LAKE ELIZABETH

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

July 2010

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EXECUTIVE SUMMARY

The Lake Elizabeth Environmental Watering Plan (EWP) documents the approach to mitigating the potential impacts of the Northern Victoria Irrigation Renewal Project (NVIRP) due to automation of the Torrumbarry 28/2 channel that outfalls into Lake Elizabeth.

The following components are the primary means by which the commitment of no net environmental loss will be achieved for the NVIRP project. The main conclusions are summarised below.

Defining the environmental values of Lake Elizabeth
Lake Elizabeth is a Wildlife Reserve and classified as a permanent saline lake. It provides habitat for a diverse range of native flora and fauna species and supports moderate numbers of waterbirds. The salt tolerant aquatic plant Sea Tassel (*Ruppia megacarpa)* is abundant in the lake and is a key determinant of the capacity of this wetland to support invertebrates and waterbirds, e.g. herbivores, filter feeders and waders.

In recent years, the combined effects of drought and increased efficiencies in the irrigation system have substantially reduced the total volumes of outfall that the lake receives and it is currently experiencing a drying phase for the first time since European settlement.

A water management goal has been developed in light of the values the lake supports and potential risk factors that need to be managed, e.g. seedbank viability of *Ruppia megacarpa*.

Lake Elizabeth water management goal To provide a watering regime that supports a submerged salt tolerant aquatic plant assemblage typical of an intermittent brackish/saline lake (dominated by Sea Tassel Ruppia megacarpa).

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

Wetland water regime: Fill wetland to ≥1.5 metres one in three years and ensure inundation period of at least 18 months (may require top-ups).

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

The desired water regime for Lake Elizabeth includes a three year cycle, where in year one, it is filled to capacity and topped-up with water to counteract evaporation. In year two, water levels are maintained at approximately 1.5 metres for six months. In the second half of year two, the lake will begin to dry as water is lost to evaporation and seepage.

In this three year cycle the total volume required to fill and maintain levels in the wetland are approximately 2,430 ML.

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

The assessment process for the requirement for mitigation water demonstrates that the **outfall water provides a significant benefit to Lake Elizabeth and mitigation water is warranted**.

The Mitigation Water Commitment for Lake Elizabeth is 67%. This will be used to calculate the interim mitigation water share of any annually calculated water savings.

Potential risks and adverse impacts associated with the recommended watering 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. For example, groundwater intrusion could result in the wetland bed being too saline for *Ruppia megacarpa* to establish.

Infrastructure requirements

Delivery of water at appropriate times and in the required quantities is dependent on having appropriate infrastructure and access to spare channel capacity when required. Infrastructure needs to be retained into the long-term and not rationalised as part of NVIRP.

Lake Elizabeth is restricted to a delivery capacity of 15 ML/day which equates to a minimum of 90 days to fill the wetland. Infrastructure upgrades have been recommended to reduce this prolonged fill time.

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 Elizabeth 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 implementation of the recommended watering regime for Lake Elizabeth.

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ACKNOWLEDGEMENTS

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

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- Wetland workshop attendees (listed in Appendix A, Table A2)
- Ernie Moore, Colin Gitsham, Jeff Gitsham (Landholders)
- Tom Lowe (Field Naturalist, Birds Australia)
- Peer Review: Brett Lane (Brett Lane & Associates), Terry Hillman (LaTrobe University) and Peter Alexander (Hydro Environmental)
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ABBREVIATIONS

AAV	Aboriginal Affairs Victoria
AVW	Atlas of Victorian Wildlife
ANCA	Australian Nature Conservation Agency
AUSRIVAS	Australian River Assessment System
BE	Bulk Entitlement
BONN	Convention on the Conservation of Migratory Species of Wild Animals
CAMBA	China–Australia Migratory Bird Agreement
CoM	Committee of Management
CMA	Catchment Management Authority
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
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
North Central CMA	North Central Catchment Management Authority
NVIRP	Northern Victoria Irrigation Renewal Project
ROKAMBA	Republic of Korea–Australia Migratory Bird Agreement
SWET	Savings at Wetlands from Evapotranspiration daily Time-Series
SEMP	Site Environmental Management Plan
TAC	Technical Advisory Committee
TIS	Torrumbarry Irrigation System
VEAC	Victorian Environmental Assessment Council
VROTS	Victorian Rare or Threatened Species

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, 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 from the NVIRP are considered a 'loss' to the irrigation system, in some cases this 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 methodologies 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 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
- McDonald Swamp
- Johnson Swamp
- Lake Yando
- Lake Leaghur
- Lake Meran
- Little Lake Meran
- Lake Murphy
- Little Lake Boort
- Round Lake

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
- identify if there is a need to provide mitigation water and, if so, determine the quantity of mitigation water
- identify the infrastructure requirements
- identify mitigation measures to minimise the potential risks and impacts associated with the provision of mitigation water
- draft protocols for ongoing water supply
- outline governance arrangements.

This EWP is not a wetland management plan, therefore it is not intended to provide management guidance for wetlands; rather it is aimed at providing a water supply protocol that can be agreed upon by 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 and 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 Elizabeth EWP was developed in collaboration with key stakeholders including G-MW, NVIRP, DSE, Parks Victoria and 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
- 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.

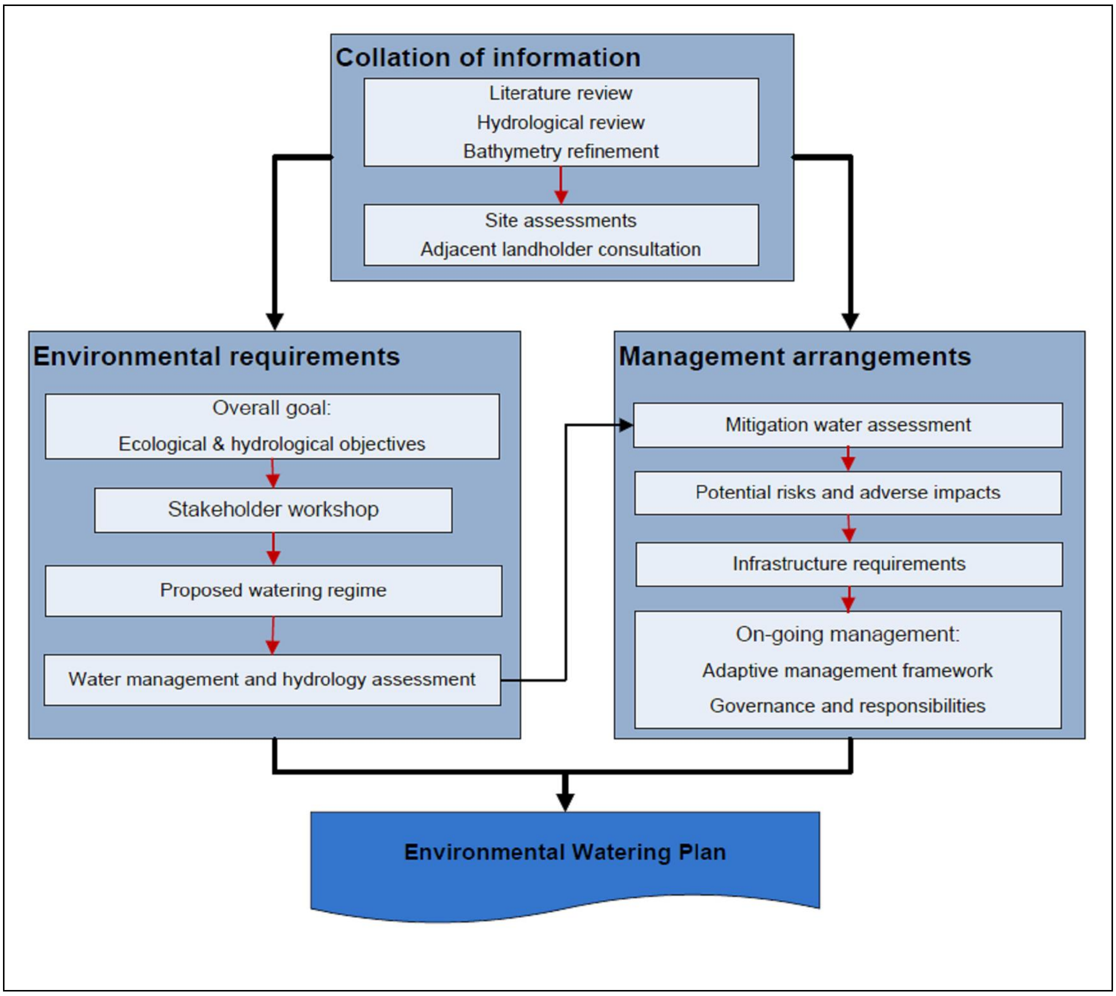

Figure 1: EWP development process

1.4.1 Consultation and engagement

To assist in collating information for the Lake Elizabeth 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 in December 2008.

A workshop was held on 19 March 2009 with key stakeholders and relevant experts (Appendix A) to refine the proposed ecological objectives and watering requirements for Lake Elizabeth. In addition, key components of the draft plan were presented and reviewed by an independent expert panel comprising Brett Lane (Brett Lane & Associates), Terry Hillman (LaTrobe University) and Peter Alexander (Hydro Environmental) on 6 April 2009.

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, including G-MW water bailiffs, duck hunters (Field & Game Association), bird observers and field naturalists. A summary of the information sourced from this process is provided in Appendix B.

