LAKE MERAN

ENVIRONMENTAL WATERING PLAN

NORTH CENTRAL
Catchment Management Authority
Connecting Rivers, Landscapes, People

PREPARED FOR THE
NORTHERN VICTORIA IRRIGATION RENEWAL PROJECT

Northern Victoria Irrigation Renewal Project
NVIRP

June 2010

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The Lake Meran 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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EXECUTIVE SUMMARY

The Lake Meran Environmental Watering Plan (EWP) documents the approach to mitigating the potential impacts of the Northern Victoria Irrigation Renewal Project (NVIRP) 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 Lake Meran will be achieved for the NVIRP project. The main conclusions are summarised below.

Defining the environmental values of Lake Meran
Lake Meran is a bioregionally important wetland occupying 180 ha of a 210 ha Lake Reserve. It is highly valued due to its size and depth, as a recreational lake, and for providing important habitat for a variety of flora and fauna species.

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

Lake Meran water management goal:
To provide a water regime that supports a permanent open freshwater lake with open water and associated flora and fauna communities, which dries out occasionally (e.g. one in ten years). In the intervening period until the lake is filled, maintain the emergent aquatic plant community (EVC 821: Tall Marsh) at the channel outfall within the natural inlet creek and southern basin to ensure a seed/egg source is sustained over dry periods.

Maintaining Lake Meran as a permanent open freshwater wetland may be achieved from a significant environmental water allocation or via Loddon River floods with the addition of top–ups from environmental water (dependent on the magnitude of the Loddon flood).

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 are identified, and a desired water regime required to achieve the water management goal is described.

Wetland water regime:
Fill wetland to 82 m AHD (~7 m), allow water levels to recede to approximately 79.5 m AHD and maintain inundation for at least nine in ten years allowing water levels to fluctuate by evaporation or as a result of operational management. Inundate the fringing Intermittent Swampy Woodland (EVC 813) with scattered Tangled Lignum (*Muehlenbeckia florulenta*) for two to three months one in five years (~ 82 m AHD).

In the interim, provide short pulse flows each year to maintain the emergent aquatic plant community (EVC 821: Tall Marsh) currently persisting at the channel outfall within the natural inlet creek to Lake Meran and the southern basin.

An indication of the volumes of water required to provide the desired water regime for Lake Meran has 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 at 79.5 m AHD for nine in ten years is 14,015 ML. The maximum volume ever likely to be required over any 12 month period (95th percentile mean annual volume) is 2,706 ML.

The additional volume of water required for surcharging levels to 82 m AHD (i.e. one in five years) is currently unquantified. It is recommended that the environmental water manager assesses and calculates the additional volume of water required when watering is planned.

Assessment of mitigation water requirement
Mitigation water is defined as the volume of water required to ensure no net impacts on high environmental values resulting from NVIRP.

The assessment of the requirement for mitigation water for Lake Meran demonstrates that the **incidental outfall water provides benefits to the wetland and that the provision of mitigation water is warranted.** If the volume of outfall water was to be reduced or removed, additional water would need to be secured to provide annual flows in order to maintain the

Tall Marsh vegetation that provides habitat for a variety of fauna species and would enhance opportunities for recolonisation of Lake Meran when filled.

The incidental water at the origin was 147 ML in the baseline year and the annualised baseline mitigation water volume was calculated as 147 ML. The Mitigation Water Commitment for Lake Meran is 100%. 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. Diversion licences permitting the opportunistic extraction of approximately 1500 ML from Lake Meran are currently held by adjoining landholders. The conditions of this licence threaten the achievement of the water management goal and associated objectives. It is recommended that alternative supply options are investigated and the licence conditions are reviewed.

Infrastructure requirements

At present, Lake Meran is empty and would require significant volumes of water to fill it to full supply level (storage capacity of 9,812 ML) or the target level of 82 m AHD (storage capacity of 7,710 ML). A delivery rate of 80 ML/day (based on the potential restriction of the siphon that passes water beneath Pickles Canal) would allow Lake Meran to be filled in approximately 115 days (assuming no losses). It is considered likely that the current delivery infrastructure would be used predominately to provide small pulse flows to maintain the emergent aquatic plant community or ‘top-ups’ when full. The current delivery infrastructure is considered adequate to deliver these smaller flows and no infrastructure upgrades are recommended as part of NVIRP.

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

Governance arrangements

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

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ACKNOWLEDGEMENTS

The information contained in the Lake Meran 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.

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- NVIRP Technical Advisory Committee (listed in Appendix A, Table A1)
- Wetland workshop attendees (listed in Appendix A, Table A2)
- Graham Hall, Bridie Velik-Lord, Rebecca Horsburgh, Peter McRostie, Lyndall Rowley (North Central CMA).

ABBREVIATIONS

AAV	Aboriginal Affairs Victoria
AVW	Atlas of Victorian Wildlife
ANCA	Australian Nature Conservation Agency
AUSRIVAS	Australian River Assessment System
BE	Bulk Entitlement
BONN	Convention on the Conservation of Migratory Species of Wild Animals
CAMBA	China–Australia Migratory Bird Agreement
CMA	Catchment Management Authority
CoM	Committee of Management
DCFL	Department of Conservation Forests and Lands
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
EC	Electrical conductivity
EES	Environmental Effects Statement
EPBC	*Environment Protection and Biodiversity Conservation Act 1999*
ERP	Expert Review Panel
EVC	Ecological Vegetation Class
EWH	Environmental Water Holder
EWP	Environmental Watering Plan
FFG	*Flora and Fauna Guarantee Act 1988*
FIS	Flora Information System
FSL	Full Supply Level
GIS	Geographic Information Systems
GL	Gigalitre (one billion litres)
GMID	Goulburn Murray Irrigation District
G-MW	Goulburn–Murray Water
JAMBA	Japan–Australia Migratory Bird Agreement
LTCE	Long-term Cap Equivalent
MDFRC	Murray-Darling Freshwater Research Centre
MNES	Matters of National Environmental Significance
North Central CMA	North Central Catchment Management Authority
NVIRP	Northern Victoria Irrigation Renewal Project
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
SEMP	Site Environmental Management Plan
SWET	Savings at Wetlands from Evapotranspiration daily Time-Series
TAC	Technical Advisory Committee
TIS	Torrumbarry Irrigation System
VEAC	Victorian Environmental Assessment Council
VROTS	Victorian Rare or Threatened Species

1. Northern Victoria Irrigation Renewal Project

The Northern Victoria Irrigation Renewal Project (NVIRP) is a $2 billion works program to upgrade ageing irrigation infrastructure across the Goulburn Murray Irrigation District (GMID) and to save water lost through leakage, seepage, evaporation and system inefficiencies. Works will include lining and automating channels, building pipelines and installing new, modern metering technology. These combined works will improve the irrigation system's delivery efficiency and recover a long term average (LTCE) of 425 GL of water per year.

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

1.1. Decision under the Environmental Effects Act 1978

On the 14 April 2009, the Minister for Planning made a decision that an Environment Effects Statement (EES) was not required for the NVIRP 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*

NVIRP have developed a Water Change Management Framework (NVIRP 2010) in response to this condition. The framework outlines the processes and methods for preparing Environmental Watering Plans to mitigate potential impacts on wetlands and waterways at risk from the implementation of the NVIRP through adaptive water management (NVIRP 2010).

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

1.2. Water Change Management Framework

The Water Change Management Framework (NVIRP 2010) sets out the overarching principles with respect to environmental management for the operation of the modified GMID. These principles include:

- NVIRP will strive for efficiency in both water supply and farm watering systems.
- NVIRP will design and construct the modernised GMID system to comply with environmental requirements as specified in the no-EES conditions.
- NVIRP will develop management and mitigation measures consistent with established environmental policies and programs in place in the GMID.
- Renewal or refurbishment of water infrastructure will be undertaken to the current best environmental practice, including any requirements to better provide environmental water. Best environmental practice will require irrigation infrastructure required to deliver environmental water to be retained (no rationalisation at these sites) or upgraded to allow for future use.
- Management and mitigation measures will be maintained into the future through establishment of or modification to operating protocols and operational arrangements.

In October 2008, the Food Bowl Modernisation Project Environmental Referrals Report (SKM 2008) assessed Stage 1 (upgrade of the backbone and connections) of the NVIRP 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) prioritised 10 wetlands and four rivers with significant environmental values that may be impacted by the NVIRP, particularly by significant reductions in channel outfalls across the GMID.

The 10 wetlands are:

- Lake Elizabeth
- Lake Murphy
- Johnson Swamp
- McDonalds Swamp
- Round Lake
- Lake Meran
- Little Lake Meran
- Lake Leaghur
- Lake Yando
- Little Lake Boort

The above wetlands are located within the North Central CMA region and require the development of an EWP. The Johnson Swamp EWP, and Interim Lake Murphy and Lake Elizabeth EWPs were completed prior to the operation of NVIRP works in the 2009-2010 irrigation season.

While NVIRP 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 NVIRP 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 (NVIRP 2010).

1.3. 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 (NVIRP 2010). Each EWP will:

- identify environmental values of the wetland
- identify the water required to protect the environmental values
- define the environmental water regime and the sources of water
- identifying if there is a need to provide mitigation water and, if so, determine the quantification of mitigation water
- identify the infrastructure requirements
- identify 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 the land, water and catchment managers.

NVIRP 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. NVIRP 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 (NVIRP 2010).

1.4. Development process

The Lake Meran EWP was developed in collaboration with key stakeholders including G-MW, NVIRP, the Department of Sustainability and Environment (DSE), Parks Victoria and the Department of Primary Industries (DPI) 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 will be reviewed by the DSE Approvals Working Group (membership comprised of departmental representatives) and the Expert Review Panel (ERP) prior to consideration by the Minister for Water.

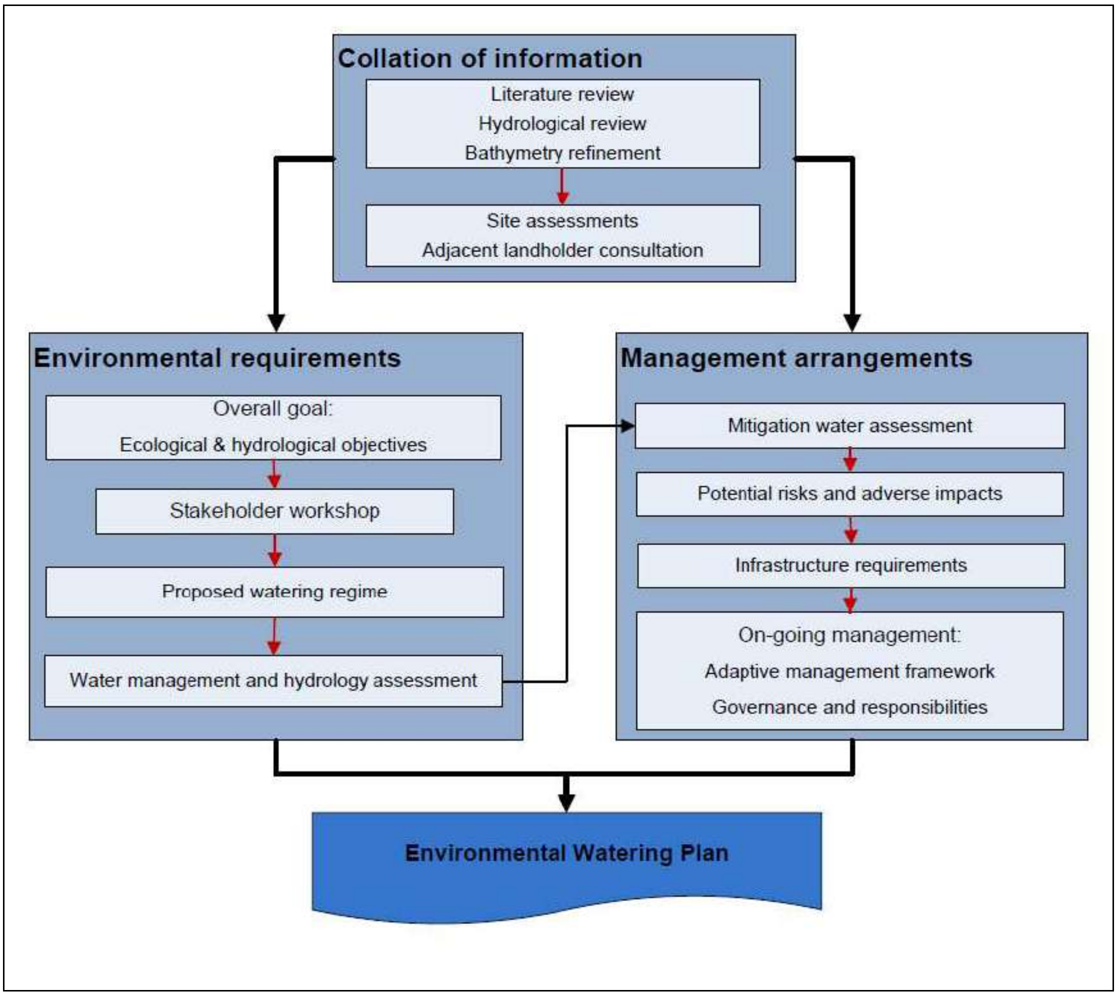

Figure 1: EWP development process

1.4.1. Consultation and engagement

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

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

A workshop was held on 17 December 2009 with key stakeholders and experts (Appendix A) in order to discuss and refine the water management goal, ecological objectives, and water requirements for Lake Meran.

Consultation was also undertaken with adjoining landholders who have had a long association with the wetland and proven interest in maintaining its environmental value. Other community and agency people were directly engaged to provide technical and historic information. A summary of the information sourced from this process is provided in Appendix B.

2. Lake Meran

Lake Meran is located within a 210 ha Lake Reserve (DSE 2009a) approximately 25 km north of the township of Boort (Figure 2). It is located in the Wandella Creek sub-catchment of the Loddon River basin and is of bioregional conservation significance (NLWRA 2002, cited in NCCMA 2005). It is a high value wetland due to its size and depth and for providing important habitat for a variety of flora and fauna species.

Lake Meran has a bed level at around 75.40 m AHD and it is described as three linked depressions/basins which become larger and deeper from south to north with a prominent lunette on the eastern side (Bartley Consulting 2009). It is the deepest lake within the Boort wetlands system with a maximum depth of 7.5 m. At 82.85 m AHD[1], Lake Meran has a storage capacity of 9,218 ML and a surface area of 180 ha.

Refer to Appendix C for the contour plan prepared for Lake Meran by Price Merrett Consulting (2006).

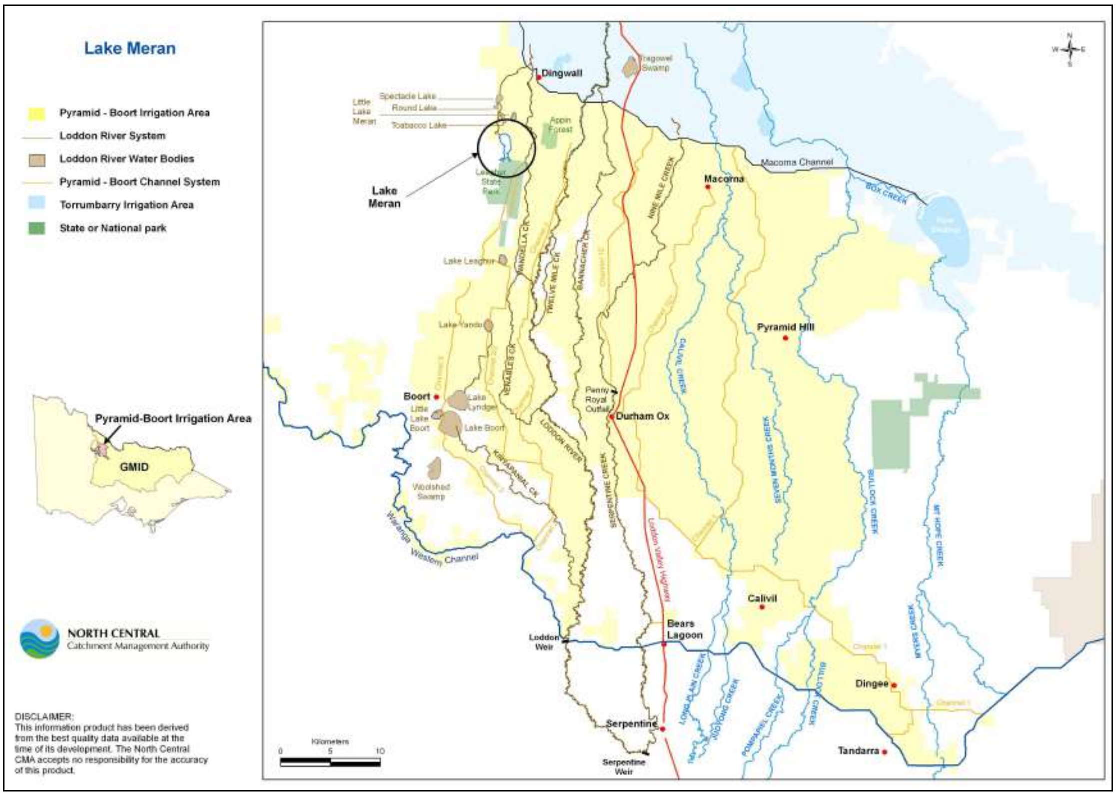

Figure 2: Location of Lake Meran

2.1. Wetland context and current condition

Prior to and following European settlement, Lake Meran has been a permanent open freshwater lake[2] characterised by shallow open water (< 5 m) and River Red Gum vegetation (*Eucalyptus camaldulensis*) (DSE 2009b; DSE 2009c). River Red Gum stumps are present within the low margins at Lake Meran indicating that lake has experienced dry periods that suited the establishment and survival of the trees for several decades in the past (Appendix B). Anecdotal evidence also suggests that it was dominated by aquatic plants including Ribbon Weed (*Vallisneria* sp.) and Cattail (*Myriophyllum* sp.). Refer to Appendix B.

Lake Meran would naturally have received floodwaters from the lower Loddon floodplain via the Wandella Creek (Appendix B). The overflow was in a north-westerly direction through a series of wetlands (Tobacco Lake, Round Lake and Spectacle Lake). Please refer to Figure 3.

The establishment of the Pyramid-Boort Irrigation System in the 1920s/1930s, construction of levees across the floodplain and the construction of Pickles Canal (which connects Lake

[1] Full supply level (FSL) confirmed with Price Merrett Consulting 7 December 2009

[2] Although, permanent open freshwater wetlands retain water for the majority of time, they may also experience a drying phase (approximately 10% of the time) (DCFL 1989a)

Meran directly to Wandella Creek) have resulted in significant changes to the hydrology of the wetland. Until recently, Lake Meran has been maintained as a permanent open freshwater lake having not dried out since 1851 (Appendix B; O'Brien and Joyce 2002). It received significant volumes of water (estimated to be in the order of 2900 ML) from channel outfalls and diverted floodwaters delivered via channel 8/2 (O'Brien and Joyce 2002).

