist within Little Lake Boort and continued monitoring would provide information feedback on the success of the carp trap. Numerous surveys and records exist to provide baseline data to enable evaluation of the response to watering. A database has also been compiled of all recordings made at Little Lake Boort and should be updated regularly following monitoring. Table J4 details the components to be incorporated in monitoring fish and macroinvertebrates. Incidental observations of reptiles should also be recorded.

The results of the monitoring should also be used to inform the assessment of habitat availability for waterbirds as they provide a significant food source for a number of species.

Table J4: Components of intervention monitoring for fish and macroinvertebrates

Component	Target	Method	Objective
Species diversity	All species including those of conservation significance	• Electrofishing, bait trapping, seine and fyke netting (Baldwin et al. 2005) • Sweep netting/AusRivas • Call playback, funnel trapping, drift fences and pit traps (Baldwin et al. 2005)	Habitat objectives, 2.1, 2.2
Species abundance			

Water Quality

A monthly water quality monitoring program is required for development prior to watering the wetland. The program will assess water quality in conjunction with water level fluctuations. Table J5 identifies elements to be considered as part of the water quality monitoring program.

Table J5: 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

Little Lake Boort

Contours and Vegetation

Legend

Parcel

Parcel

Little Lake Boort Contours

ELEVATION

1.0m

0.5m

0.1m

Watercourse

River

Stream

Channel

Connector

Roads

Freeway

Highway

Major Road

Arterial Road

Road

Residential Street

Track

Vegetation - MDFRC 2009

Exotic

Planted non-native vegetation

Native

Sago Pondweed and Chara sp.

Alive Cumbungi (part of Tall Marsh EVC 821)

Common Reed (part of Tall Marsh EVC 821)

River Club-sedge & Cumbungi (part of Tall Marsh EVC 821)

Infrastructure

Channel outfall

Waterbody

Shallow open water

Meters

260 130 0 260

1:8,000

N W E S

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