2. Lake Elizabeth

Lake Elizabeth is a 94 ha wetland situated approximately 10 km north-west of Kerang (Figure 2). It is located within the Wandella Creek sub-catchment of the Loddon river basin. The wetland is listed as being of bioregional conservation significance (NLWRA, cited in NCCMA 2005).

Refer to Appendix C for the rating table prepared for Lake Elizabeth by Archard's Irrigation Ltd. (2009).

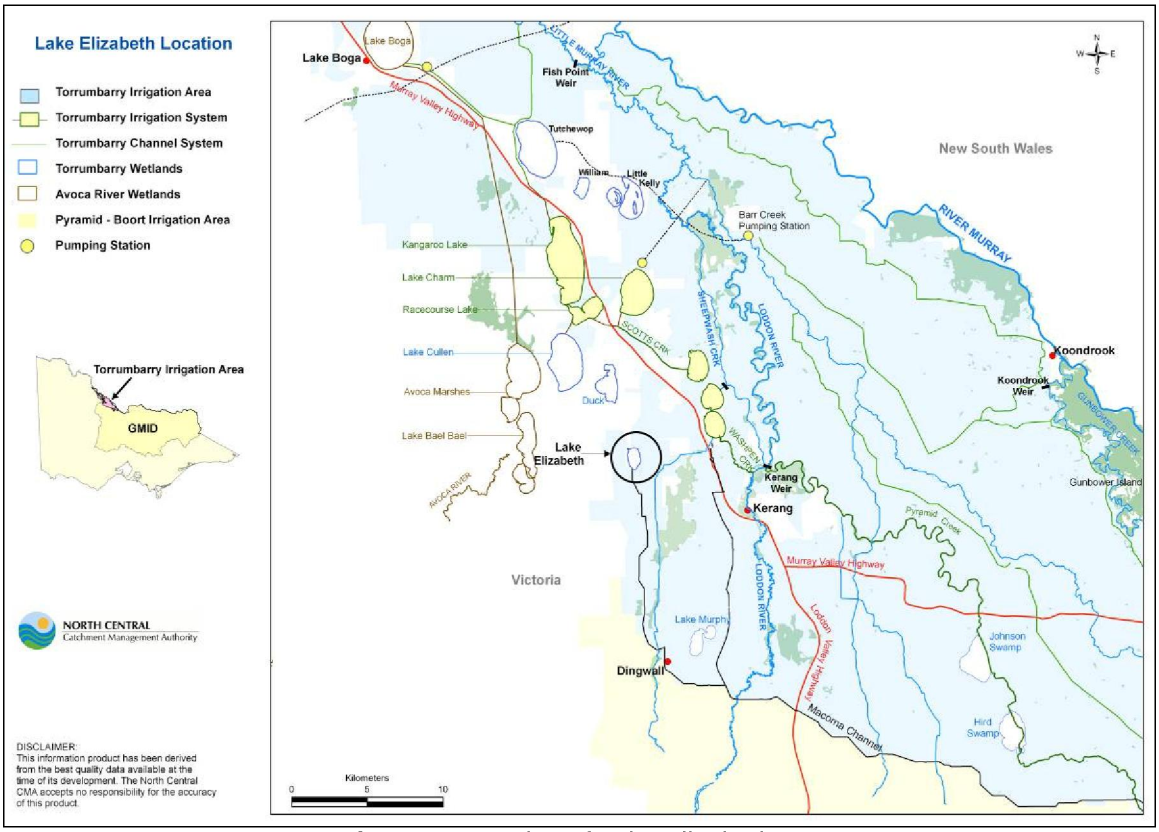

Figure 2: Location of Lake Elizabeth

2.1 Wetland context and current condition

Prior to European settlement, Lake Elizabeth was a permanent open freshwater lake (DSE 2009a). The record of large Murray Cod in the mid 1920s suggests that the lake held fresh water for a significant length of time prior to the 1920s. The lake became part of the irrigation system in the 1920s but following the cessation of diversions in the 1930s, Lake Elizabeth has become increasingly saline and it is now classified as a permanent saline lake (DSE 2009b). The aquatic vegetation altered as a result and salt tolerant submerged aquatics such as Sea tassel (*Ruppia*) thrived and supported a host of invertebrates, waterbirds and small native fish. Of particular importance was a small native fish Murray Hardyhead that existed in very high numbers (Moore et al 2009).

In recent years, the combined effects of drought and increased efficiencies in the irrigation system have substantially reduced the total volumes of outfall that the lake receives and it is currently experiencing a drying phase for the first time since irrigation commenced.

An assessment undertaken in February 2009 reported the following main components:

- A mat of dead and dying *Ruppia megacarpa* covers the bed of the lake and chenopod shrubland vegetation is colonising the drying areas, reflecting the elevated salinity levels.
- Approximately one metre of black soft sediment under the mat of dead Sea Tassel.

- The revegetation works around the fringes of the wetland remain in good health while Black Box trees (west) exhibit poor health (a combination of dead trees and live trees with varying levels of stress).
- Salt tolerant weeds, including an extensive infestation of Spiny Rush, dominate the understorey along the high water mark of both the eastern and southern boundary.

Appendix E illustrates the vegetation composition of Lake Elizabeth surveyed in March 2009.

2.2 Catchment setting

Lake Elizabeth is a terminal lake situated within the Wandella Creek sub-catchment in the Victorian Riverina bioregion. The surrounding catchment (approximately 1304 ha) land use is agriculture, consisting primarily of annual pasture (SKM 2004).

Rainfall in the Kerang region averages 377mm/year, with May to October being significantly wetter than November to April (Macumber, 2002). Maximum average temperatures range from 31.5°C in January to 14°C in July, with minimum temperatures rarely falling below zero (BOM 2009).

Lake Elizabeth is directly connected to the Torrumbarry Irrigation System via the 28/2 channel located to the south of the wetland. A number of drains also enter the lake from the surrounding land providing water from surface drainage (Figure 3).

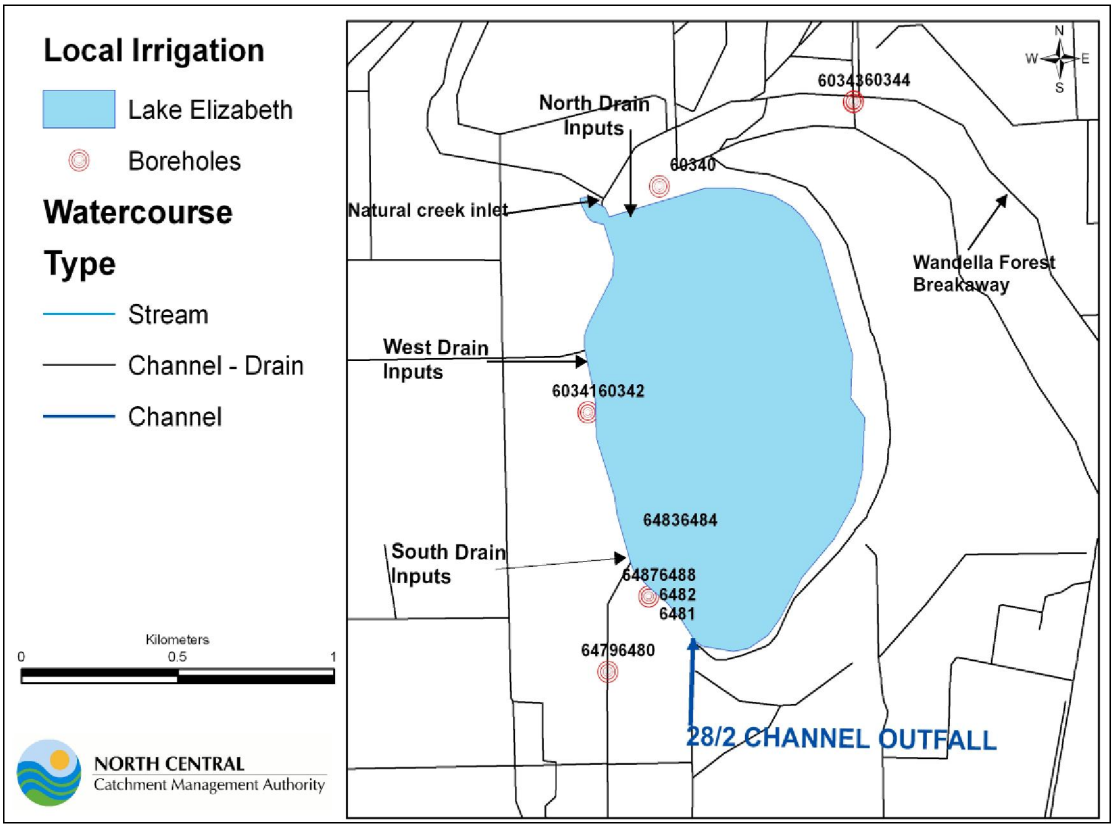

Figure 3: Inflow points at Lake Elizabeth

2.3 Land status and management

Lake Elizabeth is a State Wildlife Reserve under the *Crown Land (Reserves) Act 1978* and is managed by Parks Victoria under the *Wildlife Act 1975*. Wildlife reserves are specifically managed for the conservation of fish and wildlife and for public recreation (VEAC 2008).