In more recent times channel outfalls have reduced dramatically and extended dry conditions have resulted in the lake drying out in 2004. An assessment undertaken on 21 October 2009 (Campbell *et al*. 2009) reported that Lake Meran currently displays:

- Annual grasses and Prickly Lettuce (*Lactuca serriola*) dominating the base of the wetland (Plate 1).
- Live Cumbungi (*Typha* sp.) and Common Reed (*Phragmites australis*) in the inlet channel to the south.
- A patch of River Club-sedge (*Schoenoplectus tabernaemontani*) and Cumbungi in the southern basin.
- A patch of predominantly dead Cumbungi and another sedge (with a few live plants) in the southern basin (Plate 2).
- An inner ring of River Red Gum regeneration fringed by mature trees. River Red Gum trees are in moderate health (Plate 1).
- A small population of the *Flora and Fauna Guarantee (FFG) Act 1988* listed Downy Swainson-pea (*Swainsona swainsonioides*) to the north-east.
- Wetland vegetation dominated by weeds with a number of moderate to high threat species including Spear Thistle (*Cirsium vulgare*), Pampas Grass (*Cortaderis* sp.), Paterson's Curse (*Echium plantagineum*), Ox-tongue (*Helminthotheca echioides*), Sharp Rush (*Juncus acutus* ssp. *acutus*), Prickly Lettuce (*Lactuca serriola*), African Boxthorn (*Lycium ferocissimum*), Poppy (*Papaver* sp.), Pepper Tree (*Schinus molle*) and Tamarisk (*Tamarix ramosissima*) (Plate 2).

When inundated, Lake Meran would continue to provide extensive open water habitat which in turn would support a variety of flora, fauna and recreational values (Section 3).

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

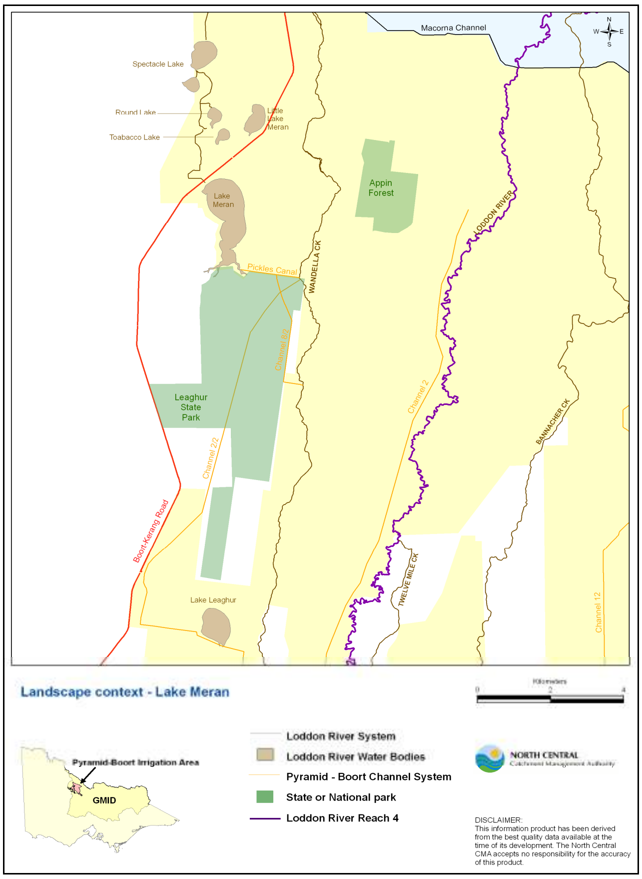

Figure 3: Lake Meran landscape map

Plate 1 Annual grasses and fringing River Red Gum (Source: MDFRC 2009)

Plate 2 Dead Cumbungi and Prickly Lettuce (Source: MDFRC 2009)

2.2. Catchment setting

Lake Meran is located within the Wandella Creek sub-catchment. The majority of the wetland is situated within the Victorian Riverina bioregion; however the DSE interactive mapping tool indicates that a small portion to the west is situated within the Murray Mallee bioregion (DSE 2009a). The surrounding area is characterised by very flat topography and low gradients (GHD 2006). Higher elevations occur in association with the lunette bordering the lake to the east.

Leaghur State Park exists to the south of Lake Meran and is an important path for floodwaters from Wandella Creek and Lake Leaghur (Figure 3). The surrounding land use is agricultural, consisting primarily of dryland agriculture with small areas of irrigation to the south. Local catchment runoff is considered to provide a negligible amount of water to the overall surface water balance of Lake Meran (pers. comm. Rob O'Brien [DPI] and Graham Hall [NCCMA] 16 March 2010).

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

Lake Meran is connected to the Pyramid–Boort Irrigation System and receives outfalls from channel 8/2 via a delivery channel approximately 1 km long (Figure 4). The delivery channel runs parallel to Pickles Canal which was established to carry floodwaters between Wandella Creek and Lake Meran depending on the height of water levels in each (Appendix B). A siphon passes flows beneath Pickles Canal. Although the channel 8/2 has a capacity of 110 ML/day the siphon has a maximum capacity of 80 ML/day (Hillemacher and Ivezich 2008).

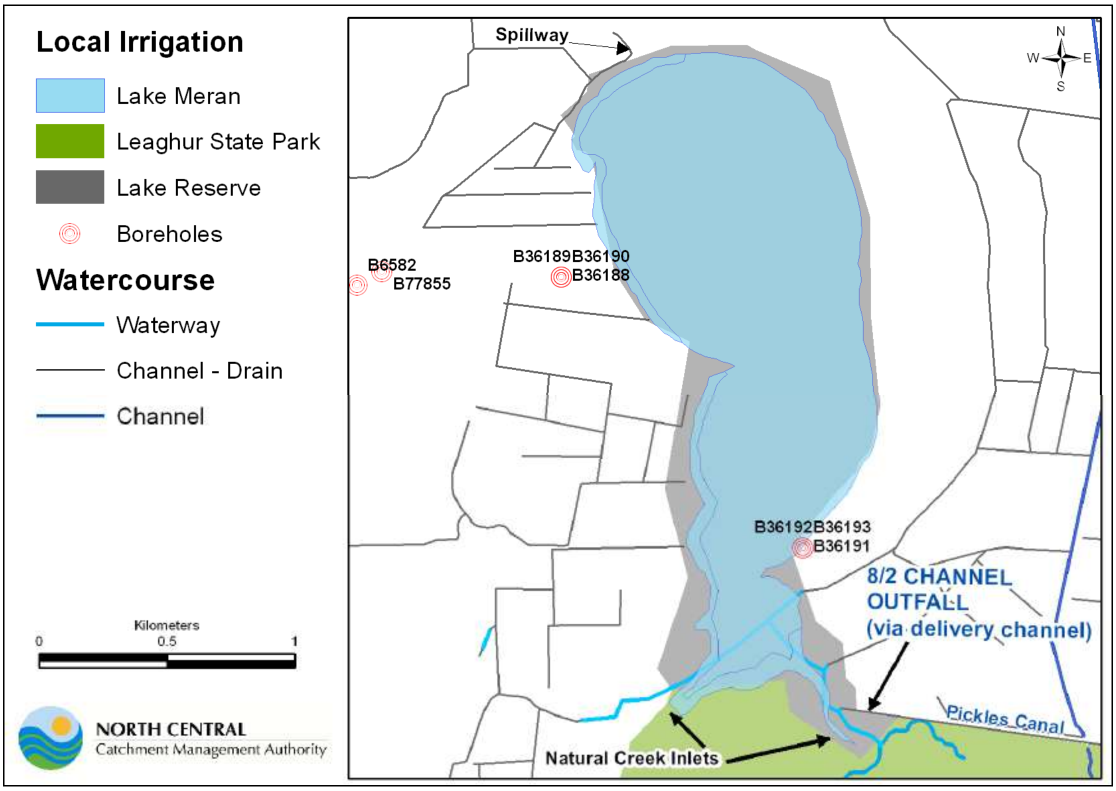

Figure 4: Inflow points at Lake Meran

2.3. Land status and management

Lake Meran is designated as a Lake Reserve occupying approximately 210 ha and is managed by the Lake Meran Committee of Management (CoM) (DSE 2009a). Lake Reserves are managed for recreation, nature conservation, scientific study, water supply drainage and other uses where appropriate (LCC 1988).

In 2009, the Victorian government endorsed (with amendments) the Victorian Environment Assessment Council (VEAC) recommendations for public land management. Lake Meran will be classified as a wildlife reserve under the “state game reserve” classification. A series of VEAC recommendations relating to the establishment of National Parks will take effect on 29 June 2010. However, the proclamation date for all other areas (wildlife reserves, nature conservation reserves, etc) is yet to be determined (pers. comm. Doug Hooley [DSE], 20 May 2010). Wildlife reserves will be managed by Parks Victoria to conserve and protect species, communities or habitats of indigenous animals and plants while permitting recreational (including hunting in season as specified by the land manager) and educational use (VEAC 2008; DSE 2009d).

2.4. Cultural heritage

Lake Meran is situated on the edge of the Mallee and Loddon floodplains and provided a wide range of resources for the Aboriginal people. Numerous archaeological sites in Leaghur State Park and Lake Meran provide evidence that this area was naturally highly productive and a popular place for Indigenous people (Appendix B).

Nine sites of Aboriginal archaeological significance have been recorded and registered with Aboriginal Affairs Victoria (AAV). All of these sites of significance are Aboriginal scar trees. Further information can be obtained from AAV.

2.5. Recreation

Lake Meran is a highly valued wetland which is popular for recreation within the Boort District Wetlands area. The wetland is known to have supported the following recreational activities, most of which are dependent on inundation:

- Camping
- Picnicking
- Walking
- Swimming
- Boating (including water skiing, yachting, power boating)
- Water skiing
- Fishing (DCFL 1989b; Ecos Environmental Consulting 2006).

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).

Lake Meran is known to support species protected by each of the above international migratory bird agreements excluding ROKAMBA (Table 1). As wetland habitat for a number of protected species, Lake Meran 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)[3].

Lake Meran is known to support protected migratory waterbirds. In addition, species listed under the *EPBC Act* have also been recorded within the lake (Table 1). Actions that may

[3] There are seven MNES that are protected under the EPBC Act, these are: World Heritage properties, National Heritage places, wetlands of international importance, listed threatened species and ecological communities, migratory species protected under international agreements, Commonwealth marine areas, and nuclear actions (including uranium mines) (DEWHA 2009).

significantly impact any of these MNES are subject to assessment and approval by the Minister for the Environment, Heritage and the Arts. The NVIRP works program is also subject to assessment and approval under the *EPBC Act*.

2.6.3. State legislation

Flora and Fauna Guarantee (FFG) Act 1988

The *FFG Act* aims to protect a number of identified threatened species and communities within Victoria. Lake Meran is known to support a number of species both protected[4] and listed under the *FFG Act* (Table 1 and Table 3). Disturbance or collection of any of these threatened species will require a permit from the DSE.

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 NVIRP works program and any associated environmental impacts are subject to assessment and approval under the Act.

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 NVIRP works program will require the implementation of the three-step process, assessment and approval under the Act.

Water Act 1989

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

Aboriginal Heritage Act 2006

All Aboriginal places, objects and human remains in Victoria are protected under the *Aboriginal Heritage Act 2006* (DPCD 2007). Lake Meran is known to support sites of Aboriginal cultural significance (Section 2.4).

Other - Threatened Species Advisory Lists

Threatened species advisory lists for Victoria are maintained by the DSE 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*. Lake Meran is known to support flora and fauna species that are included on advisory lists (Table 1 and Table 3).

[4] Includes plant taxa belonging to families or genera protected by the Act (DSE 2009e).

3. Lake Meran environmental values

The primary purpose of this EWP is to assess and advise on mitigating potential impacts on high environmental values supported by Lake Meran. While it is recognised that the wetland provides a number of broader ecological and landscape values (i.e. ecological processes, representativeness and distinctiveness in the 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; NVIRP 2010).

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

Lake Meran is highly valued as a result of its size and depth, as it provides important habitat for a variety of flora and fauna species.

3.1. Fauna

When inundated, Lake Meran provides important open water (with fringing mudflats), reed and River Red Gum habitat components which attract a range of fauna species. In the past it has supported a high number and diversity of waterbirds, with a range of ducks consistently breeding at the lake (Appendix B). Fifty bird species have been recorded within Lake Meran over time including eight species protected by international agreements (CAMBA/JAMBA/Bonn), national (*EPBC Act*) and state (*FFG Act*) legislation (Table 1 and Appendix E).

In addition, Lake Meran is known to have previously supported a rich diversity of native fish and reptile species (Appendix B) including some protected by national and state legislation including Murray Cod (*Maccullochella peelii peelii*), Silver Perch (*Bidyanus bidyanus*), and Murray River Turtle (*Emydura macquarii*).

Table 1: Significant species recorded at Lake Meran

Common Name	Scientific Name	International agreements	EPBC status	FFG status	DSE status
Birds					
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*				NT
Caspian Tern	*Hydroprogne caspia*	C/J		L	NT
Clamorous Reed Warbler	*Acrocephalus stentoreus*	B			
Diamond Firetail	*Stagonopleura guttata*			L	VU
Eastern Great Egret	*Ardea modesta*	C/J		L	VU
Grey-crowned Babbler	*Pomatostomus temporalis*			L	EN
Pied Cormorant	*Phalacrocorax varius*				NT
Rainbow Bee-eater	*Merops ornatus*	J			
Fish					
Golden Perch	*Macquaria ambigua*	-			VU
Murray Cod	*Maccullochella peelii peelii*	-	VU	L	EN
Silver Perch	*Bidyanus bidyanus*	-		L	CR
Reptiles					
Murray River Turtle	*Emydura macquarii*	-		L	DD

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
- DSE listing: CR – Critically endangered, EN – Endangered, VU – Vulnerable, NT – Near Threatened, DD – Data deficient (DSE 2007a)

3.2. Flora

Pre-1750 DSE ecological vegetation class (EVC) mapping describes vegetation within Lake Meran prior to European settlement as Freshwater Lake Aggregate (EVC 718) surrounded by Lignum Swampy Woodland (EVC 823) vegetation. The characteristic species of Freshwater Lake Aggregate 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. Semi-arid Woodland vegetation (EVC 97) is mapped as occurring on higher elevations associated with the lunette to the east. To the west of the wetland, vegetation is mapped as Ridged Plains Mallee (EVC 96) interspersed with Low Rises Grassy Woodland (EVC 66) vegetation (DSE 2009a).

Recent DSE EVC mapping suggests that Lake Meran is characterised as Freshwater Lake Aggregate (EVC 718) encircled by Lignum Swampy Woodland (EVC 823) vegetation; however the extent of surrounding vegetation classes has diminished. Small areas of Semi-arid Woodland (EVC 97) vegetation are mapped to the east and west of the wetland. Similarly, small patches of Ridged Plains Mallee (EVC 96) and Low Rises Grassy Woodland (EVC 66) are mapped to the west of the wetland (DSE 2009a).

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

However, assessments undertaken by the Murray-Darling Freshwater Research Centre (Campbell *et al.* 2009) on 21 October 2009 identified that the wetland is currently characterised by Intermittent Swampy Woodland (EVC 813) vegetation fringing a currently dry wetland that displays Tall Marsh (EVC 821) vegetation and Lake Bed Herbland (EVC 107) and has the potential to support open water habitat. These vegetation communities provide a diversity of habitat types that attract a range of fauna species as outlined in Section 3.1.1. The results of the assessment show a marked difference to the mapped 2005 EVCs and are based on up to date and field verified information. Therefore, the EVCs reported by MDFRC are included throughout the EWP as opposed to the mapped 2005 EVCs.

The current EVCs and their conservation status within bioregions traversed by Lake Meran are provided in Table 2. Refer to Appendix F for a detailed vegetation composition map illustrating EVCs observed in October 2009.

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

EVC No.	EVC Name	Bioregional Conservation Status	
		Victorian Riverina	Murray Mallee
813	Intermittent Swampy Woodland	Depleted	Vulnerable
821	Tall Marsh	Depleted	Least concern
107	Lake Bed Herbland	Depleted	Depleted

According to the state-wide Flora Information System (FIS) database and other relevant reports, ten significant flora species have been recorded at Lake Meran. Downy Swainson-pea (*Swainsona swainsonioides*) is listed under the *FFG Act*; and five species are protected as members of the Asteraceae family (DSE 2009e). The remaining four species are threatened within Victoria; however they are part of an advisory list only, and there are no legal requirements or consequences under the *FFG Act* (DSE 2005a) (Table 3 and Appendix E). Bluish Raspwort (*Haloragis glauca f. glauca*), Smooth Minuria (*Minuria integerrima*), Swamp Buttercup (*Ranunculus undosus*) and Trim Flat-sedge (*Cyperus concinnus*) are all considered either flood-dependant (VEAC 2008) or as riparian species (DNRE 2002).

Table 3: Significant flora species recorded at Lake Meran

Common Name	Scientific Name	EPBC status	FFG status	DSE status
Bluish Raspwort	*Haloragis glauca f. glauca*			k
Cotton Fireweed	*Senecio quadridentatus*		P	
Downy Swainson-pea	*Swainsona swainsonioides*		L	e
Fuzzy New-Holland Daisy	*Vittadinia cuneata* s.l.		P	
Groundsel	*Senecio sp.*		P	

Common Name	Scientific Name	EPBC status	FFG status	DSE status
Groundsel	*Senecio sp. (serrated)*		P	
Smooth Minuria	*Minuria integerrima*			r
Swamp Buttercup	*Ranunculus undosus*			v
Trim Flat-sedge	*Cyperus concinnus*			v
Woolly New Holland Daisy	*Vittadinia gracilis*		P	

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

3.3. Representativeness and distinctiveness

Although dry at present, Lake Meran is classified as a permanent open freshwater lake comprised of approximately 158 ha of shallow open water (<5m) and 16 ha of River Red Gum vegetation (DSE 2009c). As a result of modification to the water regimes of intermittent wetlands across Victoria, permanent open freshwater wetlands are estimated to have experienced only a 6% decline in area following European settlement (DNRE 1997). Table 4 illustrates the area and proportion of permanent open freshwater wetlands (excluding artificial impoundments) across various defined landscapes. Lake Meran, with approximately 174 ha currently classified (DSE 2009c) as permanent open freshwater, is classified as a permanent open freshwater lake, one of the least depleted wetland categories within Victoria.

Table 4: Current area of permanent freshwater wetlands (excluding artificial impoundments) across the landscape

	North Central region	GMID	Victorian Riverina
Permanent open freshwater[1] (ha)	18,910	14,897	12,241
Lake Meran	<1%	1%	1%

[1] Excludes artificial impoundments

Lake Meran is distinctive as a result of its size and depth. The wetland occupies 174 ha and is situated on a 210 ha reserve which is considered large in comparison to other wetlands within the North Central region. Only 6% of wetlands within the region are greater than 100 ha in size (NCCMA 2005). With a maximum depth of 7.5 m, Lake Meran is the deepest lake within the Boort wetlands area (Appendix B).

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

Lake Meran is located within the Wandella Creek sub-catchment in the Loddon River basin. Its natural water supply would have been from Loddon River floodwaters in winter and spring with flows provided via a series of creeks which break away from the Loddon River during times of high river flow. The main creeks that direct water into Lake Meran are the Wandella and Venables Creeks. In larger floods the Kinypanial Creek may also flow through the Boort Wetlands and enter Lake Meran (Appendix B). Floodwater would have flowed through Leaghur State Park to the south before filling the wetland. Due to its depth, Lake Meran could hold water for several years (four or five) after a flood event (Appendix B).

The overflow of Lake Meran is in a north-westerly direction through a series of wetlands (Tobacco, Round & Spectacle Lakes), then northwards via Little Wandella Creek towards Duck Lake.

Lake Meran is still connected to the Loddon River and maintains the ability to receive flood flows should wet conditions return. A flood of significant magnitude or a series of wet years would be necessary to penetrate Leaghur State Park and inundate Lake Meran, particularly after a sequence of dry years.

4.2. History of water management

Pickles Canal was constructed prior to construction of the irrigation system (around the 1850s) to enable direct connection between Lake Meran and Wandella Creek (Appendix B). Depending on water levels in Lake Meran and Wandella Creek, water is able to flow freely between the two. The natural overflow from Lake Meran was realigned in the early 1900s (Appendix B). Operating rules associated with the current overflow were developed by the Kerang Shire in the 1930s and determined the conditions when the structure was released and water allowed to flow onto Tobacco, Round and Spectacle Lakes (Appendix B). The operation of the outlet structure requires water levels in the lake to reach very high levels before being released to downstream wetlands. In the past, these operating rules have probably resulted in excessive inundation of the northern end of Leaghur State Park.

Following establishment of the irrigation supply system in the 1920s/1930s, Lake Meran received significant channel outfall volumes along with diverted flood flows estimated to have been in the order of 2,900 ML/year via channel 8/2 (O'Brien and Joyce 2002). Locals have advised that it was permanently inundated, drying for the first time in over 150 years in 2004 (Appendix B). Table 5 illustrates the wetland's permanency up to the early 2000s and its dry regime in more recent years. Surface water data collected by DPI between 1990 and 2007 is poor with several gaps in the monitoring record. However, it shows that lake levels were very low by November 2003 and it was completely dry by January 2004. Figure 5 illustrates fluctuating salinity levels recorded within Lake Meran between 1990 and 2007.

Table 5: Lake Meran wetting/drying calendar (Source: NCCMA 2008)

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	w	w	d	d	d	d	d

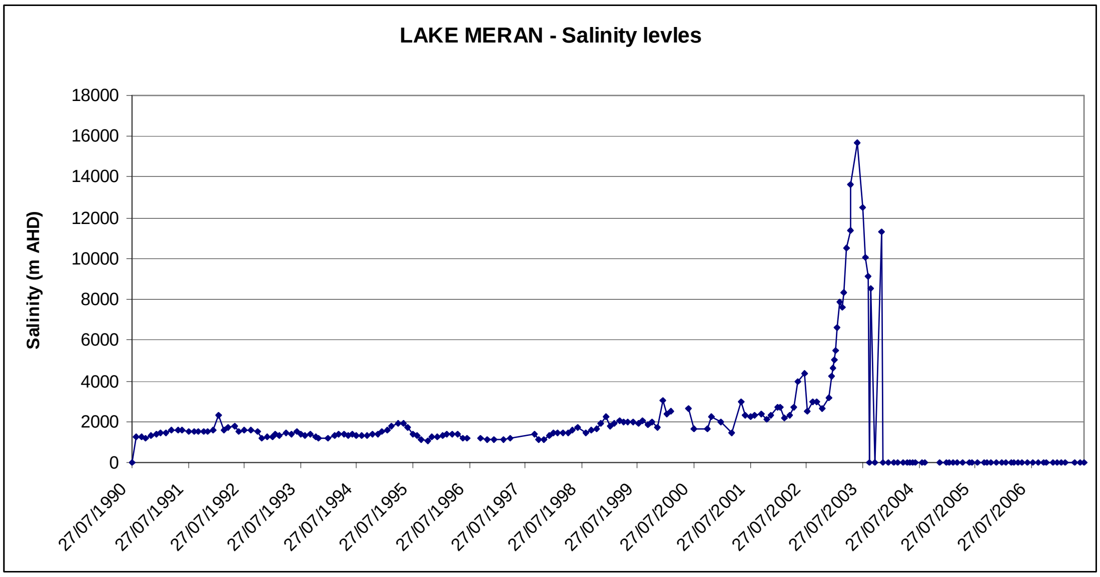

Figure 5: Salinity levels within Lake Meran as recorded by DPI between 1990 and 2007

However, increased efficiencies have reduced channel outfalls in recent years to less than 5% of the wetland's capacity at FSL (Figure 6). Figure 6 also shows that Lake Meran has never received water from any environmental entitlement.

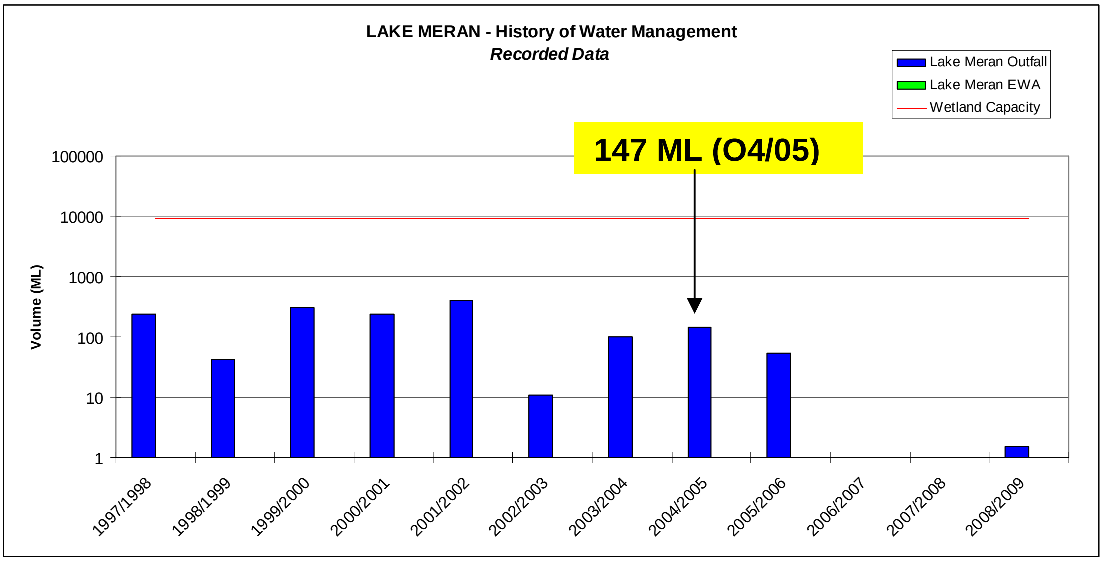

Figure 6: Recorded volumes received by Lake Meran from outfalls (log10 scale) *Note outfalls recorded from 1997/1998 onwards*

4.2.1. Recorded outfalls and NVIRP

Outfall data for Lake Meran has been recorded by G-MW since 1997/98 (Figure 6). Records indicate that outfall volumes have decreased significantly between 1997/98 (238 ML) and 2006/07 (0 ML). Historically, larger outfall volumes sustained a much wetter water regime with an estimated 2900 ML/year received from channel outfalls and diverted flood flows (O'Brien and Joyce 2002).

The baseline water year, 2004-2005, has been selected to quantify the savings as part of water savings projects (DSE 2009g). 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 2008b). This baseline year will also be used to guide the quantification of mitigation water required for wetlands (discussed in Section 5), taking into account the average annual patterns of availability.

The automated regulator that provides water to Lake Meran received a total of 147 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.

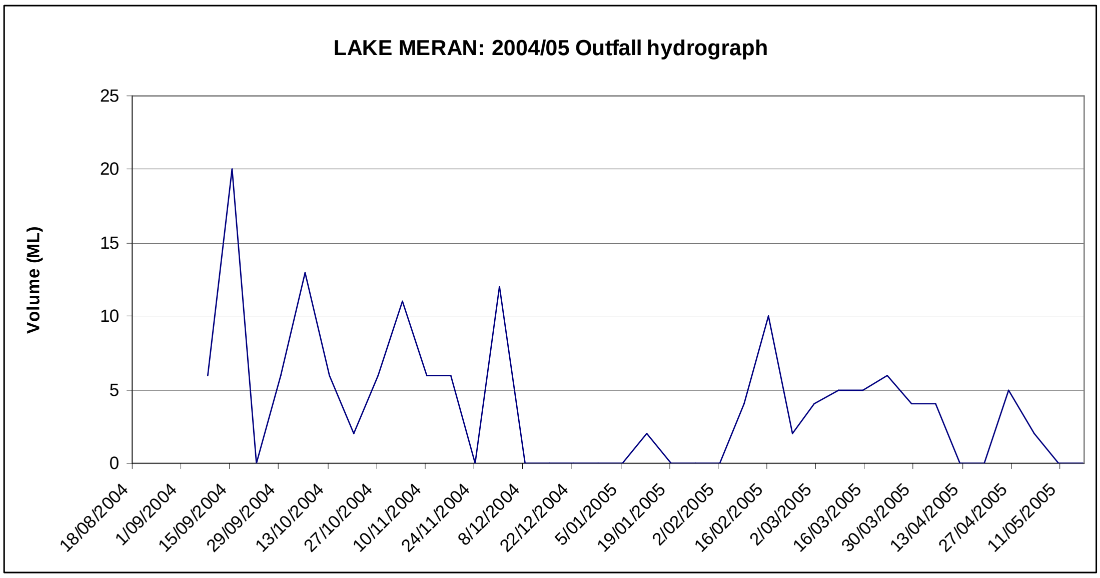

Figure 7: Lake Meran outfall hydrograph

4.3. Surface water/groundwater interactions

Lake Meran is situated on the Loddon River floodplain on upper floodplain alluvial sediments. It is approximately 6 km west of the Loddon River, is close to the Leaghur Fault and west of the Wandella Creek floodway. The Shepparton Formation sediments comprise silty clay, clay and silty fine sand and are approximately 25 m thick at the site, overlying Parilla Sand and Renmark Group sediments. Groundwater movement beneath the floodplain west of the Loddon River is from the south and southeast toward the north and northwest (Bartley Consulting 2009).

Groundwater monitoring at Lake Meran has been conducted by DSE and DPI (Future Farming Systems Research) since 1990. DSE collect groundwater data from regional bores in the State Observation Bore Network whilst data is collected from other bores within the vicinity by DPI. Regular monitoring of surface water and electrical conductivity (EC) commenced in 1990 and is also undertaken by DPI.

Regional groundwater levels have been declining since the 1990s in response to a period of below average rainfall. However, Lake Meran has a well-formed lunette on the eastern side which indicates a period of shallow groundwater levels (Appendix B). Figure 8 illustrates groundwater behaviour from bores in Leaghur State Forest (26068 and 6580), Wandella Creek (36174), and north of Lake Meran (6523 and 26073) inferred to be away from the direct influence of the wetland. This figure illustrates the regional decline in groundwater levels; however also shows that the level in these bores is higher than the bed of Lake Meran.

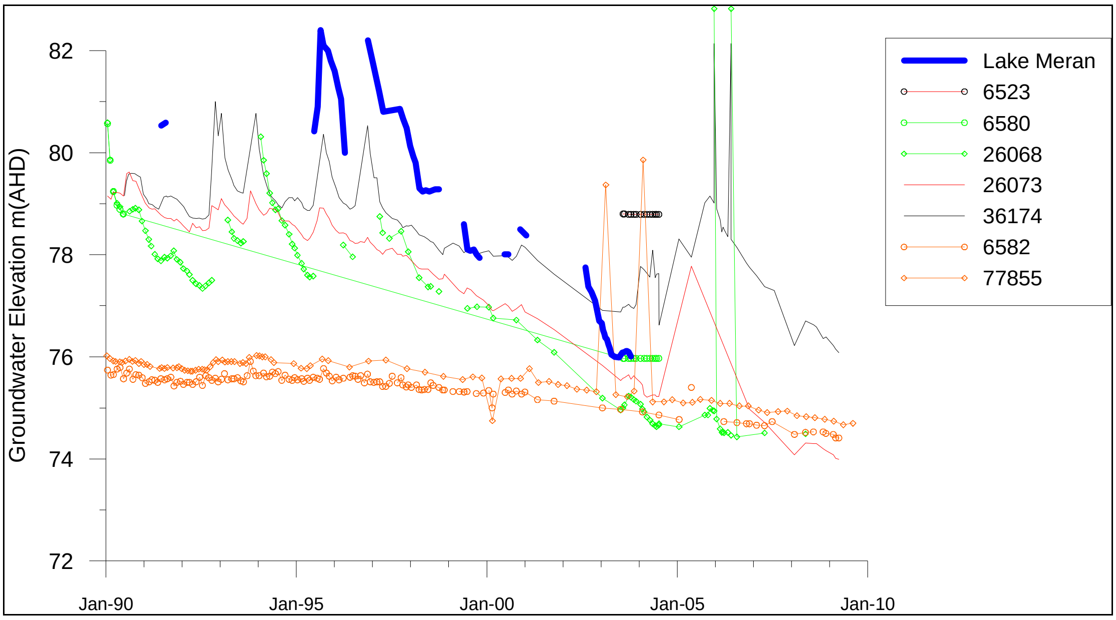

Figure 8: Groundwater levels from bores away from the direct influence of Lake Meran (Source: Bartley Consulting 2009)

Groundwater levels within the vicinity of the wetland have fluctuated over time (Figure 9). The monitoring record shows a downward hydraulic gradient beneath Lake Meran which indicates groundwater recharge. This is supported by lower groundwater EC levels in the immediate vicinity of Lake Meran (discussed below) and a watertable mound that exists beneath, resulting from surface water infiltration (Hekmeijer 2006, cited in Bartley Consulting 2009).

In the past, groundwater levels adjacent to Lake Meran have been higher than the bed level, reflecting the significant depth of the wetland. As such, there may have been times of groundwater discharge into the wetland.

Groundwater levels beneath Lake Meran began to decline around 1997, which is consistent with the broader regional decline. Based on limited data, current groundwater levels appear to be below the bed level with no significant groundwater discharge currently occurring at the wetland edge or floor; however bores further from Lake Meran show regional groundwater levels above the bed level.

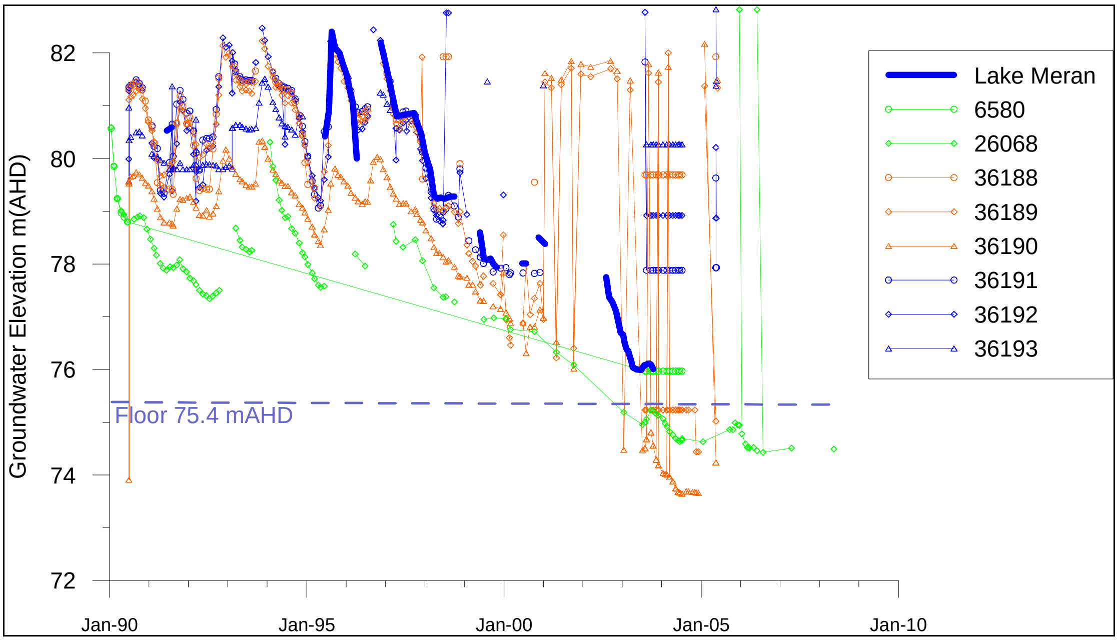

Figure 9: Groundwater levels from bores adjacent to Lake Meran. *Note: Unusual data for 36189 and 36190 indicate occasional periods when groundwater level exceeded surface water level. It is recommended that validation of these results is undertaken in the future.* (Source: Bartley Consulting 2009)

Data from bores within the vicinity of Lake Meran show fluctuating EC levels with mean values ranging from <6,000 µS/cm in bores on the west side of the wetland to >10,000 µS/cm in bores to the east[5].

Refer to Table 6 for the analysis of data from monitoring bores within the vicinity of Lake Meran.

Table 6: Analysis results of monitoring bores within the vicinity of Lake Meran (Source: Bartley Consulting 2009)

Bore	Location	Drilled depth	Screen top (m)	Screen bottom (m)	Electrical Conductivity (uS/cm)			
					Min	Max	Mean	Readings
36188	West side Lake Meran	2.50	0.35	2.35	2434	4720	3562	6
36189		9.00	6.56	8.56	2753	6150	4734	10
36190		9.00	6.54	8.54	5560	6400	5979	10
36191	Southeast side Lake Meran	3.96	1.96	3.96	8950	12600	11279	10
36192		4.01	2.01	4.01	3069	17472	10417	8
36193		5.50	3.38	5.38	10796	14250	11947	3
6582	800 m west of Lake Meran	14.63	13.00	14.00	30492	44936	40379	14
77855		112.00	44.00	49.00	17000	48000	30200	5
36174	1.8 km east, Wandella Creek	10.00	7.81	9.81	3418	46731	25710	13
36175		10.00	7.79	9.79	42000	48117	45216	13
36176		9.00	6.53	8.53	30000	42558	39644	13
6523	2.5 km northeast of Lt Lake Meran	3.05			3480	31666	15920	9
26073		13.34	11.10	13.10	15000	31784	28770	13
6580	2.3 km south – Leaghur Forest	7.00			1820	33887	9550	5
26068		8.50	6.27	8.27	3941	39000	21117	12

Similarly, surface water EC levels have fluctuated over time from 1050 uS/cm to 15,700 uS/cm, with a median of 1,588 uS/cm (142 readings). The data suggests that as the water levels decline in Lake Meran salinity increases through evaporation.

Based on current groundwater levels (Bartley Consulting 2009):

- In a flood, local groundwater levels would temporarily rise, with the possibility of groundwater discharge to Lake Meran depending on surface water levels within the wetland at the time.
- Intermittent watering of Lake Meran is likely to result in localised groundwater mounding; however, as it appears as though groundwater is currently below the bed of the wetland there is no significant risk of adverse impact on the wetland or adjacent land through watertable rise.
- Inundation while groundwater levels are so low increases the opportunity for salts to move down the profile into the groundwater.
- Maintaining Lake Meran as permanently inundated would provide a continual source of groundwater recharge, contributing to the mound that exists beneath the wetland. This would increase the risk of groundwater discharge through evapotranspiration and to low-lying areas on adjacent land. The risk would increase if regional groundwater levels were to rise.

Source: Bartley Consulting 2009.

[5] Indicating that lower EC groundwater immediately east of Lake Meran is mixing with higher EC regional groundwater flowing from up-gradient (Bartley Consulting 2009).