In 2009, the Victorian government endorsed (with amendments) the Victorian Environment Assessment Council (VEAC) recommendations for public land management. Lake Elizabeth will remain a wildlife reserve. These reserves will be managed 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 uses (DSE 2009c and VEAC 2008).

2.4 Cultural heritage

The Kerang Lakes area is a significant archaeologically important area in Victoria. To date Lake Elizabeth has not been surveyed for aboriginal sites, although it has close proximity to other significant archaeological areas (e.g. Avoca Marshes).

2.5 Recreation

Lake Elizabeth is accessed north of the Wandella Flora and Fauna Reserve via McCurdy Rd in the south-east. Previously, the lake has supported the following recreational activities:

- Recreational driving
- Picnicking
- Hunting
- Bird watching and other nature based activities (Heron and Nieuwland 1989)

The drying of Lake Elizabeth has decreased the intensity of recreational activities. However, it is expected that nature-based activities and duck hunting will return when the wetland is filled.

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

As outlined above, Lake Elizabeth is known to support protected migratory waterbirds. The lake also previously supported the Murray Hardyhead (*Craterocephalus fluviatilis*), a species listed under the EPBC Act (Table 1). Actions that may impact on 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 1999.*

2.6.3 State legislation

Flora and Fauna Guarantee (FFG) Act 1988

The *Flora and Fauna Guarantee (FFG) Act 1988* aims to protect a number of identified threatened species and communities within Victoria. Lake Elizabeth is known to support a number of species both protected[2] 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.

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[1] 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).

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

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 legislation that governs the way water entitlements are issued and allocated in Victoria. The Act also identifies water that is to be kept for the environment under the Environmental Water Reserve. The Act therefore 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 Elizabeth has not been surveyed for cultural heritage sites (Kelly 1996).

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 Victorian *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 Elizabeth is known to support flora and fauna species that are included on advisory lists (Table 1 and Table 3).

3. Lake Elizabeth environmental values

The primary purpose of this EWP is to assess and mitigate potential impacts on high environmental values supported by Lake Elizabeth. While it is recognised that the wetland provides a number of broader ecological and landscape values (i.e. ecological processes, representativeness and distinctiveness in landscape), high environmental values have previously been defined by the conservation significance of the wetland or species at an international, national or state level (SKM 2008; NVIRP 2010).

As such, in describing the values supported by the site in the sections below, an emphasis has been 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 Elizabeth is considered a high value wetland due mainly to the significant vegetation communities and flora and fauna species it supports. In addition, it has previously supported a high diversity of native waterbirds and fish species including the nationally listed Murray Hardyhead (*Craterocephalus fluviatilis*).

3.1 Fauna

Lake Elizabeth provides habitat for a diverse range of native flora and fauna species and supports high numbers of waterbirds. From 2002 up to 2006–07, Lake Elizabeth was managed as a permanent wetland to protect habitat for native waterbird and fish species, particularly the EPBC-listed Murray Hardyhead (*Craterocephalus fluviatilis*) (DSE 2006). The salt tolerant aquatic plant Sea Tassel (*Ruppia megacarpa)* is abundant in the lake and is a key determinant of the capacity of this wetland to support invertebrates and waterbirds (herbivores, filter feeders and waders).

Forty-two bird species have been recorded at Lake Elizabeth with records indicating that 16 are significant, threatened or vulnerable, including the Freckled Duck (*Stictonetta naevosa)* (Table 1 and Appendix D).

Up to the early 2000s, Lake Elizabeth supported Murray Hardyhead, and environmental water from the Murray Flora and Fauna Entitlement was frequently allocated to maintain salinity levels for this species below 45,000 EC (DSE 2006). Consecutive surveys for Murray Hardyhead in 2004, 2005 and 2006 failed to confirm the presence of the fish and an environmental water allocation was not provided in 2007–08. Although Lake Elizabeth is considered a potential translocation site for Murray Hardyhead (fourth highest priority in Victoria), the effect of the current drying phase on the wetland's future ability to support this species is unknown (DSE 2008a).

Table 1: Significant species recorded, or considered likely to occur in Lake Elizabeth

Common name	Scientific name	International agreements	EPBC listing	FFG listing	DSE listing
Australasian Shoveler	*Anas rhynchotis*				VU
Black Falcon[1]	*Falco subniger*				VU
Blue-billed Duck	*Oxyura australis*			L	EN
Common Greenshank	*Tringa nebularia*	J / C / R / B			
Curlew Sandpiper	*Calidris ferruginea*	J / C / R / B			
Double-banded Plover	*Charadrius bicinctus*	BONN			
Eastern Great Egret[1]	*Ardea modesta*	J / C			
Freckled Duck	*Stictonetta naevosa*			L	EN
Great Egret	*Ardea alba*	J / C		L	VU
Hardhead	*Aythya australis*				VU
Murray Hardyhead	*Craterocephalus fluviatilis*		VU	L	DD
Musk Duck	*Biziura lobata*				VU
Pied Cormorant	*Phalacrocorax varius*				NT
Red-necked Stint	*Calidris ruficollis*	J / C / R / B			
Royal Spoonbill	*Platalea regia*				VU
Sharp-tailed Sandpiper	*Calidris acuminta*	J / C / R / B			
White-bellied Sea-Eagle[1]	*Haliaeetus leucogaster*	C		L	VU

Conservation Status:
- J/C/R/B: JAMBA/CAMBA/ROKAMBA/Bonn International agreements listed in Section 2.3.1
- EPBC Listed: VU – Vulnerable

Common name	Scientific name	International agreements	EPBC listing	FFG listing	DSE listing
• FFG listing: L – listed as threatened • DSE listing: EN – Endangered, VU – Vulnerable, NT – Near Threatened, DD – Data Deficient					

Note 1: (DSE 2009d) – considered likely to occur.

3.2 Flora

According to DSE's pre-1750 Ecological Vegetation Class (EVC) mapping, prior to European settlement Lake Elizabeth supported a saline lake mosaic surrounded by chenopod woodland vegetation (DSE 2009e). The current EVCs and conservation status for Lake Elizabeth are presented in Table 2.

Table 2: Lake Elizabeth EVCs

EVC No.	EVC	Bioregion conservation status
717	Saline Lake Aggregate	Least concern
824	Woorinen Mallee	Vulnerable
98	Semi–arid chenopod woodland	Endangered
97	Semi–arid woodland	Endangered
826	Plains Savannah	Endangered
103	Riverine chenopod woodland	Vulnerable

Note 1: Source: (DSE 2009f)

No flora species listed under either the *EPBC Act* or *the FFG Act* have been recorded at Lake Elizabeth. However, a number of species threatened within Victoria have been recorded at the site (Table 3 and Appendix E).

Table 3: Significant flora species recorded at Lake Elizabeth

Common name	Scientific name	EPBC listing	FFG listing	DSE listing
Black-seeded Glasswort	*Halosarcia pergranulata spp. pergranulata*			VU
Cane Grass	*Eragrostis australasica*			VU
Sea Tassel	*Ruppia megacarpa*			DD
Silver Mulga	*Acacia argyrophylla*			Presumed extinct
Snow-wort	*Abrotanella nivigena*			VU
Conservation Status: • DSE listing: VU – Vulnerable, DD – Data Deficient				

As noted previously, the environmental values of Lake Elizabeth have been impacted by the current drying phase. A mat of dead and dying *Ruppia megacarpa* (confirmed in November 2009 by MDFRC, refer to Figure D1) covers the bed of the lake and chenopod shrubland vegetation is colonising the drying areas, reflecting the elevated salinity levels. Appendix E illustrates the generic vegetation composition of Lake Elizabeth surveyed in March 2009.

3.3 Representativeness and distinctiveness

Lake Elizabeth is currently classified as a permanent saline wetland. Permanent saline wetlands are the least depleted category of wetland within Victoria having decreased by 2% since European settlement. Table 4 illustrates the area and proportion of permanent saline lakes across various defined landscapes.

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

	North Central CMA region	GMID	Victorian Riverina Bioregion	State of Victoria
Permanent saline wetland (ha)[1]	2,362	2,314	2,088	154,338
Lake Elizabeth (94ha)	4%	4%	4.5%	<1%

Note 1: Areas calculated (DSE 2009g)

Lake Elizabeth is a distinctive wetland due the high numbers of waterfowl it supports (Section 3.1) as well as previously providing habitat for a population of the EPBC Act-listed Murray Hardyhead. It is also classified as a wildlife reserve.

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 2005). A wetland's hydrology is determined by surface and groundwater inflows and outflows, in addition to precipitation and evapotranspiration (Mitsch and Gosselink, 2000 in DSE 2005). Duration, frequency and seasonality (timing of inundation) are the main components of the hydrological regime for wetlands.

4.1 Natural water regime

Lake Elizabeth is located within the Wandella Creek sub-catchment in the Loddon River basin. The wetland's natural water supply originates from a series of interconnecting creeks (Wandella and Venables Creek) that break away from the Loddon River approximately 30km upstream (south). The Wandella Creek then flows parallel to the Loddon River and is linked to a series of Black Box depressions (e.g. Leaghur Forest/Appin Forest). A large Black Box depression, the Wandella Forest, is situated only 2 km to the west of Lake Elizabeth. During flood events, several break-away creeks flow out from the Wandella Forest at varying flood levels. One of the main creeks flows from a deep section (Flaxy's Swamp) in the north-west corner of the forest. This creek carries water northwards along the east side of the high ground (lunettes) of Lake Elizabeth and circles around the northern end of the wetland entering in the north-west corner (Rob O'Brien, DPI pers. comm. 2009).