4.4. Surface water balance

A daily surface water balance has been modelled in order to identify the hydrological attributes of Lake Meran. 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 Lake Meran 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. Lake Meran filled to FSL (82.85 m AHD) has a storage capacity of 9,218 ML (Price Merrett Consulting 2006).
- **Infiltration:** volume required to fill the underlying soil profile. Calculation of this volume has been adapted from measurements undertaken by G-MW (G-MW 2008a). The following assumptions were included in the application of the SWET model for Lake Meran (Gippel 2005a, Gippel 2005b, Gippel 2005c):
    - Infiltration (ML) = Soil cracking (%) x area of wetland (ha) x depth (mm))/100
    - Soil cracking – 25% of surface area
    - Average depth of 300mm
    - Ongoing losses via infiltration are considered negligible due to the low permeability of the underlying soil (G-MW 2008b)
- **Rainfall/runoff:** this includes rainfall directly falling onto the 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). Local catchment runoff is considered to contribute a negligible amount of water to Lake Meran. The wetland is surrounded by dryland agriculture with local catchment runoff required to pass through Leaghur State Park before entering the wetland (pers. comm. Rob O'Brien [DPI] and Graham Hall [NCCMA] 16 March 2010). Therefore, in modelling the surface water balance for the wetland, it has been assumed that it has virtually no local catchment area and 0.1 hectares was used (Appendix G). 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 Lake Meran as part of the overall surface water balance.*
- *The model has been set up so as to manage water levels at a single target level (79.5 m AHD). Therefore, it is not possible 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 Lake Meran are presented in Section 5.3 and Appendix G.

4.5. Operational uses

Opportunistic diversion licences (equating to approximately 1500 ML) are held by several landholders surrounding Lake Meran (pers. comm. Rob O'Brien [DPI], 19 November 2009). These licences permit water to be opportunistically pumped from the wetland for irrigation and stock and domestic use (Ecos Environmental Consulting 2006).

4.5.1. Flood mitigation

Lake Meran maintains an ability to receive flood flows from the Loddon River and Wandella Creek via a breakaway that enters the wetland to the south and Pickles Canal (Figure 4). In the past, Lake Meran has received significant volumes of diverted floodwater. Outfall and diverted flood flows may have been in the vicinity of 2900 ML/year (including end of season draw down) in order to maintain observations of the lake's level over the years (O'Brien and Joyce 2002).

5. Management objectives

Previously, Lake Meran has been managed as a permanent, open freshwater wetland in order to maintain suitable habitat for a number of flora and fauna species, and to continue providing a range of recreational values. Table 7 provides information on the proposed management objectives and water regime outlined in previous reports for Lake Meran. It should be noted that as Lake Meran is currently empty, a significant volume of water would need to be secured to achieve the recommended regime.

Table 7: Previous management recommendations for Lake Meran

Source	Proposed wetland type	Objectives	Dur.	Timing	Freq.	Quality (EC)
Ecos Environmental Consulting (2006)	Deep freshwater marsh	• Diverse habitat e.g. open water and woodlands • Waterbirds • Black Box	-	Late winter/ spring	6-7 Draw down should provide an appropriate water regime for the remaining wetland zones	n/a

5.1. Water management goal

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

Lake Meran water management goal:
To provide a water regime that supports a permanent open freshwater lake with open water and associated flora and fauna communities, which dries out occasionally (e.g. one in ten years). In the intervening period until the wetland is filled, maintain the emergent aquatic plant community (EVC 821: Tall Marsh) at the channel outfall within the natural inlet creek and the southern basin to ensure a seed/egg source is sustained over dry periods.

The water management goal for Lake Meran may be achieved from providing a significant environmental water allocation or via Loddon River floods with the addition of top–ups from environmental water (dependent on the magnitude of the Loddon flood).

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 Lake Meran (Table 8). The process for identifying ecological and hydrological objectives closely follows that recommended in FLOWs: a method for determining environmental flow requirements in Victoria (DNRE 2002). The ecological objectives outline the outcomes desired from delivery of the desired water regime.

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

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

Habitat objectives identify habitat components considered critical in achieving the water management goal. While it is recognised that each habitat component will 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 2002). All values identified have components of their life-cycle or process that are dependent on particular water regimes for success e.g. colonially breeding waterbirds require certain timing, duration and frequency of flooding to successfully breed and maintain their population. Requirements for the three characteristics of a water regime[6] were identified and described for all of the ecological values.

Source: Campbell, Cooling & Hogan 2005.

The ecological objectives and hydrological requirements for Lake Meran were developed in conjunction with agency stakeholders and technical experts at the Wetland Workshop held on 17 December 2009.

Table 8: Lake Meran proposed ecological objectives and hydrological requirements

Ecological objective	Justification	Hydrological requirement
1. Habitat objectives		
1.1 Maintain emergent aquatic plant communities (EVC 821: Tall Marsh) currently persisting at the channel outfall within the natural inlet creek and the southern basin (Appendix E)	Provides a refuge for vegetation, waterbirds (e.g. Clamorous Reed Warbler), macroinvertebrates and frogs	Provide small pulse flows every year.
1.2 Maintain health of the fringing Intermittent Swampy Woodland (EVC 813) • Maintain and improve health of existing trees	River Red Gum trees provide hollows, fallen branches, perching, nesting and shading for habitat (e.g. Pied Cormorant), and a source of seed for recruitment.	Keep the lake permanently inundated with fluctuating water levels (around approximately 79.5 m AHD[7]). Surcharge the height water levels to inundate the base of River Red Gum trees (approximately 82 m AHD[8]) for two to three months one in five years
1.3 Restore open water/submerged aquatic macrophyte habitat in the deeper sections of the wetland	Provides open water habitat for diving waterbirds (e.g. Pied Cormorant), fish, invertebrates and frogs	Maintain permanent inundation with fluctuating water levels (around approximately 79.5 m AHD[8]).
1.4 Restore Tall Marsh (EVC 821) habitat across a greater area of the lake	Provides habitat for waterbirds (e.g. Clamorous Reed Warbler), frogs and invertebrates	Keep the lake permanently filled with fluctuating water levels.
1.5 Restore abundance of Tangled Lignum vegetation within the fringing Intermittent Swampy Woodland (EVC 813)	Tangled Lignum provides foraging and nesting habitat for waterbirds e.g. Ibis	Only very scattered occurrences of Tangled Lignum were observed. Expand the distribution of Lignum in the fringing woodland by inundating for two to three months one in five years.
2. Species/community objectives		
2.1 Restore habitat and breeding opportunities for waterbirds (e.g. Pied Cormorants), fish, frogs	Linked to habitat objectives. Providing a variety of habitat types and a	Maintain as a permanent wetland with fluctuating water levels (around 79.5 m AHD).

[6] Timing, frequency and duration

[7] A map is currently being prepared to enable easy comparison of bathymetric information and vegetation mapping. This will be included prior to finalisation.

Ecological objective	Justification	Hydrological requirement
and invertebrates	permanent should promote breeding.	
3. Process Objectives		
3.1 Restore connectivity between river, floodplain and wetland	Connectivity facilitates dispersal and movement of plant propagules, micro and macro-invertebrates and fish, as well as nutrient and carbon cycling.	In times of 'natural' flood provide 'top-up' environmental water to connect the southern section of Lake Meran to the northern part of Leaghur State Park

5.3. Desired water regime

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

Past water regimes of Lake Meran have involved managing the wetland as a permanent open freshwater lake supporting its high environmental, social and economic values. Significant volumes of channel outfall were directed into Lake Meran to compensate for significant evaporative losses and pumped diversions which assisted in maintaining the lakes water levels between flood events.

The desired water regime is designed to meet the ecological objectives described in Table 8 recognising that this may be sub-optimal for social and economic values. The desired water regime will encourage the expansion of fringing native vegetation, and increase the wetland's diversity by reinstating more natural, fluctuating water levels. The partial exposure of the littoral zone by fluctuating water levels and the occasional complete draw down/drying of the lake (one in ten years) is crucial in maintaining important ecological processes, particularly improved water quality. Given that a significant volume of water is required to fill Lake Meran, a minimum requirement is also specified and this is to maintain functionality of the wetland until filled.

Figure 10 below illustrates the various components of the wetland (e.g. open water, Tall Marsh, River Red Gum) that are being targeted by the water regime.

Timing: Maintain as a permanent wetland if sufficient environmental water is allocated to the lake or by providing top-up flows following Loddon River floods.

In the intervening period provide brief pulse flows in late winter/spring each year. This will to maintain the emergent aquatic plant community (EVC 821: Tall Marsh) currently persisting at the channel outfall, natural inlet creek and southern basin of Lake Meran.

Frequency of wetting:

Optimum: permanent inundation with fluctuating water levels which may dry out occasionally (e.g. one in 10 years)

Minimum: brief pulse flows every year to maintain the emergent aquatic vegetation (EVC 821: Tall Marsh) persisting at the channel outfall in natural creek inlet and southern basin.

Duration: Permanent inundation with fluctuating water levels which may dry out occasionally (e.g. one in 10 years).

Ideally, maintain permanent inundation; inter-flood period where the wetland dries is no more than one in ten years

Extent and depth: Variable

- Maintain base of wetland as permanent standing water, allowing depth to fluctuate as a result of evaporation or as a result of operational management around approximately 79.5 m AHD.
- Inundate fringing Intermittent Swampy Woodland (EVC 813) for two to three months by filling to a target level at 82 m AHD (one in five years); depth not important. Allow water levels to recede naturally to around 79.5 m AHD. The aim of surcharging water

levels to 82 m AHD is to maintain the health of the fringing Intermittent Swampy woodland vegetation dominated by large River Red Gums.

- Where possible flood northern section of Leaghur State Park for two to three months to create connectivity between wetland and floodplain (frequency may be dependent on availability of water and delivery method)

Variability: Moderate. Target water depths will shift between inundation events depending on the previous wetting/drying cycle parameters and the status of vegetation communities determined through vegetation monitoring.

Wetland water regime:
Fill wetland to 82 m AHD (~7 m), allow water levels to recede to approximately 79.5 m AHD and maintain inundation for at least nine in ten years allowing water levels to fluctuate by evaporation or as a result of operational management[8]. Inundate the fringing Intermittent Swampy Woodland (EVC 813) with scattered Tangled Lignum for two to three months one in five years (~ 82 m AHD).

In the interim, provide short pulse flows each year to maintain the emergent aquatic plant community (EVC 821: Tall Marsh) currently persisting at the channel outfall within the natural inlet creek and southern basin of Lake Meran.

Where possible (e.g. in times of natural flood and where a delivery method is available) inundate the northern section of Leaghur State Park to create connectivity between the wetland and floodplain and maintain tree condition.

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

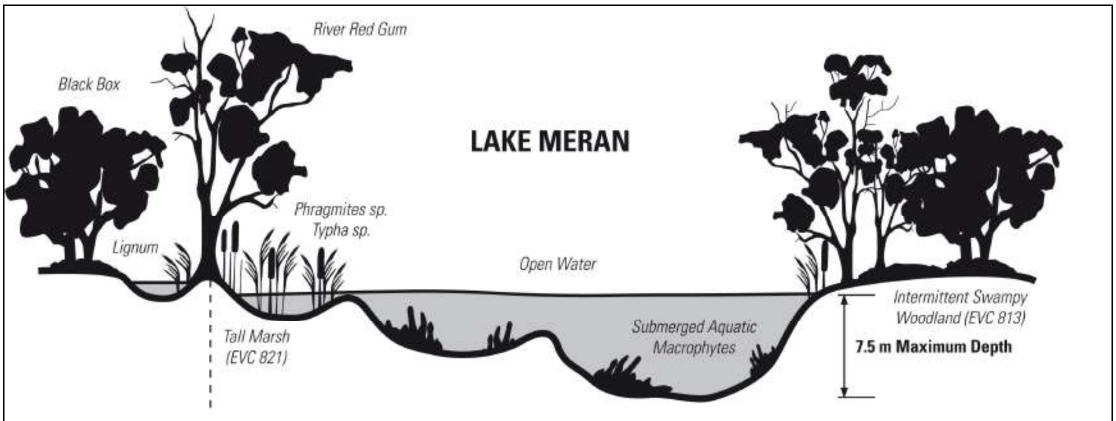

Figure 10: Schematic of wetland areas to be targeted (not to scale)

The volumes of water required to maintain levels at 79.5 m AHD are provided in Table 9 to give an indication of the volumes required to provide the desired water regime for Lake Meran. These volumes reflect the results from the SWET modelling (model described in Section 4.4 and results presented in Appendix G). The additional volume of water required for surcharging levels to 82 m AHD (i.e. one in five years) is currently unquantified. It is recommended that the environmental water manager assesses and calculates the additional volume of water required when watering is planned.

[8] This aligns with the regime described for deep permanent open freshwater lakes which are greater than 5 m in depth and are permanently inundated but can experience a dry phase.

Table 9: Volumes required to maintain levels at 79.5 m AHD (SWET modelling output)

Result	
Mean long-term (LT) annual controlled inflow requirement	1,440 ML/year
95th percentile of mean LT annual controlled inflow requirement	2,706 ML/year
Average LT controlled inflow requirement for filling periods	14,015 ML
Record length	118
No. of periods	11
Years with no inflow	11 in 118
No. of draw downs over record	11
No. of draw downs not fully drawn down	11
% of draw downs not fully drawn down	100%
95th percentile duration of full period (months)	99.5
50th percentile duration of full period (months)	66.6

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. water may be required for nine in ten years). A mean long term annual volume of 1,440 ML would be required to be put into Lake Meran maintain levels around 79.5 m AHD m AHD.

- **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 (2,706 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. nine years). This excludes natural inflows from rainfall and local catchment runoff. Therefore, over a nine year inundation period (allowing for a year where no controlled inflows are provided), the total volume required to fill Lake Meran and maintain levels around 79.5 m AHD would be approximately 14,015 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 watering is planned. Surface water inflows to Lake Meran 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 NVIRP on wetlands that have become reliant on this water to support high environmental values is termed ‘mitigation’ water. The potential impact of NVIRP considered in the Lake Meran EWP is related mainly to a reduction in outfalls. Other potential impacts to the wetland will be managed in accordance with the Water Change Management Framework (NVIRP 2010) 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 watering

plans. Water quality will need to be considered for all sources of water to ensure it is appropriate.

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

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

Step 1: Describe the desired water or flow regime

Step 2: Determine the baseline year incidental water contribution

Step 3: Assess dependency on baseline incidental water contributions

Step 4: Calculate the annualised baseline mitigation water volume

Step 5: Calculate the mitigation water commitment

Step 6: Calculate the LTCE mitigation water volume

5.4.1. Lake Meran mitigation water

Step 1: Describe the desired water or flow regime

The desired water regime for Lake Meran is to maintain it as a permanent wetland with fluctuating water levels which may dry out occasionally (e.g. one in 10 years). In the intervening period a critical objective towards achieving the water management goal is to maintain the Tall Marsh (EVC 821) vegetation currently persisting near the channel outfall in the inlet creek and southern basin (Appendix E). The aim is to provide a refuge pending future inundation of the lake from other sources. Further detail is provided in Section 5.3.

As an indication, a total of 14,015 ML would be required to maintain permanent inundation below 79.5 m AHD over 9 years.

Step 2: Determine the baseline year incidental water contribution[9]

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. Preliminary calculations to estimate the potential contributions to Lake Meran from leakage and seepage from the no. 8/2 main supply channel were completed based on the localised impact assessment method outlined in the Water Change Management Framework (NVIRP 2010). As Lake Meran is greater than 200 m from the main supply channel, leakage and seepage from this channel are not considered to contribute to the surface water balance of the wetland (Appendix H). However, if future NVIRP actions are likely to impact the potential for leakage and seepage to Lake Meran (for example decommissioning any spur channels within 200 m of the wetland), an analysis will be triggered in accordance with the WCMF.

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

The baseline year (2004-05) outfall volume recorded at the regulating structure was 147 ML, refer to Section 4.1. The delivery or outfall channel to Lake Meran is approximately 1 km in length. An estimated 50 ML/km/irrigation year[10] are lost from an open channel as a result of evaporation and seepage (pers. comm. Chris Solum [NVIRP], 27 January 2010). Based on conservative assumptions relating to channel wetness when outfalls occur, and with an average fill time of approximately 115 days (based on 80 ML/day), the loss from the open channel in the baseline year is estimated to be 21 ML. Therefore, as much as 86% (or

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

[10] These losses assume the channel is constantly inundated. Therefore losses may be less depending on the length of intervals between outfalls (pers. comm. Chris Solum [NVIRP] 30 March 2010).

126 ML) of this outfall volume is estimated as having contributed to the wetland's water balance in 2004-05.

The determination of the baseline year incidental water contribution is summarised in Table 10.

Table 10: Determination of the baseline year incidental water contribution

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 #ST023656	147	21	126

<u>**Step 3:** Assess dependency on baseline incidental water contributions</u>

The Water Change Management Framework (NVIRP 2010) 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 Lake Meran with the results presented in Table 11.

Table 11: 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 (~1 km) delivers outfall water to Lake Meran from the automated regulator.
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)	There are no impediments or diversions restricting outfalls being delivered to Lake Meran. 86% (or 126 ML) of the outfall water is estimated to have reached the wetland and equates to approximately 10% of the mean long term annual inflows required to provide the desired water regime (1,440 ML/year).
2. Mitigation water may be assessed as not required where the wetland or waterway receives water from the irrigation system:	
2.1 That is surplus to the water required to support the environmental values (e.g. changing from a permanently wet to an intermittently wet or ephemeral regime is beneficial or has no impact)	The lake does not have more water than is required to support the desired state of the environmental values, even if operated under a drier regime. It is currently dry.
2.2 That occurs at a time that is detrimental to the environmental values	Timing is not critical to the environmental values.
2.3 That is of poor quality (or results in water of poor quality entering a site e.g. seepage resulting in saline groundwater intrusions to wetlands) and the removal of which would lead to an improvement in the environmental values	Losses (Irrigation outfalls) are of acceptable water quality for the lake.
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 maintain Tall Marsh (EVC 821) vegetation persisting at the channel outfall within the inlet creek and southern basin of Lake Meran (Appendix E). Maintaining this community enhances opportunities for recolonisation of Lake Meran when filled.
4. Mitigation water may be assessed as zero 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)	During years in which the lake is full there may be negligible benefit from mitigation water, but mitigation water has an important role in maintaining the Tall Marsh (EVC 821) vegetation and the relict populations it supports. The removal of the incidental outfall contribution would put these environmental values at risk.
4.2 Diminish the benefits of deploying any environmental water allocations (over and above the contribution from the irrigation system).	If outfall volumes were reduced or removed, additional water would need to be secured for providing annual flows to maintain the Tall Marsh (EVC 821) community at the outfall within the inlet creek and southern basin.

The assessment of the requirement for mitigation water for Lake Meran demonstrates that the **incidental outfall water provides benefits to the wetland and that the provision of mitigation water is warranted**. If the volume of outfall water was to be reduced or removed, additional water would need to be secured to provide annual flows in order to maintain the Tall Marsh vegetation that provides habitat for a variety of fauna species and would enhance opportunities for recolonisation of Lake Meran when filled.

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.

During years in which Lake Meran is at (or near) FSL there may be negligible benefit from mitigation water. However, mitigation water has an important role in maintaining the emergent aquatic plant community (EVC 821: Tall Marsh) currently persisting at the channel outfall within the natural inlet creek and southern basin, during dry periods. Therefore, mitigation water is required annually unless:

- Lake Meran is filled and kept near full by a significant environmental water allocation or Loddon River flood and;
- Monitoring identifies that the provision of mitigation water is not contributing to achieving the ecological objectives or water management goal (Section 8).

As there is no other more efficient infrastructure options for delivering mitigation water, BMW has been calculated at outfall #ST023656 (gross).