The natural hydrological cycle of Lake Elizabeth would have consisted of flooding in winter and spring with drawdown due to evaporation and groundwater recharge occurring over the summer months (SKM 2004). The fluctuating water levels would have supported a diversity of flora (aquatic and terrestrial) and fauna (Rob O'Brien, DPI, pers. comm. 2009).

4.2 History of water management

From the late 1880s to the 1980s Lake Elizabeth was used as a freshwater irrigation storage, which enabled flushing of water through the lake. When diversions ceased, Lake Elizabeth became a terminal system. Salt began to accumulate and salt tolerant aquatics such as Sea Tassel (*Ruppia megacarpa*) established and thrived.

In the 1970s, Murray Hardyhead was discovered in Lake Elizabeth and management of the lake's hydrology subsequently focused on maintenance of this species.

Lake Elizabeth has historically received significant outfalls from the No. 2 channel system, these outfalls averaged 800 ML/yr in the 1990s (Rob O'Brien, DPI, pers. comm. 2009). Channel outfalls to the wetland decreased significantly over the following five to eight years due to a combination of increased channel efficiency, lower water allocations, reduced rainfall and local catchment runoff. Reduced inflows resulted in lower lake water levels and increased salinity levels (O'Brien, Moore, Gitsham and Bills 2009). To counteract the potential impacts rising salinity levels would have on the Murray Hardyhead, environmental water was regularly allocated from the Murray Flora and Fauna Bulk Entitlement (2002 onwards) (Figure 4 and Table 5) to maintain salinity levels below 45,000 EC (DSE 2006).

Consecutive surveys for Murray Hardyhead in 2004, 2005 and 2006 failed to confirm the presence of this fish species and an environmental water allocation was not provided in 2007-08. A considerable reduction in the outfall volumes received by the lake in addition to climatic conditions and the reduced availability of environmental water, meant that the lake began to dry in 2007 and is now almost completely dry (Table 5 and Plates 1 and 2).

Table 5: Lake Elizabeth wetting/drying calendar (Source: DSE 2008b)

Year	**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**
Wetting / drying cycle[1]	w	w	w	w	w	w	w	w	w	w	w	w	w	w/d	w/d

Note 1: w – water present, d – wetland dry

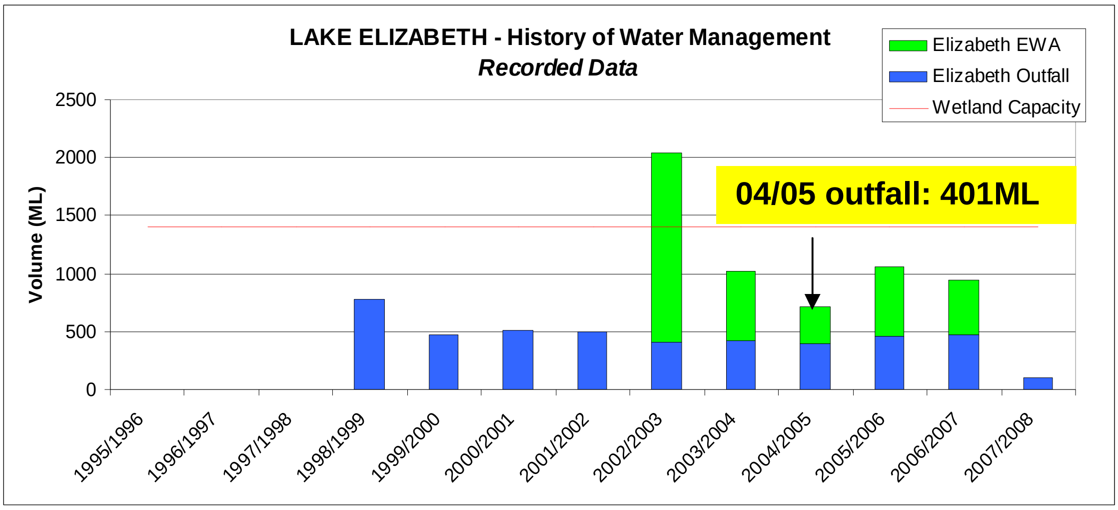

Figure 4: Recorded volumes received by Lake Elizabeth from outfalls and environmental allocations Note: outfalls recorded from 1998 onwards.

Plate 1: Wet phase (date unknown)

Plate 2: Drying phase (2009)

4.2.1 Recorded outfalls and NVIRP

Outfall data for Lake Elizabeth has been recorded by G-MW since 1998 (Figure 4). Records illustrate that outfall volumes have decreased significantly during this period from 782 ML in 1998–99 to 104 ML in 2007–08. Anecdotal information suggests that outfall volumes historically averaged 800 ML/year.

The baseline water year, 2004–05, has been selected to quantify the savings as part of water savings projects. 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 2008c). 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.

Lake Elizabeth received a total of 401 ML of outfall water in 2004–05. The timing of the outfalls over the irrigation period of September to May is shown in Figure 5.

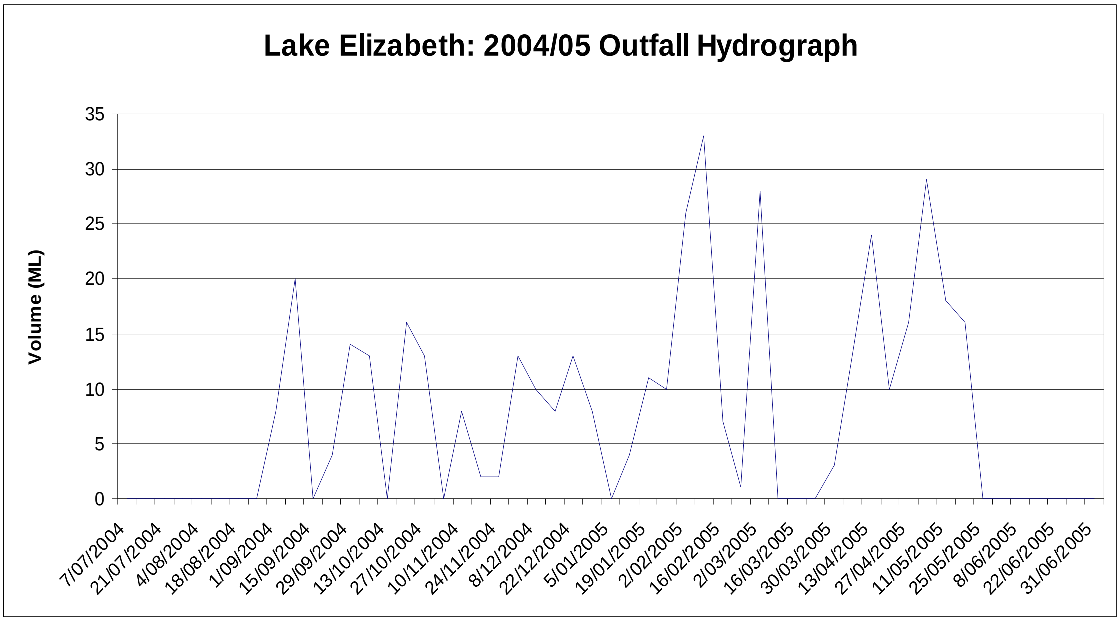

Figure 5: Lake Elizabeth outfall hydrograph

4.3 Surface water/groundwater interactions

There is significant interaction between the surface water in Lake Elizabeth and the underlying groundwater table (which has historically recorded salinity levels of between 30,000 and 40,000EC) (DPI 2004). Considerable work has previously been done on the hydrology and hydrogeology of Lake Elizabeth (e.g. SKM 2004 and 2006 Macumber 2002, 2006 and 2007). A short review of this work was undertaken as part of the development of the EWP (Reid and O'Brien 2009). A synopsis of the report is provided below.

The most definitive study in terms of the hydrogeology and water management implications for Lake Elizabeth was undertaken by Macumber (2002 and 2007). Using extensive data and interpretation, Macumber concluded that Lake Elizabeth is a through-flow lake. Groundwater generally enters at one end and leaves at the other with output from the lake itself, which leaks.

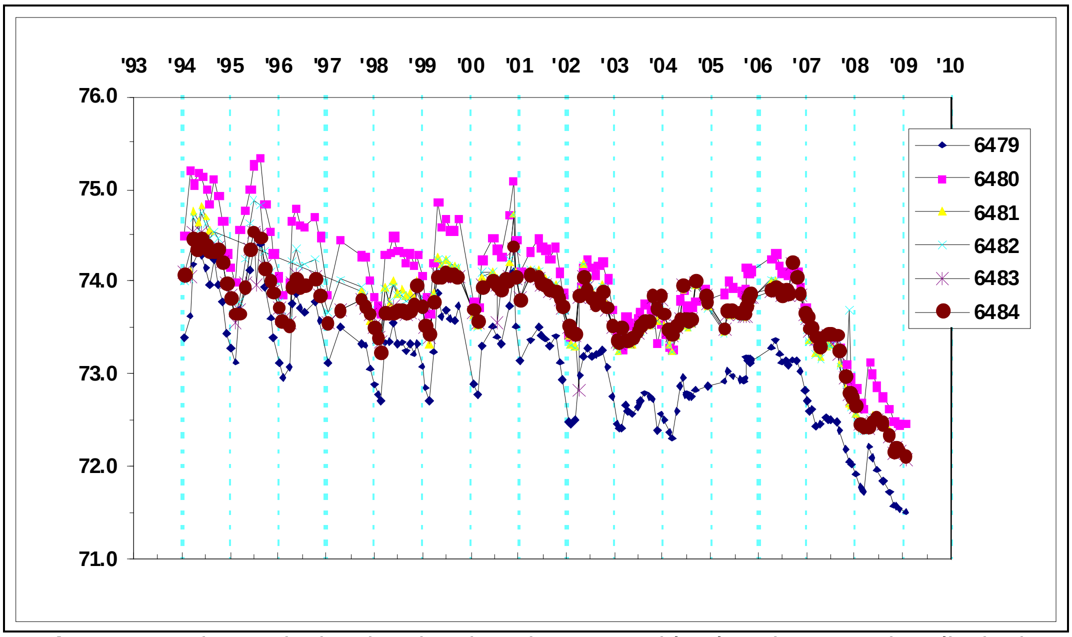

Figure 6: Hydrograph showing the changing watertable elevations at Lake Elizabeth

The regional groundwater flow direction is north-west with a hydraulic head generated from the Loddon floodplain and the Wandella Forest to the south-east. In wetter periods, the groundwater flow towards the lake is strong, but in drier periods flow is significantly reduced.

Over the past year, Lake Elizabeth has dropped to previously unrecorded low levels and presently holds very little water (Plate 3). Groundwater levels around the wetland have also declined at varying rates, but especially since 2007.

Plate 3: Lake Elizabeth (11 March 2009) looking north showing the current low level of the lake (approx. 71.5 m AHD), which has fallen steadily since 2007.

Groundwater levels as at 20 January 2009 were approximately 0.5m above the lake level (72m to 72.1m AHD). The current groundwater/surface water levels indicate that Lake Elizabeth could be acting as a groundwater sink and accumulating salt. However, the current lake level is an estimate and this would need to be more accurately determined. If the actual lake level is closer to 72 m AHD or higher, it is likely that there is a more even balance of inflow versus outflow, and hydrograph evidence to date is more consistent with this scenario.

The remaining water in Lake Elizabeth (Plate 1) is likely to be the result of a groundwater outcrop. It is also currently being replenished by periodic outfalls, which are reducing the opportunity for the lake to dry out completely. Groundwater levels are therefore being maintained rather than being allowed to fall below the lake bed. The rising levels will mean that the wetland bed will be too saline and waterlogged for plants to colonise. This is an important consideration when assessing the impact of residual outfalls on a drying wetland into the future. The ability of the lake bed to recover and support the colonisation of plants in the future will be dependent on the amount of residual salt in the lake bed and the amount of leakage (with salt removal) to the groundwater system on refilling.

Lack of data and the only very recent and previously unrecorded low lake level (and lack of certainty about the accuracy of the current AHD lake level) makes it difficult to predict with much confidence how the local groundwater configuration will alter with continuing dry conditions and lack of inflow. If the lake is kept at low levels and accumulating salt, an additional threat could arise from increased groundwater heads to the south-east generated from episodic flooding of the Wandella Forest and/or Loddon river floodplain.

Source: Reid and O’Brien 2009

4.4 Surface water balance

A daily surface water balance has been modelled in order to identify the hydrological attributes of Lake Elizabeth. 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 optimal 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 Elizabeth 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 Elizabeth filled to a two metre depth (73.5mAHD) equates to 1264 ML (Archard 2009).
- **Infiltration:** volume required to fill the underlying soil profile. Calculation of this volume has been adapted from measurements undertaken by G-MW (G-MW 2008):
    - 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). A catchment area of 1304 hectares was used. The contributing volume is dependent on the rainfall intensity (15-40%).
- **Climate data:** SILO DataDrill including wind data (Bureau of Meteorology)
- **Evaporation data:** a modelled approach (combination of the Penman-Monteith method with a deBruin adjustment; recommended by the CSIRO) to assessing evaporation at the wetland has been incorporated into the water balance (McJannet et al.2009).

Please note: groundwater is not included in the model. While groundwater may contribute in some circumstances it is not readily quantifiable or not easily factored into the model.

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 Elizabeth are presented in Section 5.3 and Appendix G.

4.5 Operational uses

Lake Elizabeth is a terminal system filled by rainfall, channel outfalls from the G-MW 28/2 channel (either as operational outfall or environmental water), community surface drainage water and groundwater. No operational plans or procedures exist for the G-MW management of the wetland.

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

4.5.1 Flood mitigation

The natural flooding of Lake Elizabeth from the Wandella Creek sub-catchment is prevented by road crossings and levees.

The wetland is not actively managed for distribution or storage of floodwater, although surrounding landholders do use it for minor flood mitigation and drainage disposal. There is some potential for flood mitigation through the G-MW 28/2 channel, though a risk of overfilling the wetland and creating a flood risk to adjacent landowners restricts the viability of this option (O'Brien 2009 and Appendix B).

4.5.2 Drainage

Lake Elizabeth has a local catchment area of approximately 1300 ha (SKM 2004). The Lake Elizabeth Drainage Study identified six main drainage routes into the wetland. Drainage inflows are dominated by rainfall runoff rather than irrigation drainage (HydroTechnology 1995). However, local catchment runoff that enters the wetland has shown evidence of extreme salt levels that are likely to be associated with groundwater pumping (the North Drain has generated a very high proportion of the overall salt input into the lake) (SKM 2006).

5. Management objectives

Lake Elizabeth has historically had at least two management objectives; the first was as an irrigation storage up to the 1980s, and more recently it has been managed as a permanent saline lake, with the objective of providing habitat for common and rare fauna species (Table 1 and Appendix E). As previously noted, up until the early 2000s, it supported Murray Hardyhead (listed under the *EPBC Act*) and previous management recommendations targeted this species (Table 6).

Table 6: Previous management recommendations

Source	Wetland Type	Objectives	Dur	Timing	Freq[1]	Quality
Lugg *et al.*, 1989	Permanent Saline	• To flood littoral zone • Murray Hardyhead • Waterbirds – resting, feeding and breeding • Salinity < 25,000	12 months	Winter/ Spring	1 in 1 yrs	In wetland <25,000 EC
Kelly, 1996	Permanent Saline Lake	• Species diversity • Habitat diversity • Ecological productivity • Native fish and waterbirds • Salinity - flushing	12 months	Winter/ Spring	1 in 1 yrs	<5,000 @ FSL <25,000 all times

Note 1: Frequency of filling: 1 in 1 year is annual filling or top-up to maintain water in the wetland

5.1 Water management goal

The water management goal for Lake Elizabeth has been derived from a variety of sources, including previous management goals, local expertise and knowledge, and current climate predictions, and has been appraised by agency stakeholders and technical experts (wetland workshop, Appendix A Table A2). It takes into consideration the values the lake supports and potential risk factors that need to be managed e.g. seedbank viability of *Ruppia megacarpa*.

Lake Elizabeth water management goal

To provide a water regime that supports a submerged salt-tolerant aquatic plant assemblage typical of an intermittent brackish/saline lake (dominated by Sea Tassel Ruppia megacarpa with wader habitats.

The goal for Lake Elizabeth recommends a drier operating regime and hence differs from previous management goals, which focused on maintaining the values of a permanent lake. The process for determining the goal involved assessing the values the wetland has historically supported and the likely values it could support into the future considering climate change. It was determined that the goal needed to be achievable and that the water regime needed to support the values in the long-term (i.e. ensure viability of species and habitats in into the future).

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 Elizabeth (Table 7). The process for identifying ecological and hydrological objectives closely follows that recommended in FLOWs: a method for determining environmental flow requirements in Victoria (DNRE 2002b). The ecological objectives specify the outcomes from delivery of the desired water regime.

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

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

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

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

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

Hydrological requirements describe the water regimes required for achieving ecological outcomes (ecological objectives) (DNRE 2002b). All values identified have components of their life-cycle or process that are dependent on particular water regimes for success e.g. colonially breeding waterbirds require certain timing, duration and frequency of flooding to successfully breed and maintain their population. Requirements for the three components of a water regime[3] were identified and described for all of the ecological values.

Source: Campbell, Cooling & Hogan 2005.

The ecological objectives and hydrological requirements for Lake Elizabeth were presented to agency stakeholders and technical experts at the Wetland Workshop held in March. In addition, they were presented to the ERP on 30 March 2009. Any amendments or alterations have been incorporated and are provided in Table 7.