Gross BMW

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

= (147 ML) / 1 (required annually for an unspecified period)

= 147 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 (Step 2). 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 2009g) and will become available in any following year.

MWC (%)

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

= (147/147) x 100

= 100% (for an unspecified period of time)

The overall MWC for Lake Meran is 100%.

Step 6: Calculate the LTCE mitigation water volume

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

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

5.5. Other water sources

The annualised baseline mitigation water volume represents 10% of the mean long-term annual volume of water required to deliver the desired water regime to Lake Meran (1,440 ML). NVIRP 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 Lake Meran as a permanent open freshwater lake with fluctuating water levels. Beyond natural flooding, the most likely additional sources of water will be existing and future environmental entitlements.

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

5.5.1. Murray flora and fauna bulk entitlement

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

5.5.2. 75 GL environmental entitlement

Water savings generated by NVIRP 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 (NVIRP 2010).

In addition, the Australian Government may co-invest in Stage 2 of NVIRP which will generate up to 100 GL of water savings, some of which will be allocated to the environment. This water will be available for use across the Murray Darling Basin.

5.5.3. Commonwealth environmental water

Under Water for the Future the Australian Government has committed $3.1 billion 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 DEWHA, 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 Lake Meran is not a wetland of international importance, it is a refuge for species listed under other International conventions. A case for the receipt of Commonwealth environmental water could be made.

6. Potential risks or adverse impacts

An important component of the EWPs is the identification of potential risks, limiting factors and adverse impacts associated with the delivery of the desired water regime of which the annualised baseline mitigation water volume represents 10% of the mean long-term annual volume of water required to deliver the desired water regime to Lake Meran (1,140 ML). Awareness of the potential risks and impacts will influence future intervention and long-term condition monitoring undertaken at Lake Meran, will inform the adaptive management of the water regime and the provision of mitigation water (Section 8).

Table 14 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 NVIRP 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 Lake Meran. 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 12: Additional potential risks, impacts and mitigation measures associated with the desired water regime recommended for Lake Meran

Risks/limiting factors	Impacts	Mitigation measures
Limited water availability (i.e. no flood or environmental water allocation to provide desired water regime)	Loss of high environmental values. Failure to achieve identified objectives and water management goal	Deliver mitigation water on an annual basis to maintain the refuge of aquatic plants (EVC 821) at the outfall within the natural inlet creek and within the middle depression/basin enhancing opportunities for recolonisation when filled to target level.
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).
Opportunistic diversion licences (equating to approximately 1500 ML)#	Artificial lowering of water level threatening achievement of identified objectives and goal. Using environmental and mitigation water for consumptive use.	Investigate options for alternative supply.
Bed modification resulting in opportunistic harvesting of inflows	Failure to achieve identified objectives and water management goal	Investigation options for removing existing bed modifications diverting inflows

#G-MW stage 5 roster suspensions on diversions are currently in place. These are to remain in place, or appropriate restrictions implemented if not already in place, to ensure that any mitigation water delivered to wetlands and waterways is protected until such time more permanent measures are established. The roster suspensions may be temporarily lifted to allow extraction to occur where there are demonstrable alternative water supplies entering the waterway or wetland (e.g. as a result of flood).

7. Water delivery arrangements

Lake Meran receives outfalls from the 8/2 channel via the delivery channel running parallel to Pickles Canal. The reported capacity of channel 8/2 is 110 ML/day; however a siphon that passes water beneath Pickles Canal has a reported capacity of 100 ML/day. The outfall structure is fully automated and has a capacity of 80–100 ML/day (Hillemacher and Ivezich 2008).

The lake's outlet is situated at the northern end of Lake Meran and consists of a grated structure with drop boards (Figure 11). FSL is at 82.85 m AHD; however the spill level when drop boards are removed is 82.39 m AHD. From the outlet, water travels north to the Boort–Kerang Road, following it in a north-easterly direction before passing under the road via eight box culverts and being carried along a floodway north-west to Tobacco Lake (GHD 2006).

At a flow rate of 80 ML/day (capacity of the outfall regulating structure) it would take a minimum of 115 days to fill Lake Meran from empty, assuming that the system is fully saturated and there are no losses (Hillemacher and Ivezich 2008).

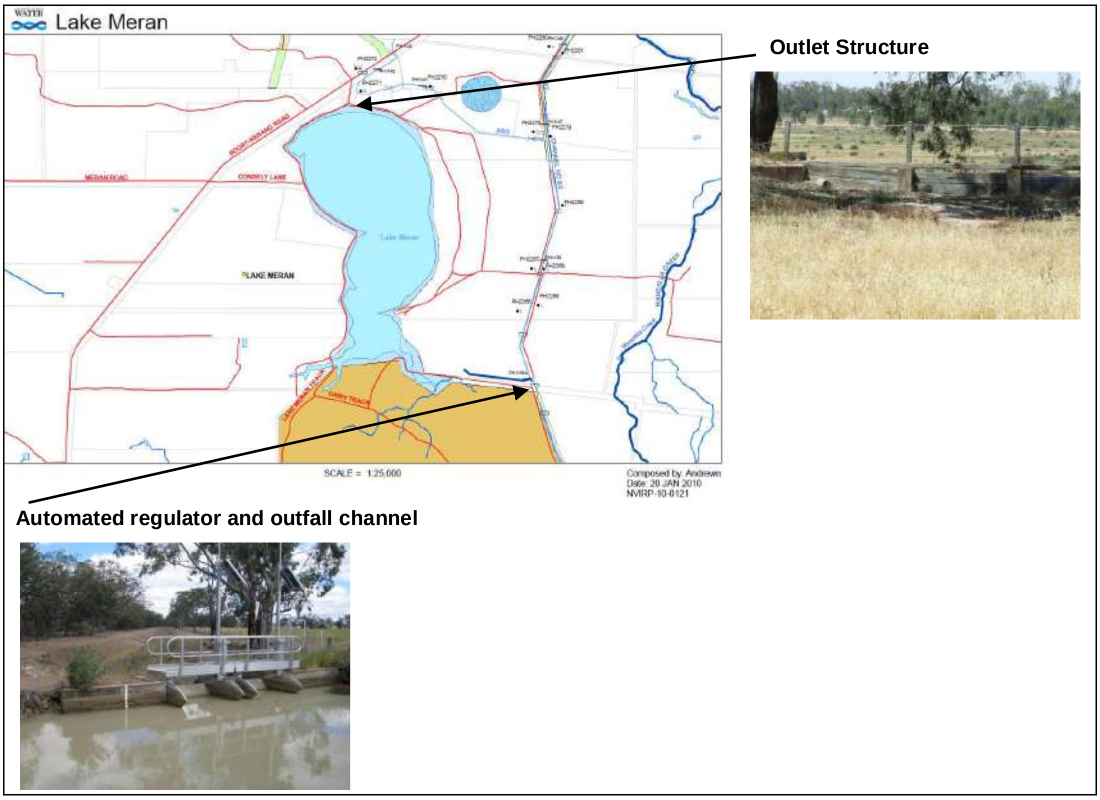

Figure 11: Lake Meran Infrastructure

7.1. NVIRP works program – channel 8/2

The Stage 1 NVIRP 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 8/2 channel, on which the Lake Meran outfall structure is located, is the backbone within the vicinity of Lake Meran. At this stage it is unlikely to be rationalised from the irrigation water supply system as part of the NVIRP Connections Program and connection to Lake Meran is likely to remain.

NVIRP are responsible for "retain(ing) infrastructure and improving where practicable, where it will be required for delivering environmental water…." (NVIRP 2010). A review of the infrastructure requirements and supply arrangements will need to be undertaken if channel 8/2 is considered for rationalisation. Similarly, the potential impact of providing a new supply point will need to be investigated if the current supply point is likely to alter.

7.2. Infrastructure requirements

Presently, Lake Meran is empty and would require significant volumes of water to fill it to FSL. At a delivery rate of 80 ML/day (based on the potential restriction of the siphon) would allow Lake Meran to be filled in approximately 115 days (assuming no losses). As such, it is considered likely that the current delivery infrastructure would be used predominately to provide small pulse flows to maintain the aquatic refuge or 'top-ups' when full. The current delivery infrastructure is considered adequate to deliver these smaller flows and no infrastructure upgrades are recommended if the lake is initially filled from a natural flood.

However, minor upgrade options to improve operational management of Lake Meran delivery infrastructure could be undertaken to increase the flows that can be released into the wetland from 80 – 100 ML/day to 110 ML/day. These involve:

- conveying the constrained amount of 10 - 30 ML/day[11] directly into the outfall channel either by pumping or by installation of another outfall structure and channel from the upstream side of the siphon. Estimated cost: $30,000 (Hillemacher and Ivezich 2008)
- removing the siphon. Estimated cost: $40,000 (Hillemacher and Ivezich 2008)
- increasing the capacity of the siphon.

For each of these options, the capacity of the outfall channel and outfall regulating structure must also be confirmed to ensure they are capable of conveying 110 ML/day. This has been factored into the estimated costs given above (Source: Hillemacher and Ivezich 2008).

In addition, European Carp are abundant within the G-MW channel system and there is currently no carp screen between the channel system and Lake Meran. Carp are known to have significant detrimental impacts on wetlands by increasing the turbidity of the water, preventing the establishment of aquatic vegetation and competing with native species. In particular, there is potential for enormous benefit in installing a carp screen to prevent larger fish entering the wetland when filling from empty following a dry period (pers. comm. Rob O'Brien [DPI] 30 March 2010).

It is recommended that a carp screen is installed to prevent larger carp entering the wetland. A screen with a spacing size of 50 mm would minimise blockage while restricting the passage of large breeding sized carp (SKM 2005). Although it would not totally exclude the passage of carp, particularly if the lake is filled by flood flows, it will significantly reduce the population size, facilitating regeneration of wetland vegetation. A carp screen is seen as a beneficial upgrade to Lake Meran, particularly as the desired water regime encourages an infrequent dry phase rather than permanent inundation (i.e. dry for no more than one year in ten).

The following should be considered prior to installation:

- The screen should be positioned to prevent fish entrainment.
- It should be designed to rotate about a vertical axis (to clear any weed or debris accumulating).
- It should be fitted so it can be easily removed and readily accessible.
- Regular maintenance will be required during regulator operation to prevent blockages.
- Installation will reduce the hydraulic capacity of the regulator (SKM 2005).

The works and potential upgrade options recommended above are outside the scope of NVIRP, unless rationalisation of channels impacts on the current delivery system to the wetland.

[11] Channel capacity of 110 ML/day is currently restricted to 80-100 ML/day by the siphon that passes water beneath Pickles Canal

8. Adaptive management framework

A key NVIRP principle is that an adaptive management approach is adopted to ensure an appropriate response to changing conditions.

Adaptive management is a continuous management cycle of assessment and design, implementation, monitoring, review and adjustment. Table 13 shows how the adaptive management approach will be applied in the context of this EWP.

Table 13: Adaptive management framework

Adaptive management phase	Application to this EWP (Responsible agency)	When
Assessment and design	Assessment identifies environmental values, their water dependencies, and the potential role of incidental water. Design determines the desired water regime to support environmental values and determines any mitigation water commitment. Details of both these phases are documented in this EWP. (NVIRP)	2010
Implementation	Implementation is the active management of environmental water, of which mitigation water may form a portion, consistent with this EWP. (Agencies as appropriate)	Continuous
Monitoring (and reporting)	Monitoring is gathering relevant information to facilitate review and enable any reporting obligations to be met. Two types of monitoring are required. Compliance monitoring is checking that the intended water regime is applied. Performance monitoring is used to inform the review of the effectiveness of the interim mitigation water contribution to achieving the water management goal. (NVIRP – to resource or coordinate monitoring to meet its reporting obligations; other agencies – monitoring to inform assessment of achievement of environmental objectives).	Annual
Review	Review is evaluating actual results against objectives and identifying any improvement opportunities which may be needed. (NVIRP, until responsibilities transferred to other agencies)	2012, 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. (NVIRP, until responsibilities transferred to other agencies)	2012, 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 NVIRP will be maintained. NVIRP will report, annually, on the contribution, or provision, of “NVIRP Mitigation Water” towards achieving the water regime. 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 environmental water holder will monitor environmental water delivery (i.e. quantity, timing, duration and frequency) and implement a detailed monitoring program to enable assessment of ecological condition. NVIRP will not implement a detailed monitoring program. It is beyond the scope of this EWP to provide a detailed monitoring program to determine the effectiveness of the desired water regime in achieving ecological objectives and the water management goal.

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

8.2. Review

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

It is expected this EWP will be reviewed in 2012, 2015, 2020 and every five years thereafter, or at any time, if requested by the Victorian Minister for Water or Commonwealth Minister for Environment Protection.

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 14 (NVIRP 2010). The table outlines the roles and responsibilities before and during the implementation of NVIRP in the modified GMID.

Table 14: Roles and responsibilities

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during NVIRP implementation
NVIRP	• identify and account for water savings, subject to audit by DSE 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 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 improve management and mitigation measures. • Arrange for the provision of delivery and measurement infrastructure including capacity and operational flexibility for mitigation water • Work closely with system operator.
Catchment Management Authority	• Identify and inform NVIRP of opportunities for best practice. • Inform NVIRP of its infrastructure requirements to deliver environmental water. • Participate in Technical Advisory Committee. • Agree to implement relevant components of Environmental	• Advise Environmental Water Holder and system operator on priorities for use of environmental entitlements (including mitigation water) in line with recommendations outlined in the EWPs • Implement the relevant components of Environmental Watering Plans. • Operate, maintain and replace, as agreed, the infrastructure required for delivery of mitigation water, where the infrastructure is not part of the G-

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during NVIRP implementation
	Watering Plans. • Agree to implement other relevant regional management and mitigation measures required due to the implementation of NVIRP.	MW irrigation delivery system. • Report on environmental outcomes (e.g. wetland or waterway condition) from the delivery of the water, in the course of normal reporting on catchment condition. • Where agreed conduct the periodic review of EWPs and report results to NVIRP. • Manage and report on other relevant catchment management and mitigation measures required due to the implementation of NVIRP.
Land Manager (Public and private as relevant)	• Identify and inform NVIRP of opportunities for best practice. • Participate in 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 NVIRP.	• Implement the relevant components of Environmental Watering Plans. • Operate, maintain and replace, as agreed, the infrastructure required for delivery of mitigation water, where the infrastructure is not part of the G-MW irrigation delivery system. • Where agreed, participate in the periodic review of relevant EWPs. • Manage and report on other relevant catchment management and mitigation measures required due to the implementation of NVIRP.
System Operator	• Identify and inform NVIRP of opportunities for best practice. • Participate in Technical Advisory Committee. • Agree to implement relevant components of Environmental Watering Plans. • Administer management and operational arrangements.	• Implement the relevant components of Environmental Watering Plans, namely delivery of mitigation water. • Operate, maintain and replace, as needed, the infrastructure required for delivery of mitigation, or other, water, where the infrastructure is part of the G-MW irrigation delivery system. • May negotiate transfer of ownership of infrastructure to the environmental water/land manager for provision of mitigation water if it is no longer required for the public distribution system, in accordance with the principles set out in section 9. • Where the infrastructure assets are due for renewal or refurbishment, the water corporation will undertake the upgrade to the best environmental practice, including any requirements to better provide Environmental Water Reserve.

Agency	Assess and develop management and mitigation measures	Deliver and review management and mitigation measures during NVIRP implementation
		• 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. • Work closely with NVIRP
DSE	• Identify and inform NVIRP of opportunities for best practice. • Participate in Technical Advisory Committee. • Arrange funding to enable environmental water manager, catchment manager and land manager to deliver agreed measures. • Develop policies to address relevant issues (assuming that other agencies will participate in policy development).	• Participate in the periodic review of the Water Change Management Framework and relevant EWPs. • Conduct review as part of the long-term water resource management; a requirement specified in Section 22L of the *Water Act 1989*. The process will allow: - the balance of the environmental obligations and consumptive water to be assessed and restored based on certain conditions - the need for the obligation reviewed based on the environmental values at the time of the review.
Environmental Water Holder (to be established) **DSE pending appointment of the Environmental Water Holder**	Environmental Water Holder not yet in place. Role fulfilled by DSE in the meantime.	• 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. • Participate in the periodic review of relevant EWPs. • 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 in one of two ways:

- by amendment to the River Murray and Goulburn System Bulk Entitlements held by G-MW; or
- by agreement (contract) between the Minister for Environment and G-MW, under section 124(7) of the *Water Act 1989*.

Both agreements are legally binding and reflect the commitments of the Northern Victoria Irrigation Renewal Project to provide water to mitigate potential impacts to high value environmental assets. The arrangements require G-MW to set aside water in the Goulburn and Murray Systems to meet the mitigation water needs, calculated in accordance with the methods in the Water Change Management Framework, for future use at wetlands and waterways that have an approved 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 Lake Meran requires the coordination of information, planning and monitoring among a number of agencies.

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

The main components are:

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

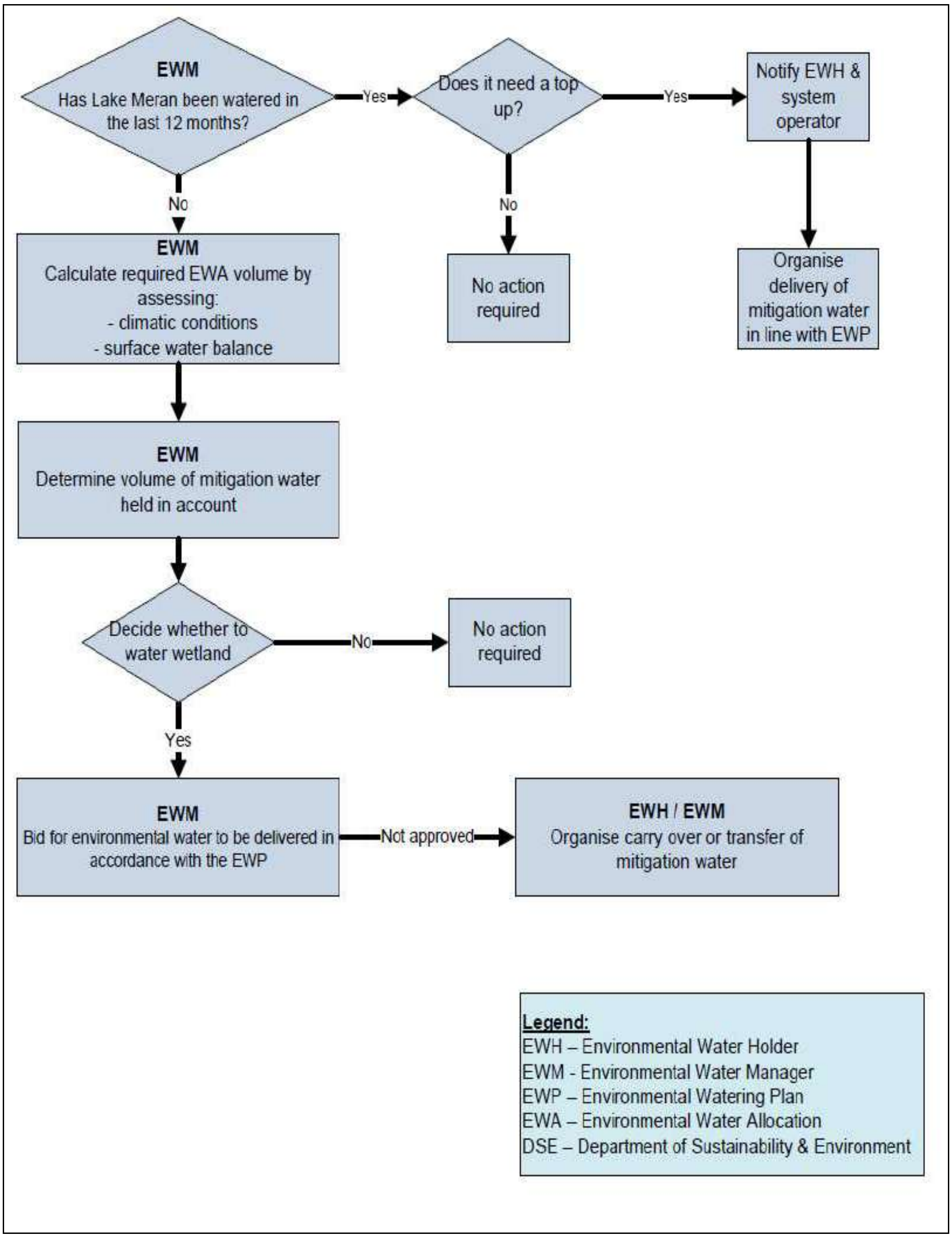

Figure 12: Operational management framework

10. Knowledge gaps

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

10.1. Works program

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

- channel 8/2 will be considered for rationalisation
- the current supply point is likely to be altered and details of any potential alternative supply points.

10.2. Lake Meran

- The additional volume of water required to surcharge levels to 82 m AHD therefore inundating the fringing Intermittent Swampy Woodland vegetation remains unquantified. It is recommended that the environmental water manager assesses and calculates the additional volume of water required when watering is planned.
- Determination of whether the fluctuating water levels between the proposed heights will result in Pickles Canal transferring water from Lake Meran into Wandella Creek is required. This may impact the achievement of the water management goal and objectives.
- Continued monitoring and evaluation of groundwater and surface water data is recommended to ensure no detrimental impacts from implementation of the water regime.
- 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).

10.3. Roles and responsibilities

The roles and responsibilities of key agencies in the operational management of mitigation water (and other sources of environmental water) have not yet been clearly defined. A process has been recommended (Section 9.1). However, in light of changes recommended in the Northern Region Sustainable Water Strategy (Victorian Environmental Water Holder) and the Land and Biodiversity White Paper, roles and responsibilities will need to be reviewed.

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Appendix A: NVIRP TAC and Wetland workshop participants

Table A1: NVIRP TAC members

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 – 17 December 2009

Name	Organisation and Job title
Andrea Joyce	Program Leader – Wetlands and Environmental Flows Department of Sustainability and Environment
Anne Graesser	Manager – Water Systems Health Goulburn Murray Water
Bridie Velik-Lord	Environmental Flows Officer North Central CMA
Cherie Campbell	Senior Ecologist Murray Darling Freshwater Research Centre
Chris Solum	Environmental Program Manager NVIRP
Emer Campbell	Manager NRM Strategy
Geoff Sainty	Wetland Specialist Sainty and Associates Pty Ltd
Karen Weaver	Biodiversity and Ecosystem Services Department of Sustainability and Environment
Mark Tscharke	Senior Ranger Parks Victoria
Michelle Bills	Strategic Environmental Coordinator North Central CMA
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

Appendix B: Community Interaction/Engagement

Rob O'Brien, Department of Primary Industries

Community Engagement purpose

An important component of the EWPs involves identifying the goal, underlying environmental objectives and wetland type for each of the wetlands being assessed for the 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 G-MW water bailiffs, duck hunters (Field & Game Association), bird observers and field naturalists. These people often possess valuable information across several of the wetlands currently being studied.

The method of obtaining information was informal and occurred at the lake (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 (Lake Meran)

- Brett Condely (landholder)
- Morton & Val Richie (landholder)
- Paul Haw (community member)

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

- Lake Meran is located on the Loddon River floodplains and receives water via a series of creeks which break away from the Loddon River during times of high river flow.
- The Loddon River's capacity diminishes downstream of Bridgewater and during wet seasons a series of subtle, meandering; shallow creeks spread water out across the floodplain.
- The floodplain in the Lake Meran area is very flat and the creeklines that encourage the water to spread out both sides of the river are referred to as the "Loddon Fan"
- The main creeks that direct water into Lake Meran are the Wandella and Venables Creeks. In larger flood the Kinypanial Creek may also penetrate through the Boort Wetlands and enter Lake Meran.
- Lake Meran was a deep freshwater lake and the deepest lake within the Boort wetlands system.
- The lake could hold water for several years (4 – 5yrs) after a flood event, as it was about 20 ft deep.
- The lake had a well-formed lunette on the eastern side and some of elevated lighter soils supported Mallee vegetation.
- Lake Meran is abutted by a large Black Box Forest (Leaghur State Park) to the south, where the Wandella Creek floodwater enters, spreads out and flows northwards into Lake Meran.
- The overflow of Lake Meran is in a north-westerly direction through a series of wetlands (Tobacco, Round & Spectacle Lakes), then northwards through a Black Box creekline (Little Wandella Creek) towards Duck Lake.

- Lake Meran was surrounded by a wide band of mature River Red Gums and understorey species and linked to wide treed corridors (mainly Black Box) associated with the drainage lines.
- Red Gum stumps are present within the low margins at Lake Meran indicating that lake has experienced dry periods that suited the establishment and survival of the trees for several decades in the past.
- During flood events Loddon River, creeklines and wetlands would all be connected which allowed fish to spread out and repopulate the wetlands.
- Lake Meran supported a rich diversity of native fish, particularly Murray Cod, Yellowbelly and Catfish.
- The diversity of different vegetated plant communities of differing age classes offered great habitat for a range of animal and bird life.
- The plants and animals on the Loddon floodplain were well adapted to the highly variable nature of the rainfall and flooding being able to tolerate a wide range of conditions.
- Lake Meran is situated on the edge of the Mallee and Loddon floodplains and provided a wide range of resources for the Aboriginal people.
- There are numerous archaeological sites in Leaghur State Park and Lake Meran, evidence that this area was naturally highly productive and a popular place for indigenous people.

Changed Management

- The Lake Meran area was dramatically impacted as part of European Settlement. The introduction of domestic livestock, managed as part of large land holdings (stations), lead to overgrazing, soil compaction and the extinction of some species.
- In the droughts around 1851, Lake Meran dried and lots of cattle died at the lake when the area was managed as large stations.
- Lake Meran and other nearby wetlands had a greater diversity of native plants and animals than what is present today.
- Waterways and wetland came under considerable stock pressure as they provide water and shade in a hot, semi arid landscape.
- The need for a more secure water supply lead to the manipulation of the Loddon River and diverting water out from the Loddon River, then through the natural creeks and then into Lake Meran to secure stock and domestic supplies.
- A channel was dug from the Wandella Creek to the south end of Lake Meran (Pickles Canal) to transfer more water from the creek into Lake Meran.
- The natural overflow from Lake Meran was realigned in the early 1900's. Operating rules associated with the current overflow were developed by the Kerang Shire in the 1930's and determined the conditions when the stucture was released and water allowed to flow onto Tobacco, Round and Spectacle Lakes.
- The operating rules at the Lake Meran overflow have often resulted in water being held at high levels in Lake Meran for extended times. This was considered to be damaging to the surround vegetation but also to the northern end of Leaghur Forest where it experienced long inundation periods.
- Lake Meran has also been used to extract water for irrigation since agriculture development intensified.
- In the dry times in 1939 Lake Meran almost dried.
- The irrigation supply system was developed in around the 1920s and 1930s and water was regularly delivered into Lake Meran. This artificial water supply maintained water permanently within the lake and supplemented natural flood events.
- There are several licensed water diverters who can access water from Lake Meran. These diversions have assisted in maintaining good quality water within the lake and also resulting in more significant water level fluctuations.
- Since the development of the irrigation supply system there have been significant outfall contributions into the lake. The channels always were run at high levels and all additional water was escaped into nearby waterways and wetlands.

Environmental & Other Values

- Lake Meran is the best, natural, deep freshwater lake in the district. It is surrounded by healthy old River Red Gums, possesses sandy beaches and connects to a high value Black Box wetland (Leaghur State Park).
- Lake Meran has not completely dried out since the 1851 and this permanent deep freshwater lake supported a high value fishery, particularly Cod and Freshwater Catfish.
- A large 90 lb Cod was trapped in Condely’s pump and there are other examples of large Cod been taken from the lake.
- Lake Meran has supported high numbers and high diversity of waterbird numbers. Most duck varieties bred and fed at Lake Meran.
- The southern end of Lake Meran becomes shallower where it abuts Leaghur State Park. This area was the most popular for waterbirds.
- There have been complete bird lists developed and provided as part of the previous reports (i.e. “The Meran Lakes Complex Project 2006”).
- The lake was full of aquatic plants particularly Ribbon Weed and Cats Tail. The water was very clear and visibility was up to 12 ft within the water.
- Lake Meran is a very deep wetland and there is minimal water losses compared to all of the other less efficient, shallower wetlands.
- The aquatic plants grew so prolifically people wishing to net the lake for fish had to cut paths through the water plants to set their nets. Additionally water plants had to be harvested and removed from the popular swimming area to allow access.
- Red fin were a popular and sought after fish in Lake Meran.
- Carp entered Lake Meran during the 1970’s floods and devastated the lake, eating out all of the aquatic plants, muddying the water and disrupting the food chain. Fisheries Officers estimate that 15, 000 carp died in 2002 when the lake dried up.
- The lake is one of the prettiest lakes in the district and attracts large numbers of visitors.
- The very old River Red Gums around Lake Meran are at times water stressed however in reasonable health. They must be well adapted to these dry conditions and possibly very deep rooted to withstand drought conditions.
- In the 1990’s recorded visitor numbers at Lake Meran ranked it as the third highest visited lake in the Gannawarra Shire.
- Lake Meran has good visitor access and been a hub for districts people but also drawing people to it from across the state.
- New Years day family sport celebrations have been held at Lake Meran for about 100 years. Old-fashioned competitions were held such as sheath throwing, athletics, sack races and egg & spoon races etc. In more recent times family ski races were also included in the new years day events.
- The surrounding Lake Meran residents have always managed Lake Meran well and its current good environmental condition is proof of that.
- The size of Lake Meran may disadvantage it in the prioritization process for environmental water in comparison to other, smaller wetlands.

Suggested Future Management

- Lake Meran is a natural very deep freshwater lake with very high environmental values and water should be allocated and returned to the wetland.
- Lake Meran also possesses very high cultural, social and recreational values that should make it a priority for improved management.
- During the current dry times it may require a flood event to fill or partially fill the lake however water needs to be allocated in subsequent years to maintain the lake for several years thereafter. This will allow the ecology of the lake to recover and reestablish.

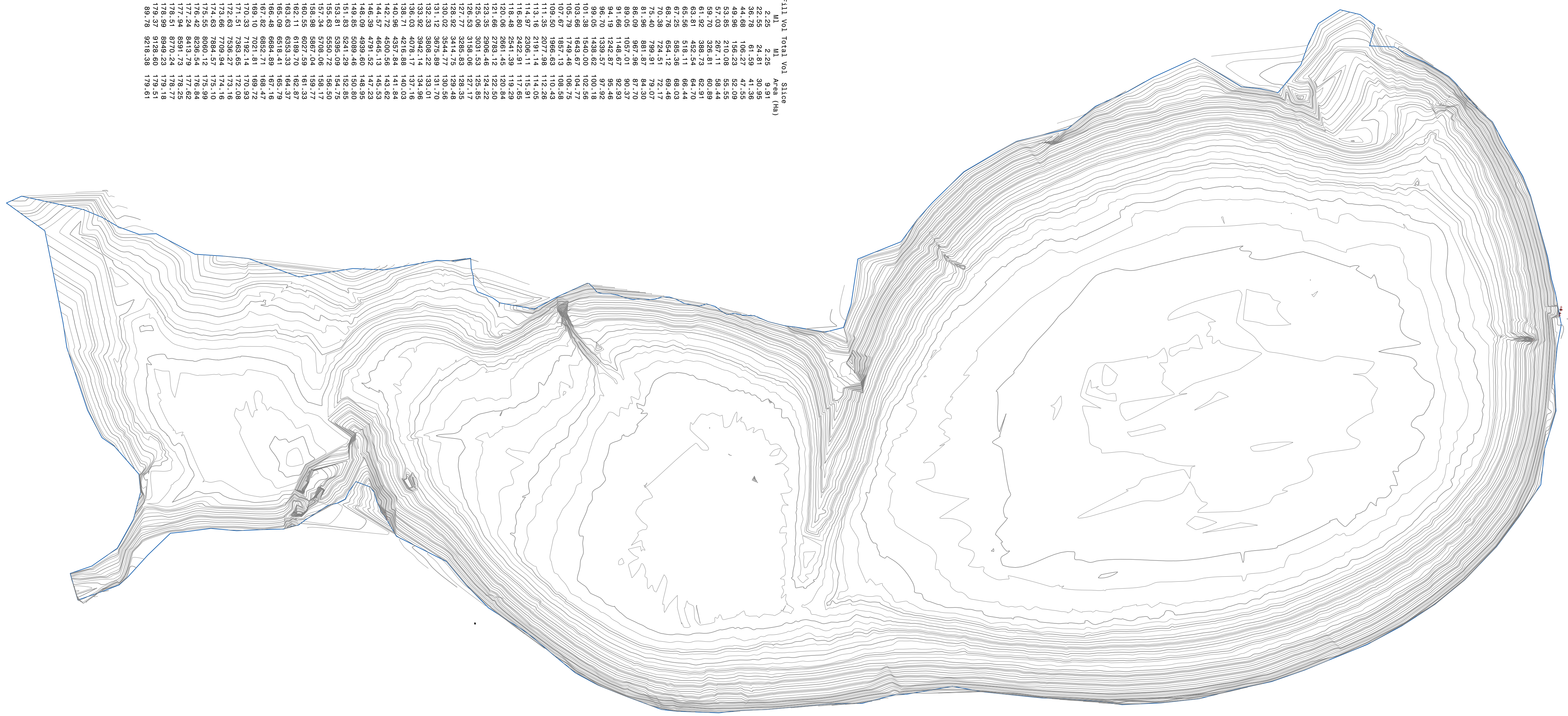
- Environmental allocations need to recognize that a unique, healthy, deep lake like Lake Meran requires environmental water if its values are going to be maintained. Water delivered into Lake Meran will result in benefits for several years there after.
- Fluctuating water levels at Lake Meran have been historic and should be continued to maintain its health.
- Half to three quarter filling the Lake Meran would still provide environmental benefits to the wetland.
- The southern section of Lake Meran, should be managed for wildlife and recreational visitors confined to the northern end.
- An extended dry phase at Lake Meran will result in the loss of many of the important aquatic species. Already some key species have died out after a decade without water.
- Grazing livestock can cause damage to the frontage areas and lakebed and this needs to be carefully managed in the future. Mechanical clearing of vegetation, branches, sticks and leaf litter around the frontage area should be discouraged.
- Education program should be established to ensure visitors have minimal impact on the wetland and promotion/education of how best to manage the frontage areas that abut the lake.
- Pickles Canal linking Lake Meran to the Wandella Creek needs to be maintained and prevented from blocking up with debris. By periodically maintaining this structure it will assist in allowing Wandella Creek Floodwater to flow into Lake Meran. It is also important in large flood event to allow floodwater to flow the opposite direction from Lake Meran to the Wandella Creek as the floodwater subsidies.

Key Points

- Lake Meran is a natural, high value, attractive, deep freshwater lake still in excellent condition.
- This wetland requires a water regime to preserve its environmental, cultural, social, recreational and economic values. Environmental water needs to consider larger wetlands.
- The surround local community and their predecessors have done an excellent job for over 100 years managing this lake.
- During dry times water should be allocated to top up and maintain Lake Meran for several years after a flood event.
- If more normal, wetter conditions return to the catchment then Lake Meran should be maintained more permanently. Natural periodic flooding and then supply channel inputs (environmental allocation) should be delivered.
- More education programs for visitors and residents of the area promoting the best management and use of the wetland to preserve its many values.
- Pickles Canal needs to be maintained to ensure the health of the wetland.

Appendix C: Contour Plan and Rating Table
Price Merrett Consulting (2006)

Elevation From	Elevation To	Fill Vol Ml	Total Vol Ml	Slice Area (Ha)
75.31	75.40	2.25	2.25	9.91
75.40	75.50	22.55	24.81	30.95
75.50	75.60	36.78	61.59	41.36
75.60	75.70	44.68	106.27	47.55
75.70	75.80	49.96	156.23	52.09
75.80	75.90	53.85	210.08	55.55
75.90	76.00	57.03	267.11	58.44
76.00	76.10	59.70	326.81	60.89
76.10	76.20	61.92	388.73	62.91
76.20	76.30	63.81	452.54	64.70
76.30	76.40	65.56	518.11	66.44
76.40	76.50	67.25	585.36	68.03
76.50	76.60	68.76	654.12	69.46
76.60	76.70	70.38	724.51	72.17
76.70	76.80	75.40	799.91	79.07
76.80	76.90	81.96	881.87	84.30
76.90	77.00	86.09	967.96	87.70
77.00	77.10	89.05	1057.01	90.37
77.10	77.20	91.66	1148.67	92.93
77.20	77.30	94.19	1242.87	95.46
77.30	77.40	96.70	1339.57	97.92
77.40	77.50	99.05	1438.62	100.18
77.50	77.60	101.38	1540.00	102.56
77.60	77.70	103.66	1643.67	104.77
77.70	77.80	105.79	1749.46	106.75
77.80	77.90	107.67	1857.13	108.58
77.90	78.00	109.50	1966.63	110.43
78.00	78.10	111.35	2077.98	112.26
78.10	78.20	113.16	2191.14	114.05
78.20	78.30	114.97	2306.11	115.91
78.30	78.40	116.80	2422.91	117.65
78.40	78.50	118.48	2541.39	119.29
78.50	78.60	120.06	2661.45	120.84
78.60	78.70	121.66	2783.12	122.50
78.70	78.80	123.35	2906.46	124.22
78.80	78.90	125.06	3031.53	125.85
78.90	79.00	126.53	3158.06	127.17
79.00	79.10	127.77	3285.83	128.35
79.10	79.20	128.92	3414.75	129.48
79.20	79.30	130.02	3544.77	130.56
79.30	79.40	131.12	3675.89	131.70
79.40	79.50	132.33	3808.22	133.01
79.50	79.60	133.92	3942.14	134.96
79.60	79.70	136.03	4078.17	137.16
79.70	79.80	138.71	4216.88	140.03
79.80	79.90	140.96	4357.84	141.84
79.90	80.00	142.72	4500.56	143.62
80.00	80.10	144.57	4645.13	145.53
80.10	80.20	146.39	4791.52	147.23
80.20	80.30	148.09	4939.60	148.95
80.30	80.40	149.85	5089.46	150.80
80.40	80.50	151.83	5241.29	152.85
80.50	80.60	153.81	5395.09	154.75
80.60	80.70	155.63	5550.72	156.50
80.70	80.80	157.34	5708.06	158.17
80.80	80.90	158.98	5867.04	159.77
80.90	81.00	160.55	6027.59	161.33
81.00	81.10	162.11	6189.70	162.87
81.10	81.20	163.63	6353.33	164.37
81.20	81.30	165.09	6518.41	165.79
81.30	81.40	166.48	6684.89	167.16
81.40	81.50	167.82	6852.71	168.47
81.50	81.60	169.10	7021.81	169.72
81.60	81.70	170.33	7192.14	170.93
81.70	81.80	171.51	7363.65	172.08
81.80	81.90	172.63	7536.27	173.16
81.90	82.00	173.66	7709.94	174.16
82.00	82.10	174.63	7884.57	175.10
82.10	82.20	175.55	8060.12	175.99
82.20	82.30	176.42	8236.54	176.84
82.30	82.40	177.24	8413.79	177.62
82.40	82.50	177.94	8591.73	178.25
82.50	82.60	178.51	8770.24	178.77
82.60	82.70	178.99	8949.23	179.18
82.70	82.80	179.37	9128.60	179.51
82.80	82.85	89.78	9218.38	179.61



REV	DATE		DRN	CHKD
		ORIGINAL CREATED		
		REVISIONS		

JOB DETAILS

DESIGNED :
DRAWN : R.J.MACLEAN
SURVEY DATE : 22/05/2006
DATUM : A.H.D.
GRID INTERVAL : RANDOM
LEVEL BOOK :
FIELD BOOK : F026
AREA : 180.30 ha

SCALE OF METRES
40 0 80 160

ORIGINAL DRAWING SCALE
1 IN 4000 (A1 SHEET SIZE)

MGA ZONE 54

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DEPARTMENT OF PRIMARY INDUSTRIES
CONTOUR PLAN
LAKE MERAN

CROWN ALLOTMENT	SECTION	PARISH	FILE NUMBER	SHEET NUMBER	DRAWING No.	REVISION	SHEET SIZE
		MEERING	F3948	1 of 1	LAKE MERAN	0	A1

Appendix D: Wetland characteristics

Characteristics	Description
Wetland Name	Lake Meran
Wetland ID	7626 533258
Wetland Area	179.61 ha at 82.85 m AHD, 210 ha reserve
Conservation Status	Bioregionally Important Wetland
Land Manager	Lake Meran Committee of Management
Surrounding Land Use	Dryland cropping and grazing
Water Supply	Natural: Wandella Creek Current: Channel outfalls (8/2) via the natural inlet creek • Channel capacity of 100 ML/day, Outfall regulating structure capacity 80–100 ML/day (approx. 115 days to fill)
1788 Wetland Classification	Category: Permanent Open Freshwater
1994 Wetland Classification	Category: Permanent Open Freshwater Subcategories: Shallow (<5m), River Red Gum
Wetland Capacity	9,218 ML, *FSL 82.85 m AHD* (Price Merrett Consulting 2006)
Outfall Volumes	147 ML (04/05) 127 ML (97/98 to 08/09 average)

Appendix E: Flora and fauna species list

Compiled: September 2009

Sources:

Campbell *et al*. (2009)

DSE (2009a)

Ecos Environmental Consulting (2006)

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.