Table 7: Lake Elizabeth proposed ecological objectives and hydrological requirements

Ecological objective	Justification	Hydrological requirement
1. Habitat Objectives		
1.1 Maintain submerged aquatics • *Ruppia megacarpa*	Food for waterbirds (Objective 2.2 & 2.3, e.g. swans, coots, ducks and waders) *Ruppia* (Sea Tassel) key primary producer and extremely important to retain in regional wetland mix.	Develop a semi-permanent brackish saline lake by filling 1 in 3 - 5yrs to moderate level ≥1.5m deep and top up to ensure inundation period of 18 months (timing for *Ruppia megacarpa* to establish and seed).
1.2 Restore and maintain (expansion) of chenopod shrubland from the littoral zone to wetland margins.	Habitat & food source (fruits) for waterbirds and waders. Improves soil condition and structure for micro-organisms and invertebrates.	Ensure variability in water levels.
1.3 Restore littoral zone of wetland	Open water and mudflat habitat for waterbirds	Ensure variability in water levels
2. Species/Community Objectives		
2.1 Restore breeding of waterbird species	Lake Elizabeth is a saline wetland that has provided breeding sites for: • Australian Pelicans, Blue-billed Ducks and Black Swans[1]	Refer to hydrological requirement 1.1
2.2 Restore feeding opportunities (food source) for water birds (listed in Table 1)	Linked with habitat objectives – wetland and dryland flora, shallow water, mudflats and waters edge. Saline lakes enable light penetration; therefore submerged macrophytes establish and support high abundance of invertebrates	Ensure variability in water levels
2.3 Restore diversity and abundance of invertebrate community		
3. Process Objectives		

[3] Timing, frequency and duration

Ecological objective	Justification	Hydrological requirement
3.1 Restore connectivity between river and floodplain and between floodplain components	Invertebrate source Nutrient and carbon cycling Species population sources	Variable

Note 1: Recorded breeding events by waterbird species at Lake Elizabeth

5.3 Desired water regime

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

Figure 7 illustrates the various components of the wetland (e.g. *Ruppia megacarpa* and mudflats) that are being targeted by the water regime.

Timing: Autumn or spring filling (influenced by potential for an algal bloom, turbidity and seed viability)

Frequency of wetting: Minimum: one (1.5) in five years
Optimum: one (1.5) in three years
Maximum: Permanent

Duration: 18 months

To maintain levels in the second year, inflows are required

Extent and depth: Approximately 1.5 metres

Variability: Moderate (determined by the response of the aquatic plants)

Wetland water regime:

Fill wetland to approximately 1.5 metres one in three years and ensure inundation period at this level is for at least 18 months (will require inflows in the second year

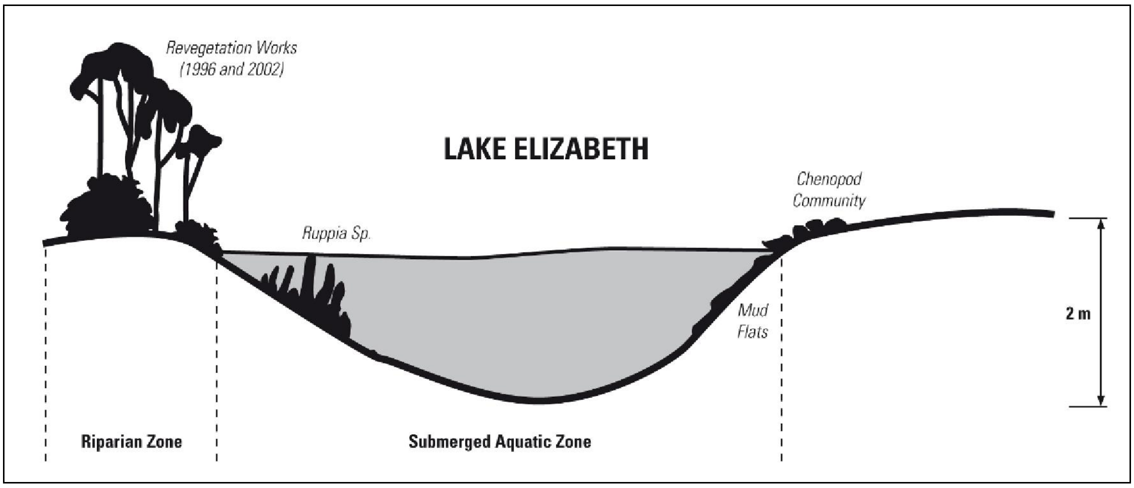

Figure 7: Schematic of wetland areas to be targeted (not to scale)

The volumes of water required to provide the desired water regime for Lake Elizabeth are presented in Table 8. These volumes incorporate the results from the SWET modelling (model described in Section 4.4 and results presented in Appendix G).

The desired water regime for Lake Elizabeth is a three year cycle, where in year one, it is filled to capacity and topped-up with water to counteract evaporation. In year two, water levels are maintained at approximately 1.5 metres for six months. In the second half of year two, the lake will begin to dry as water is lost to evaporation and seepage.

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

Result	
Mean long-term (LT) annual controlled inflow requirement	556 ML/year
95th percentile of mean LT annual controlled inflow requirement	1967 ML/year
Average LT controlled inflow requirement for filling period	2430 ML
Record length	118
No. of periods	27
Years with no inflow	64 in 118 years
No. of draw downs over record	27
No. of draw downs not fully drawn down	4
% of draw downs not fully drawn down	15%
95th percentile duration of full period (months)	15.2
50th percentile duration of full period (months)	14.0

A brief description of each the main results provided is below:

- **Mean long-term annual controlled inflow requirement**: the total amount of water required to be delivered into the wetland annually in a controlled fashion to achieve the specified level and the desired regime (excludes natural inflows from rainfall and runoff). This is the average over the modelled period (three years), which may include years with zero water required (i.e. water is required two years in three) and does not include rainfall and runoff from rainfall events. A mean long term annual volume of 556 ML is required to fill Lake Elizabeth to 73.5 m AHD one (1.5) in three years.
- **95th percentile of mean long-term (required) annual water inflows**: an estimate of the maximum volume ever likely to be required over any 12 month period (1967 ML/yr).
- **Average water inflows for filling period:** the total amount of water required to be delivered to the wetland in a controlled fashion to achieve the desired water level regime for the recommended cycle (i.e. three years). This does not include rainfall and runoff from rainfall events. Therefore, over a three year cycle, the total volume required to fill Lake Elizabeth and maintain levels for 18 months is 2,430 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 Elizabeth and rainfall will vary considerably from year to year, depending on seasonal conditions.

5.4 NVIRP 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 Elizabeth EWP is related mainly to a reduction in outfalls. Other potential impacts to the wetland will be managed through the Water Change Management Framework 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 EWPs. 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 Elizabeth mitigation water

Step 1: Describe the desired water or flow regime

The desired water regime for Lake Elizabeth is filling to FSL one in three years and maintaining for at least 18 months (i.e. 1.5 in 3 years). Further detail is provided in Section 5.3. For this three year cycle the average volume required to fill and maintain levels is 2,430 ML.

Step 2: Determine the baseline year incidental water contribution[4]

This step determines the baseline year incidental water contribution from hydrological connections- outfalls, leakage and seepage.

Leakage and seepage have not been accounted for within the following steps. However, preliminary calculations to estimate the potential incidental water contributions from leakage and seepage from the no. 28/2 channel were completed based on the localised impact assessment method outlined in the Water Change Management Framework (NVIRP 2010). The results indicate that a range of 7 ML/year to 27 ML/year may be received by Lake Elizabeth (Appendix H). If future NVIRP actions are likely to impact the potential for leakage and seepage to reach Lake Elizabeth (i.e. lining the main supply channel or decommissioning other channels within 200 m of the wetland), an analysis will be triggered in accordance with the Water Change Management Framework.

Therefore, only one hydrological connection (outfall) has been included within the mitigation water calculations and the potential contributions from leakage and seepage have been excluded.

The baseline year (2004-05) outfall volume recorded at the regulating structure was 401 ML, refer to Section 4.2.1. 100% of this outfall volume is considered to have contributed to the wetland's water balance in 2004-05. The determination of the baseline year incidental water contribution is summarised in Table 9.

Table 9: Determination of the baseline year incidental water contribution

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 #ST004154	401	0	401

Step 3: Assess dependency on baseline incidental water contributions

The WCMF specifies the 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 Elizabeth with the results presented in Table 10.

[4] 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.

Table 10: Mitigation water dependency assessment

Criteria by which mitigation water may be assessed as not required	Link between incidental water (losses) and environmental values
1. Mitigation water may be assessed as not required where:	
1.1 There is no hydraulic connection (direct or indirect) between the irrigation system and the wetland or waterway	Outfall water is received directly by Lake Elizabeth.
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 diversions or impediments that prevent the water from reaching the wetland. The losses reach the wetland (direct outfall) and support the environmental values associated with the wetland, e.g. bird species, through the maintenance of *Ruppia megacarpa* for feeding.
1.3 The margin of error in the estimate of mitigation water is greater than the savings available from the relevant system operating component (e.g. the specific outfall)	N/A
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 wetland does not have more water than is required to support the desired state of the environmental values, even if operated under a drier regime as a semi-permanent wetland. It is currently almost dry.
2.2 That occurs at a time that is detrimental to the environmental values	Losses generally occur between September and May.
2.3 That is of poor quality (or results in water of poor quality entering a site e.g. seepage resulting in saline groundwater intrusions to wetlands) and the removal of which would lead to an improvement in the environmental values	Losses (irrigation outfalls) are of acceptable water quality, although the turbidity of water could be an issue for aquatic plant growth.
3. Mitigation water may be assessed as not required where the environmental values:	
3.1 Do not directly benefit from the contribution from the irrigation system (e.g. River Red Gums around a lake may not directly benefit from an outfall and may be more dependent on rainfall or flooding)	Outfall volumes provide freshening flows, maintaining salinity levels in the wetland. A reduction in outfall water will cause a resultant increase in salinity unless water is supplemented from another source. Outfall volumes contribute to maintaining the duration of inundation. Maintenance of depth is important to enable *Ruppia megacarpa* to complete its life cycle.
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)	The losses occur at a time when they counteract high evaporation rates (over the summer period). Outfalls contribute to reducing groundwater intrusions at Lake Elizabeth by maintaining water levels in the wetland. The removal of losses increases the risk of high salinity levels within the wetland which will reduce its environmental values, in particular its capacity to support threatened bird species.
4.2 Diminish the benefits of deploying any environmental water allocations (over and above the contribution from the irrigation system).	Outfall volumes counteract seepage and evaporation. Additional water would need to be supplied to wet the bed prior to filling. If outfall volumes were reduced, additional water would need to be secured for providing the desired water regime for Lake Elizabeth.

The assessment of the requirement for mitigation water for Lake Elizabeth demonstrates that **outfall water provides a benefit to the wetland and that the provision of mitigation water is warranted.**

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

The BMW volume is expressed as the baseline incidental water contributions divided by the number of years in the cycle of the desired water regime. Mitigation water is required in the years that Lake Elizabeth is scheduled to be filled (i.e. one (1.5) in three years for 18 month period). Therefore, mitigation water is required for two out of the three year cycle as inflows are required in those years (refer Table 11). When the wetland is in a dry phase, no mitigation water is required.

Table 11: Desired water regime and years in which mitigation water is required

Year	Water regime	Mitigation water required
1	Fill to FSL ≥1.5m	401ML
2	Top-up to maintain levels for 18 months	401 ML
3	Dry phase	0 ML
Total		**802 ML (267 ML/year)**

As there is no other more efficient infrastructure options for delivering mitigation water, BMW will be calculated at Outfall #ST004154 (gross).

Gross BMW

= Baseline year incidental water contribution at Lake Elizabeth (Step 2) / Desired water regime for Lake Elizabeth (years) (Step 1)

= 401ML / 1.5 (18 month wetting duration in 3 years)

= 267 ML

Step 5: Calculate the mitigation water commitment (MWC)

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

MWC (%) = $BMW_{(Lake\ Elizabeth\ 2004\text{-}05)}$ (Step 4) / Baseline incidental water contributions $_{(2004\text{-}05}$ (Step 2)

= (267 / 401) X 100

= 0.67 or 67%

The overall MWC for Lake Elizabeth is 67%.

Step 6: Calculate the LTCE mitigation water volume

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

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

5.5 Other water sources

The annualised baseline mitigation water volume represents 41% of the annual long-term volume of water required in order to provide the desired water regime (556 ML/year). 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 achieve the water management goal for Lake Elizabeth. The most likely additional sources of environmental water will be existing and future environmental entitlements.

Potential sources of environmental water to provide the desired water regime to Lake Elizabeth are discussed below.

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 2009).

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 Elizabeth is not a wetland of international importance, it is a refuge for species listed under other international conventions. Therefore, a case for the receipt of Commonwealth environmental water could be made.

6. Potential risks or adverse impacts

An important component of the EWPs is the identification of potential risks, limiting factors and adverse impacts associated with the delivery of the desired water regime. The annualised baseline mitigation water volume represents 41% of the mean long-term annual volume required (556 ML/year). Awareness of the potential risks and impacts will influence future intervention and long-term condition monitoring undertaken at Lake Elizabeth, will inform the adaptive management of the water regime and the provision of mitigation water (Section 8).

Table 12 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 Elizabeth. 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 of the risk occurring and/or its potential impact.

Table 12: Potential risks, impacts and mitigation measures associated with the provision of mitigation water to Lake Elizabeth

Risks/limiting factors	Impacts	Mitigation measures
Limited water availability	Failure to achieve identified ecological objectives and overall goal	Ensure sufficient information is collected for prioritisation of Lake Elizabeth in environmental allocation processes. Review rainfall and climate data to utilise natural inflows where possible.
Mitigation water calculated is insufficient	Loss of high environmental values. Failure to achieve identified objectives and overall water management goal	Review Lake Elizabeth EWP recommendations in 2012
Ineffective outfall delivery	Inability to deliver water in order to achieve objectives and overall water management goal	Upgrade of the culvert is required to enable more effective water delivery.
Opportunistic diversion licences (only opportunistic irrigation diversion permits exist)#	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.
Future NVIRP actions inhibit significant leakage and seepage loss contributions	Loss of high environmental values. Failure to achieve identified objectives and water management goal	If future actions are likely to impact seepage and leakage loss contributions (i.e. lining or decommissioning any channels within 200 m of the wetland) detailed analysis of the loss contributions is required and incorporated into the mitigation water recommendations.
Delivery of mitigation water causes adverse impacts on habitat, surrounding land, etc	Adverse impacts may result from delivery of mitigation water e.g. Flooding of adjacent land, fluctuations in turbidity and salinity.	Build management and delivery of mitigation water into environmental water management framework

#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

Delivery of water at appropriate times and in the required quantities is dependent on having appropriate infrastructure and access to spare channel capacity when required.

The 28/2 channel that supplies Lake Elizabeth has a reported capacity of 30 ML/day. The outfall structure located on the southern side of the lake (Figure 8) also has a reported capacity of 30 ML/day. The regulator has recently been upgraded to a fully-automated outfall structure.

The capacity of the outfall structure is restricted by:

- a 600mm culvert from the outfall to the wetland (approximately 22 metres in length) with a reported capacity of 15 ML/day (Figure 8)
- an upstream regulator (Gitsham #2 spur) with a reported capacity of 25 ML/day.

At a flow rate of 15 ML/day it will take a minimum of 90 days to fill Lake Elizabeth from empty, subject to the availability of water and the ability of the G-MW system to deliver flows in conjunction with competing customer demands.

There is less demand for channel capacity in the winter/spring period when it is the optimum time for delivery of environmental water. However, arrangements for water delivery will need to be adaptively managed as part of the annual operational planning for the wetland (refer to section 8).

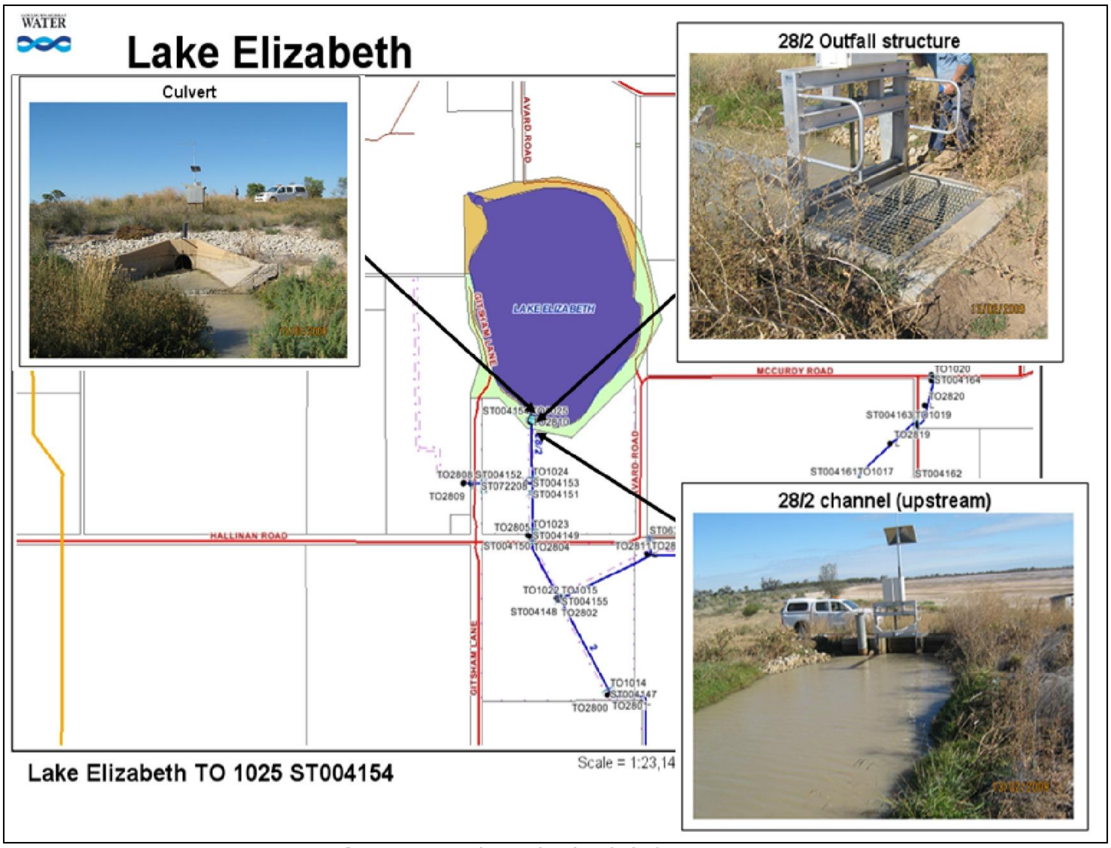

Figure 8: Lake Elizabeth infrastructure

7.1 NVIRP works program – channel 28/2

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 backbone within the vicinity of Lake Elizabeth is the Torrumbarry No 2 (Macorna) Channel which is being automated to just upstream of the channel 28/2 offtake, approximately 1.7 km upstream of the Lake Elizabeth outfall structure.

The automation works on the No 2 channel were to be undertaken in the winter of 2009.