Common Name	Scientific Name
Fauna - native	
Australian Hobby	*Falco longipennis*
Australian Magpie	*Gymnorhina tibicen*
Australian Pelican	*Pelecanus conspicillatus*
Australian Raven	*Corvus coronoides*
Australian Shelduck	*Tadorna tadornoides*
Australian Smelt	*Retropinna semoni*
Black Kite	*Milvus migrans*
Black Swan	*Cygnus atratus*
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*
Black-fronted Dotterel	*Elseyornis melanops*
Black-winged Stilt	*Himantopus himantopus*
Bony Herring	*Nematalosa erebi*
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*
Caspian Tern	*Hydroprogne caspia*
Chestnut Teal	*Anas castanea*
Clamorous Reed Warbler	*Acrocephalus stentoreus*
Common Long-necked Turtle	*Chelodina longicollis*
Darter	*Anhinga novaehollandiae*
Diamond Firetail	*Stagonopleura guttata*
Dusky Moorhen	*Gallinula tenebrosa*
Eastern Great Egret	*Ardea modesta*
Eastern Rosella	*Platycercus eximius*
Eurasian Coot	*Fulica atra*
Flat-headed Gudgeon	*Philypnodon grandiceps*
Galah	*Eolophus roseicapilla*
Golden Perch	*Macquaria ambigua*
Great Crested Grebe	*Podiceps cristatus*
Grey Fantail	*Rhipidura albiscarpa*
Grey Shrike-thrush	*Colluricincla harmonica*
Grey Teal	*Anas gracilis*
Grey-crowned Babbler	*Pomatostomus temporalis*
Lesser Long-eared Bat	*Nyctophilus geoffroyi*
Little Black Cormorant	*Phalacrocorax sulcirostris*
Little Forest Bat	*Vespadelus vulturnus*
Little Pied Cormorant	*Microcarbo melanoleucos*
Magpie-lark	*Grallina cyanoleuca*
Masked Lapwing	*Vanellus miles*
Masked Woodswallow	*Artamus personatus*
Murray Cod	*Maccullochella peelii peelii*
Murray River Turtle	*Emydura macquarii*
Noisy Miner	*Manorina melanocephala*
Pacific Black Duck	*Anas superciliosa*
Peaceful Dove	*Geopelia striata*
Pied Cormorant	*Phalacrocorax varius*
Rainbow Bee-eater	*Merops ornatus*

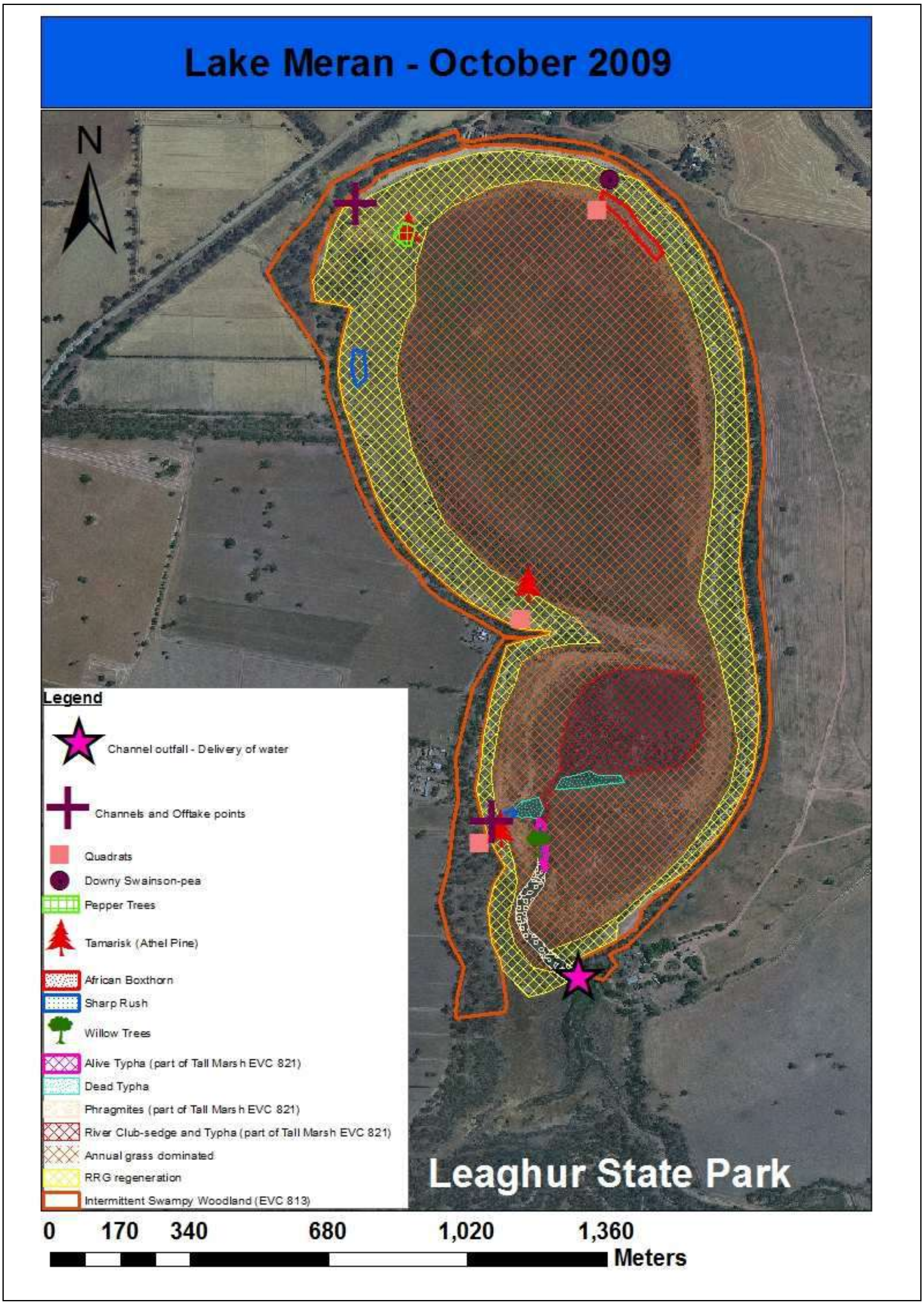
Common Name	Scientific Name
Red-rumped Parrot	*Psephotus haematonotus*
River Blackfish	*Gadopsis marmoratus*
Sacred Kingfisher	*Todiramphus sanctus*
Silver Gull	*Chroicocephalus novaehollandiae*
Silver Perch	*Bidyanus bidyanus*
Southern Forest Bat	*Vespadelus regulus*
Straw-necked Ibis	*Threskiornis spinicollis*
Tree Martin	*Hirundo nigricans*
unidentified Free-tailed Bat	Mormopterus sp.
Welcome Swallow	*Hirundo neoxena*
Western Carp Gudgeon	*Hypseleotris klunzingeri*
Whistling Kite	*Haliastur sphenurus*
White-breasted Woodswallow	*Artamus leucorynchus*
White-faced Heron	*Egretta novaehollandiae*
White-plumed Honeyeater	*Lichenostomus penicillatus*
Willie Wagtail	*Rhipidura leucophrys*
Yellow-billed Spoonbill	*Platalea flavipes*
Fauna - exotic	
Common Carp	*Cyprinus carpio*
Common Starling	*Sturnus vulgaris*
Goldfish	*Carassius auratus*
House Sparrow	*Passer domesticus*
Redfin Perch	*Perca fluviatilis*
Tench	*Tinca tinca*
Flora - native	
Annual Cudweed	*Euchiton sphaericus*
Australian Hollyhock	*Malva preissiana*
Australian Lilaeopsis	*Lilaeopsis polyantha*
Australian Saltmarsh-grass	*Puccinellia stricta*
Balcarra Spear-grass	*Austrostipa nitida*
Black Box	*Eucalyptus largiflorens*
Bluebush	*Maireana* sp.
Bluish Raspwort	*Haloragis glauca f. glauca*
Box Mistletoe	*Amyema miquelii*
Brown-back Wallaby-grass	*Austrodanthonia duttoniana*
Clove-strip	*Ludwigia peploides subsp. montevidensis*
Common Blown-grass	*Lachnagrostis filiformis var. 1*
Common Blown-grass	*Lachnagrostis filiformis*
Common Nardoo	*Marsilea drummondii*
Common Reed	*Phragmites australis*
Common Spike-sedge	*Eleocharis acuta*
Common Swamp Wallaby-grass	*Amphibromus nervosus*
Common Wallaby-grass	*Austrodanthonia caespitosa*
Common Wheat-grass	*Elymus scaber var. scaber*
Common Woodruff	*Asperula conferta*
Cotton Fireweed	*Senecio quadridentatus*
Couch	*Cynodon dactylon*
Crested Spear-grass	*Austrostipa blackii*
Cumbungi	*Typha sp.*
Dense Crassula	*Crassula colorata*
Dodder	*Cuscuta spp.*
Downy Swainson-pea	*Swainsona swainsonioides*
Feather Spear-grass	*Austrostipa elegantissima*
Finger Rush	*Juncus subsecondus*
Fuzzy New-Holland Daisy	*Vittadinia cuneata* s.l.
Giant Rush	*Juncus ingens*
Gold Rush	*Juncus flavidus*

Common Name	Scientific Name
Grassland Wood-sorrel	*Oxalis perennans*
Grassy Bindweed	*Convolulus remotus*
Groundsel	*Senecio sp.*
Groundsel	*Senecio sp. (serrated)*
Hairy Willow-herb	*Epilobium hirtigerum*
Jersey Cudweed	*Pseudognaphalium luteo-album*
Knob Sedge	*Carex inversa*
Knotweed	*Persicaria lapathifolia*
Lesser Joyweed	*Alternanthera denticulata s.l.*
Mallee Love-grass	*Eragrostis dielsii*
Moss	
Narrow-leaf Cumbungi	*Typha domingensis*
New Holland Daisy	*Vittadinia* non-lobed edges
Nitre Goosefoot	*Chenopodium nitrariaceum*
Nodding Saltbush	*Einardia nutans ssp. nutans*
Pink Bindweed	*Convolvulus erubescens spp. agg.*
Poison Pratia	*Lobelia concolor*
Pondweed	*Potamogeton sp.*
Prickly Saltwort	*Salsola tragus*
Rat-tail Couch	*Sporobolus mitchellii*
Red Bird's-foot Trefoil	*Lotus cruentus*
Red-leg Grass	*Bothriochloa macra*
River Club-sedge	*Schoenoplectus tabernaemontani*
River Red-gum	*Eucalyptus camaldulensis*
Rough Spear-grass	*Austrostipa scabra*
Ruby Saltbush	*Enchylaena tomentosa var. tomentosa*
Rush	*Juncus sp.*
Saltbush	*Atriplex sp.*
Short-leaf Bluebush	*Maireana brevifolia*
Sieber Crassula	*Crassula sieberiana s.l.*
Slender Knotweed	*Persicaria decipiens*
Slender Monkey-flower	*Mimulus gracilis*
Slender-fruit Salt-bush	*Atriplex leptocarpa*
Small Knotweed	*Polypogon plebeium*
Small Loosestrife	*Lythrum hyssopifolia*
Small Spike-sedge	*Eleocharis pusilla*
Smooth Minuria	*Minuria integerrima*
Southern Cane-grass	*Eragrostis infecunda*
Spear Grass	*Austrostipa sp.*
Spider-grass	*Enteropogon acicularis*
Spiny Flat-sedge	*Cyperus gymnocaulis*
Spiny-fruit Salt-bush	*Atriplex suberecta*
Swamp Buttercup	*Ranunculus undosus*
Swamp Wallaby-grass	*Amphibromus fluitans*
Tangled Lignum	*Muehlenbeckia florulenta*
Trim Flat-sedge	*Cyperus concinnus*
Tufted Bluebell	*Wahlenbergia communis s.l.*
Unidentified Reed	*(#123)*
Variable Plantain	*Plantago varia*
Wallaby Grass	*Austrodanthonia spp.*
Windmill Grass	*Chloris truncata*
Woolly New Holland Daisy	*Vittadinia gracilis*
	Paspalidium paspaloides (sic)

Common Name	Scientific Name
Flora - exotic	
African Boxthorn	*Lycium ferocissimum*
Annual Beard-grass	*Polypogon monspieliensis*
Aster-weed	*Aster subulatus*
Athel Pine	*Tamarix aphylla*
Barley Grass	*Hordeum sp.*
Barrel Medic	*Medicago truncatula*
Brome	*Bromus sp.*
Buffalo Grass	*Stenotaphrum secundatum*
Burr Medic	*Medicago polymorpha*
Camel Thorn	*Alhagi maurorum*
Cat's Ear	*Hypochoeris radicata*
Celery Buttercup	*Ranunculus sceleratus*
Common Peppercress	*Lepidium africanum*
Common Sow-thistle	*Sonchus oleraceus*
Curled Dock	*Rumex crispus*
Fescue	*Vulpia sp.*
Great Brome	*Bromus diandrus*
Hairy Hawkbit	*Leontodon taraxacoides ssp. taraxacoides*
Hogweed	*Polygonum aviculare*
Hop Clover	*Trifolium campestre var. campestre*
Little Medic	*Medicago minima*
London Rocket	*Sisymbrium irio*
Narrow-leaf Clover	*Trifolium angustifolium var. angustifolium*
Oat	*Avena sp.*
Ox-tongue	*Helminthotheca echioides*
Pampas Grass	*Cortaderia sp.*
Paradoxical Canary-grass	*Phalaris paradoxa*
Paterson's Curse	*Echium plantagineum*
Pepper Tree	*Schinus mollee*
Perennial Rye-grass	*Lolium perenne*
Pimpernel	*Anagallis arvensis*
Poppy	*Papaver sp.*
Prickly Lettuce	*Lactuca serriola*
Rat's-tail Fescue	*Vulpia myuros*
Red Brome	*Bromus rubens*
Red Sand-spurrey	*Spergularia rubra*
Ribwort	*Plantago lanceolata*
Rough Sow-thistle	*Sonchus asper*
Saffron Thistle	*Carthamus lanatus*
Scorzonera	*Scorzonera laciniata*
Sea Barley-grass	*Hordeum marinum*
Sharp Rush	*Juncus acutus ssp. acutus*
Soft Brome	*Bromus hordeaceus ssp. hordaceus*
Spear Orache	*Atriplex patula*
Spear Thistle	*Cirsium vulgare*
Spiny Rush	*Juncus acutus*
Subterranean Clover	*Trifolium subterraneum*
Sweet Melilot	*Melilotus indicus*
Tall Mallow	*Malva sylvestris var. sylvestris*
Tamarisk	*Tamarix ramosissima*
Wall Fescue	*Vulpia muralis*
Water Buttons	*Cotula coronopifolia*

Common Name	Scientific Name
Water Couch	*Paspalum distichum*
Wild Oat	*Avena fatua*
Willow	*Salix sp.*
Willow-leaf Lettuce	*Lactuca saligna*
Wimmera Rye-grass	*Lolium rigidum*
Woolly Clover	*Trifolium tomentosum*
Yorkshire Fog	*Holcus lanatus*

Appendix F: Vegetation composition map – 21 October 2009



Appendix G: Hydrology (SWET OUTPUT)

set	Wetland Name	Lake Meran							
		Degrees	Degrees	Minutes					
set	Latitude	-35.87342	-35.00	52.4049					
set	Longitude	143.80558	143.00	48.3349					
		Metres (AHD)							
	Altitude	82.85						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	352	0	0.057	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	80							
		mm/day							
adjust	Maximum artificial filling rate	20							

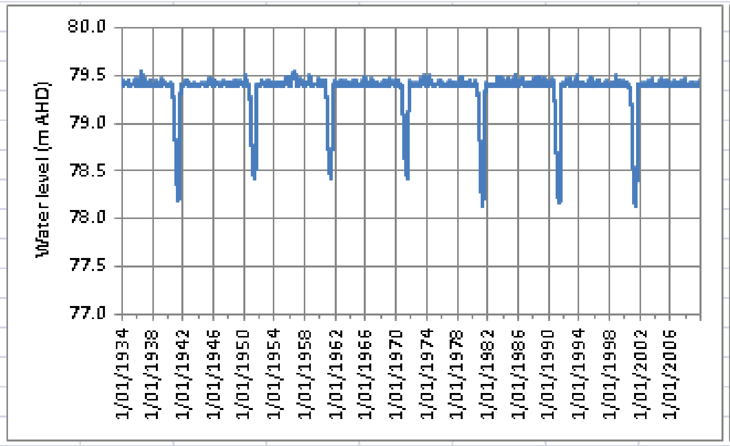
	Management parameters	Day	Month	Start day
adjust	Earliest start to fill	1	8	213
adjust	Latest start to fill	31	12	
adjust	Duration wet cycle - includes filling	3285	108	
adjust	Duration dry cycle - includes drawdown	365	12	
set	Start condition	Wet		Years
set	Maximum wet-dry cycle length			10

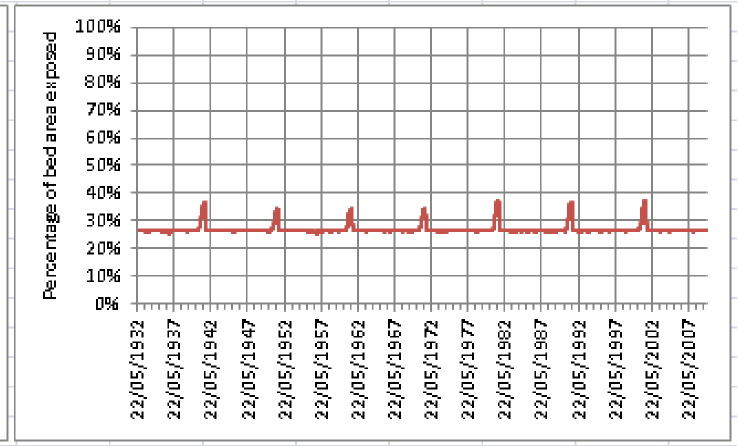
To operate the model
First fill in the required input data cells. Calculation is set to Manual, so when ready press Function9 (F9) key
It takes 20 seconds to re-calculate and plot

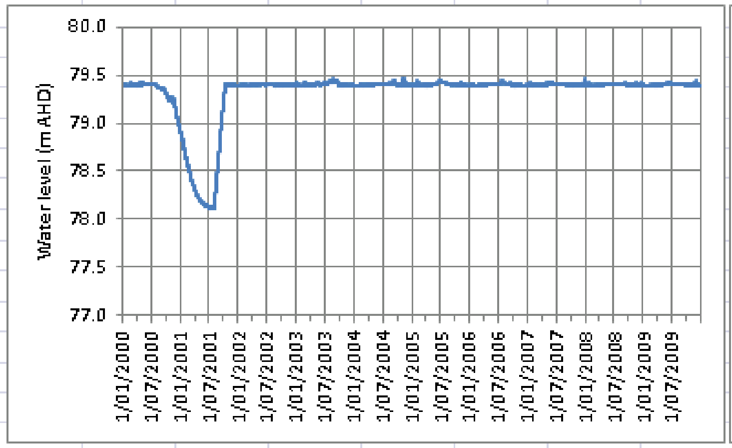
		Day	Month	
adjust	Irrigation year start	1	8	
		Elevation	Volume	Area
adjust	Target level	79.5	3675890	1317000
		Elevation	Volume	Area
set	Wetland spill level	82.85	9218380	1796100
		Elevation	Tolerance for drying (m)	
adjust	Lowest wetland level	75.31	0.1	
			1 = Pan; 2 = Modelled	
choose	Factored Pan evaporation or modelled ET method?		2	

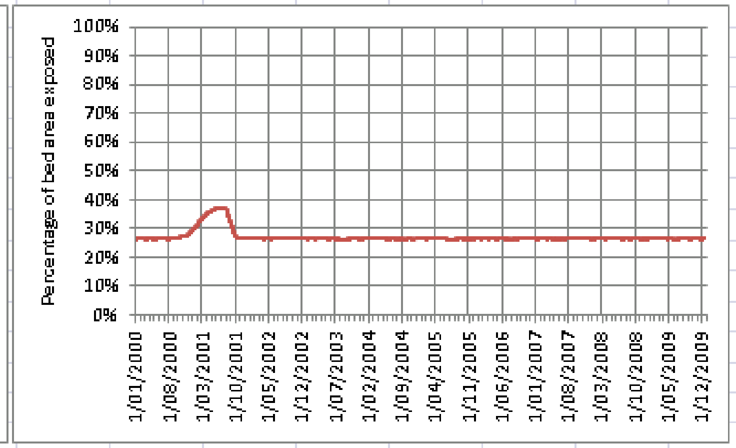
RESULT			
	ML/year	P95 (ML/yr)	Years with no inflow
Mean long-term annual artificial water inflows	1,440	2,706	11 in 118 years
	ML	No. Periods	Record length (years
Average water inflows for filling periods	14,015	11	118
Drawdowns over record (number of)	11		
Drawdowns not fully dried out (number of)	11		
Drawdowns not fully dried out (percentage)	100%		
95th percentile duration of full period (months)	99.5		
50th percentile duration of full period (months)	66.6		

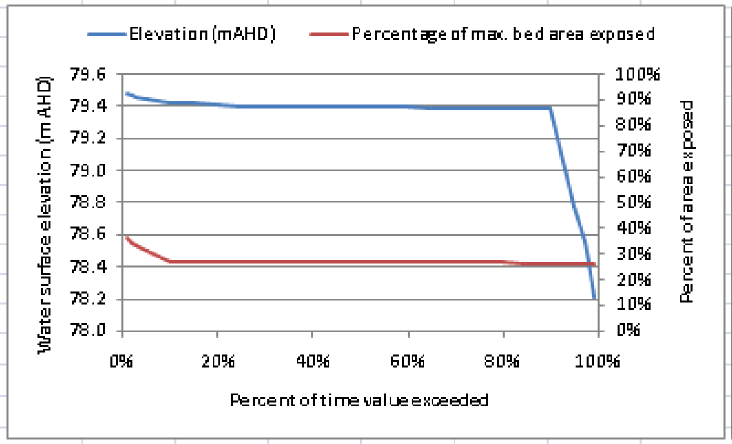
Fill cycle length (yr)	No. cycles
1	
2	
3	
4	
5	
6	
7	
8	
9	
10	10

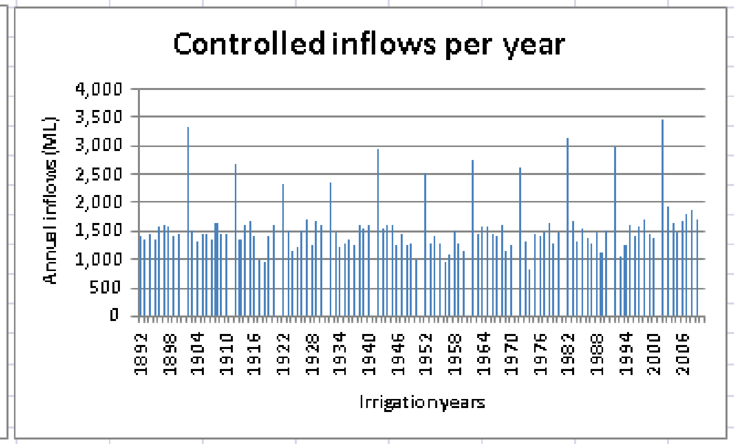












Appendix H: Preliminary leakage and seepage loss contribution calculations

Wetland	Wetland within 200 m of main supply channel (Yes/no)	Length of channel (m) <200 m	Channel width (m)	Irrigation channel	Seepage Calculation Figures					Seepage Range (min - max)	
					Channel width category	5 mm/day (ML/yr)	10 mm/day (ML/yr)	15 mm/day (ML/yr)	20 mm/day (ML/yr)	ML/yr (@ 5 mm/day)	ML/yr (@20 mm/day)
Lake Meran	No (850 m)	n/a	n/a	channel 8/2	n/a	n/a	n/a	n/a	n/a	n/a	n/a

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, waterbird monitoring, water quality and groundwater Adaptively manage water regime and delivery. Re-model volumes required in light of changing climatic conditions and wetland phase.
Inappropriate operation rules for the outlet	Excessive inundation leading to a loss of high environmental values by maintaining artificially high water levels	Review operation rules in light of desired water regime proposed.
Inability to achieve the 1 in 5 year surcharge resulting from small flood flows or a lack of environmental water	Failure to achieve identified objectives and water management goal	Adaptively manage water regime and delivery. Re-model volumes required in light of changing climatic conditions and wetland phase.
Lack of connectivity between Lake Meran and Wandella Creek	Excessive flooding of adjacent land	Maintain Pickles Canal for water transfer between Lake Meran and Wandella Creek
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. Confirm historic cooperative arrangement to opportunistically deliver floodwater into Lake Meran Regularly review rainfall and climate data to utilise natural inflows where possible. Re-model volumes required in light of changing climatic conditions and wetland phase.
Climatic variability	Variability in water availability (e.g. wet seasons during a planned dry phase)	Adaptive management of water regime and delivery options as above. Re-model volumes required in light of changing climatic conditions 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. Adaptively manage water regime and delivery. Re-model volumes required in light of changing climatic conditions and wetland phase.

Risks/limiting factors	Impacts	Mitigation measures
Groundwater intrusion or discharge to low-lying surrounding area resulting from elevated groundwater levels[12]	Poor vegetation health Limited regeneration and dominance of salt tolerant species Unsuitable habitat for waterbirds and food sources Lack of flora and fauna sources for repopulation	Monitoring of groundwater levels and salinity within wetland and surrounding area (Bartley Consulting 2009 and Appendix G). Adaptive management of water regime.
Ecological Response		
Fluctuating groundwater height and salinity levels	Saline groundwater intrusion or discharge onto low-lying surrounding land	Groundwater monitoring and adaptive management of desired water regime (Bartley Consulting 2009 and Appendix G)
Unreliable supply of food/nesting sites	Limited occurrences of waterbirds	Seasonal water delivery, regular monitoring (spring assessments) and adaptive management of water regime to ensure suitable habitat is provided throughout breeding events.
Lag time between wetland water and bird breeding	No successful breeding events	Seasonal water delivery, regular monitoring (spring assessments) and adaptive management of water regime Top-ups may be required complete bird breeding events
Proliferation of pest plants and animals	Reduced habitat and resource availability Predation Limited establishment of native vegetation	Carp screen installation, regular monitoring (e.g. IWC assessments), active management (weed and pest control)
Lack of seedbank viability	Emergence of unexpected native or exotic species Restricted regeneration	Monitoring (e.g. IWC) and adaptive management (Appendix G). Fluctuation of water levels will be required to support River Red Gum germination.
High soil salinity	Poor vegetation health Limited regeneration and dominance of salt tolerant species	Monitoring and adaptive management of desired water regime to reduce potential groundwater intrusion or discharge to low-lying surrounding areas.
Other		
Recreational pressures e.g. hunting increases in response to water event	Loss of non-game species	Monitoring of waterbird numbers and diversity. Reporting of information to relevant bodies including Field and Game and DSE (particularly the occurrence of listed species prior to opening of the hunting season).
Increased uncontrolled grazing pressure during prolonged dry phases	Loss of high environmental values	Active management, monitoring and adaptive management

[12] Under current conditions of low groundwater levels, this is unlikely. However, if conditions where to change and groundwater levels rose there would be a risk of saline groundwater intrusion into the wetland or discharge onto low-lying adjacent land (Bartley Consulting 2009).

Appendix J: Monitoring program recommendations

It is not a requirement of NVIRP to provide long-term condition or intervention monitoring nor does this document represent a comprehensive management plan for Lake Meran. 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 lake, to ensure planned analysis and reporting of the impacts of the adopted water regime (Bartley Consulting 2009).

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 Lake Meran.

Vegetation Condition and Distribution

A number of photo points and objectives for long term vegetation monitoring need to be established for Lake Meran 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 Lake Meran, 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 Lake Meran 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 Lake Meran is currently conducted by DSE, DPI 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 lake 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 Lake Meran and to enhance the quality of data being collected (Bartley Consulting 2009).

Table J1: Additional groundwater monitoring recommendations (Bartley Consulting 2009)

Target	Recommendation
Long-term groundwater monitoring	A review of the groundwater-related aspects of the site, including a re-assessment of environmental risks, should be undertaken at least every seven years and sooner if the water regime is changed or regional groundwater levels rise again
	The impact of any water regime change should be 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 on nearby lakes and wetlands, and a water budget that includes estimates of accession to groundwater.
Data quality	Installing data loggers in selected groundwater bores, to provide data before

Target	Recommendation
	water and throughout the wetting and drying cycle at the site
	Data loggers to record surface water level and salinity at the inlet, in the wetland, and at the outlet if there is overflow
	Confirming the water level gauge elevation, ensure the position and height are adequate to cover the full water level range, and use volume rating tables to assist recording level and volume, to verify surface water data logger readings
	Recording the inflow and outflow volumes during the water event
Breadth of data collected	Regular liaison with neighbouring landholders to understand their water use and irrigation practices, and how these change over time
	Monitoring neighbouring areas that are considered susceptible to salinisation or waterlogging
	Installation of shallow and deep groundwater monitoring bores, at the northern end of the site
	Assessing the condition of the current bores, including the reason for the apparently anomalous readings in some bores
	Assessing the watertable depth as well as groundwater pressure in the Parilla Sand aquifer, and soil and salinity profile beneath the site floor
If the water regime does not change, since some of the monitoring bores in the vicinity are now dry, there should be an evaluation of the groundwater monitoring purpose, and the need for replacement bores or for changed monitoring frequency	

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 Lake Meran and should be updated following regular monitoring.

Table J2: Components of vegetation intervention monitoring

Component	Target	Method	Objective
Vegetation distribution	Tall Marsh, Intermittent Swampy Woodland, submerged aquatic macrophyte habitat	• Distribution mapping • Photo points	Habitat objectives, 2.1
Vegetation condition		• Photo points	Habitat objectives, 2.1
Species diversity	Additional species with a focus on submerged aquatic macrophyte habitat	• Species list comparison	Habitat objectives, 2.1

Waterbirds

The diversity and abundance of waterbirds at Lake Meran 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.

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. 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 Lake Meran 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 diversity	All species including those of conservation significance	• Area searches (Baldwin et al. 2005)	Habitat 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 (native and exotic), amphibians and macroinvertebrates is monitored following watering as they provide important food sources for several waterbirds. 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 Lake Meran 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 G4: 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
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

<table>
<tr><th>Component</th><th>Target</th><th colspan="2">Method</th><th>Objective</th></tr>
<tr><td rowspan="5">Water quality</td><td>Electrical conductivity</td><td>Conductivity metre</td><td rowspan="4">Water quality meter</td><td rowspan="5">Habitat objectives, 2.1, 2.2</td></tr>
<tr><td>pH</td><td>pH metre</td></tr>
<tr><td>Turbidity</td><td>Turbidity metre</td></tr>
<tr><td>Dissolved oxygen</td><td>Oxygen metre</td></tr>
<tr><td>Nutrients</td><td colspan="2">Laboratory analysis</td></tr>
</table>

Appendix K: Contour and vegetation map

Lake Meran

Contours and Vegetation

Legend

Parcel

Lake Meran Contours (0.5m)

ELEVATION

- 0.5m
- 1.0m

Watercourse

- River
- Stream
- Channel
- Connector

Roads

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

Vegetation - MDFRC 2009

Exotic

- Tamarisk
- Willow
- Peppercorn
- African Boxthorn
- Annual grass and Thistle
- Sharp Rush

Native

- Downy Swainson-pea
- Alive Cumbungi (part of Tall Marsh EVC 821)
- Dead Cumbungi
- Common Reed (part of Tall Marsh EVC 821)
- Intermittent Swampy Woodland (EVC 813)
- River Red Gum regeneration
- River Club-sedge & Cumbungi (part of Tall Marsh EVC 821)

Infrastructure

- Channel outfall
- Outlet and Offtake points

Meters

350 175 0 350

1:10,000

N W E S

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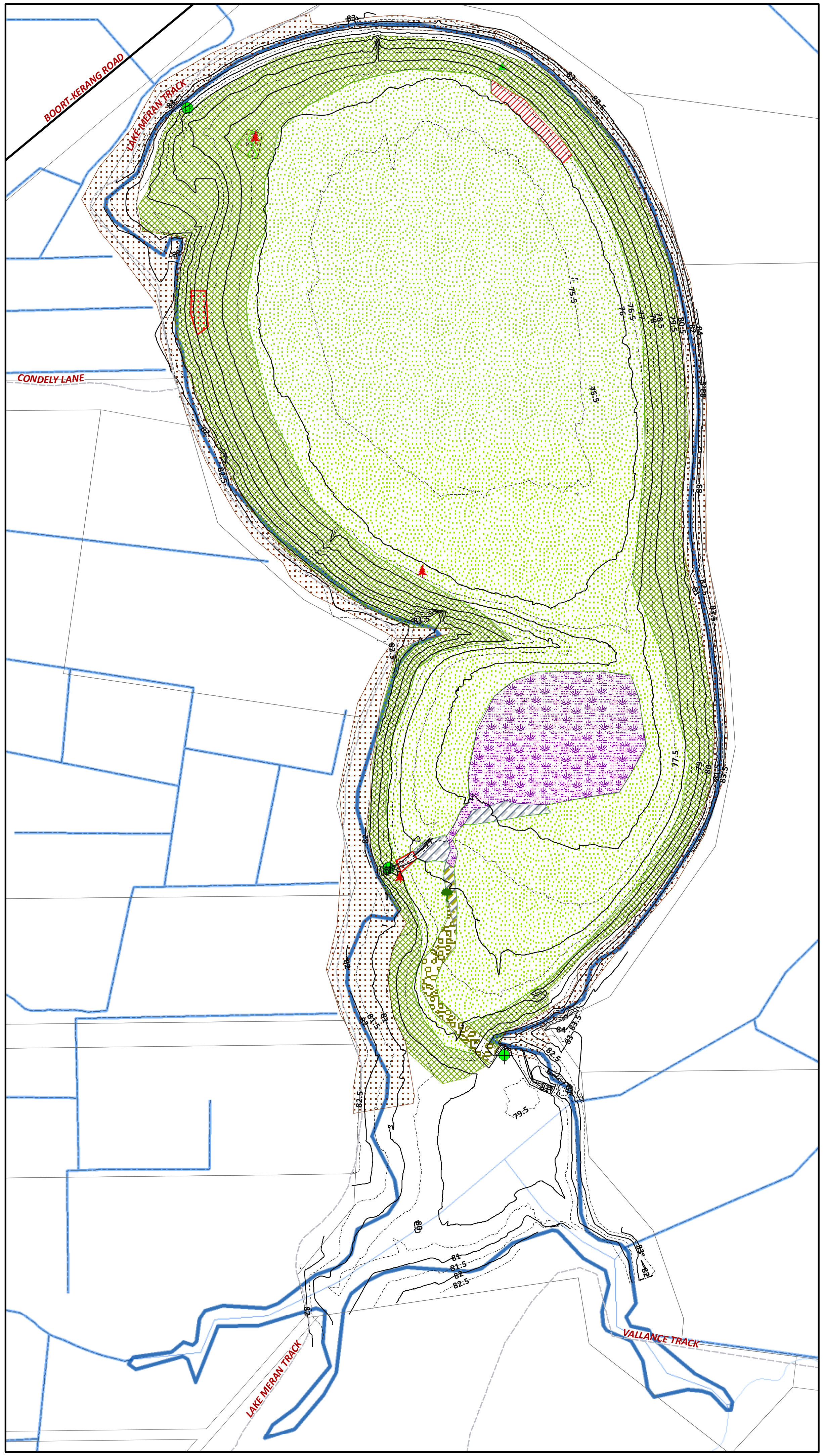

NORTH CENTRAL
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Connecting Rivers, Landscapes, People

Connecting Rivers, Landscapes, People