Channel 28/2, on which the Lake Elizabeth outfall structure is located, is not part of the automated backbone and may be rationalised from the irrigation water supply system as part of the NVIRP Connections Program.

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 28/2 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

As indicated above, the culvert that conveys flows from the 28/2 channel restricts the capacity of the outfall from 30 ML/day to 15 ML/day. Previously, Lake Elizabeth has only required top-up flows to maintain it as a permanent system; therefore the flow rate was not a large limiting factor. With changed operating arrangements (i.e. filling from empty) it is recommended that the capacity of the culvert is increased to reduce the fill time from 90 days. Options for upgrading include:

- Upgrading the culvert and Gitsham #2 spur to 30 ML/day which will reduce the fill time to a minimum of 45 days. The cost estimate to undertake these works is $60,000 (Paul Lacy and Rob Chant, pers comm. 2009).
- Upgrading the culvert, channel outfall, Gitsham #2 spur and increasing the 28/2 channel capacity (desilting) to 50 ML/day. This will reduce the fill time to a minimum of 26 days. The cost estimate to undertake these works is $130,000 – culvert and outfall structure ($100,000), Gitsham #2 spur ($20,000), 28/2 channel capacity ($10,000) (Paul Lacy, NVIRP and Rob Chant G-MW pers comm. 2009).

Common Carp are abundant within the G-MW channel system and there is currently no carp screen between the channel system and Lake Elizabeth. 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.

It is recommended that a carp screen is installed to prevent 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 it will significantly reduce the population size, facilitating regeneration of wetland vegetation (e.g. *Ruppia megacarpa*). 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 above recommendation assumes that the salinity levels within the wetland remain within the tolerance range for Common Carp.

As the works are beyond the irrigation delivery system being upgraded by the NVIRP, it is not considered to be the responsibility of NVIRP to fund or undertake the works.

8. Adaptive management framework

A key NVIRP principle is that an adaptive management approach is adopted to ensure an appropriate response to changing conditions (Section 9.4, NVIRP 2010).

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 (Sections 15 and 19, NVIRP 2010)
Assessment and design	Assessment identifies environmental values, their water dependencies, and the potential role of incidental water. Design determines the desired water regime to support environmental values and determines any mitigation water commitment. Details of both these phases are documented in this EWP. (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 (Section 18, NVIRP 2010). 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 wetland.

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 (Sections 15 and 19, NVIRP 2010).

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 Watering Plans.	• 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
	• 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 arrangements are legally binding and reflect the commitments of the NVIRP to provide water to mitigate potential impacts to high value environmental assets. The arrangements require G-MW to set aside water in the Goulburn and Murray Systems to meet the mitigation water needs, calculated in accordance with the methods in the Water Change Management Framework, for future use at wetlands and waterways that have an approved EWP.

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

Delivery of environmental water to Lake Elizabeth 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 9. This has been developed to describe the decision-making process required to coordinate implementation of the desired water regime for Lake Elizabeth. 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.

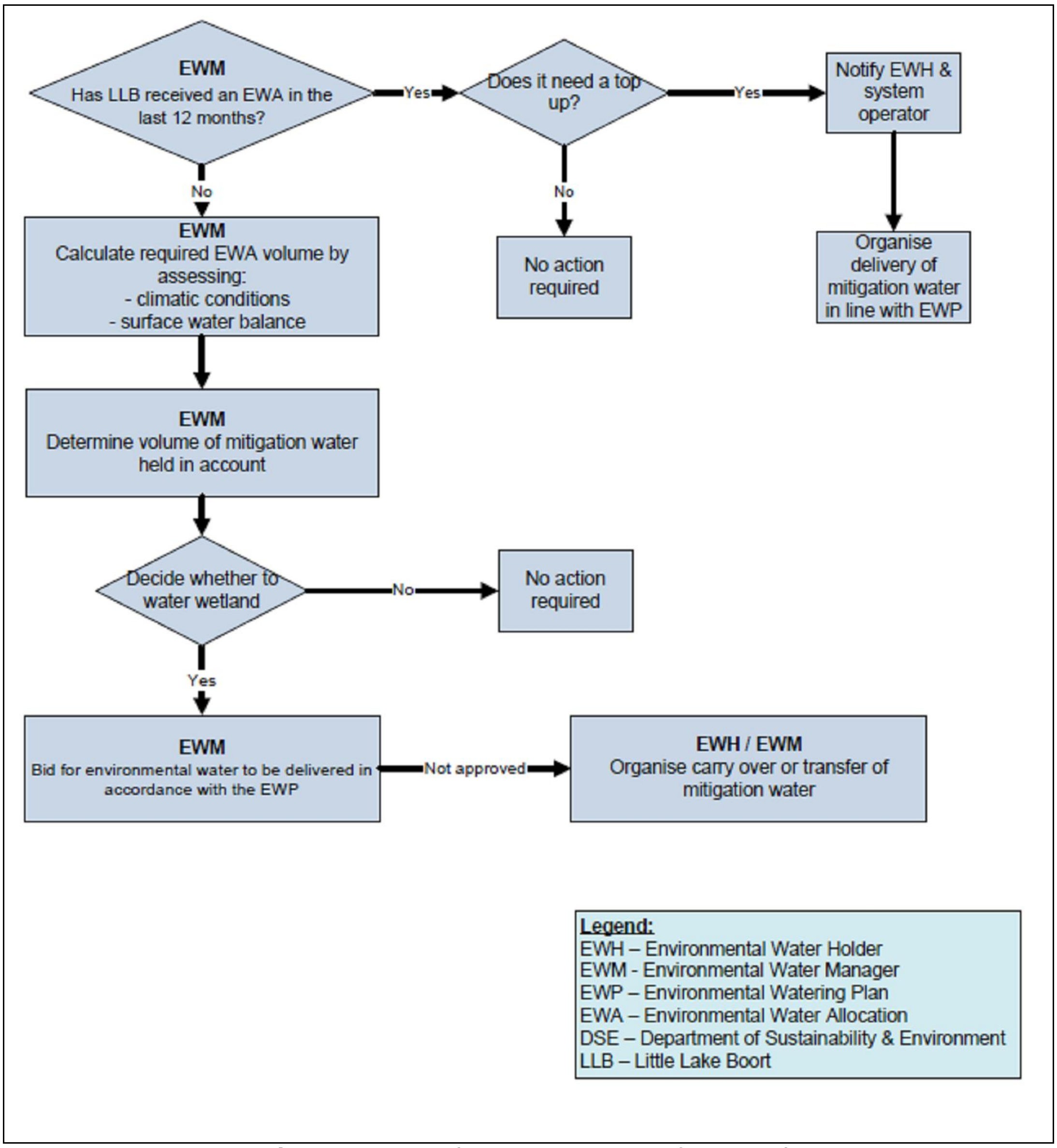

Figure 9: Operational management framework

10. Knowledge gaps

The Lake Elizabeth 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

- The potential rationalisation of Channel 28/2, on which the Lake Elizabeth outfall structure is located.

10.2 Lake Elizabeth

- The medium to long-term impacts of the drying out of Lake Elizabeth for the first time in recorded European history, are unknown.
- The current dry climate conditions are impacting on groundwater levels around Lake Elizabeth and it is difficult to predict how the local groundwater configuration will alter with continuing dry conditions and lack of inflow. Additional observation bores should be installed, particularly on the western and eastern sides of the wetland to more accurately assess groundwater trends.
- Salinity levels in the wetland bed (through an accumulation of salt) may impact on the ability for plants to recolonise in the future.
- Continued monitoring and evaluation of groundwater and surface water data is recommended as well as lake bed levelling to verify the current lake level.
- 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.

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
Rohan Hogan	Science & Strategy Leader North Central CMA

Table A2: Wetland workshop participants – 19 March 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
Chris Solum	Environmental Program Manager, NVIRP
Emer Campbell	Manager – NRM Strategy, North Central CMA
Geoff Sainty	Wetland Specialist, Sainty and Associates Pty Ltd
Jo Deretic	Regional Wetland Coordinator Department of Primary Industries
Karen Weaver	Biodiversity and Ecosystem Services Department of Sustainability and Environment
Keith Chalmers	Wetland Officer, Department of Primary Industries
Mark Tscharke	Senior Ranger, Parks Victoria
Michelle Bills	Strategic Environmental Coordinator, North Central CMA
Paulo Lay	Senior Policy Officer Department of Sustainability and Environment
Rebecca Lillie	Environmental Scientist (Ecology), Kellogg Brown and Root
Rob O'Brien	Senior Environmental Officer Department of Primary Industries
Rohan Hogan	Science & Strategy Leader, North Central CMA
Shelley Heron	Manager – Water Ecosystems, Kellogg Brown and Root
Tamara Boyd	State Parks and Environmental Water Coordinator Parks Victoria
Tim Shanahan	Team Leader – Irrigation and Water Resources North Central CMA

Appendix B: Community Interaction/Engagement

Rob O'Brien, Department of Primary Industries

Background and purpose

EWPs are currently being developed for three wetlands in the Kerang–Boort area to determine the ecological impact of the current irrigation outfall (surplus water). An important component of this work involves identifying the environmental objective and wetland type for each of these wetlands. This requires an understanding of physical attributes, the history and the main biological processes associated with each of the wetlands.

There have been various levels of planning and monitoring on each of the wetlands currently being studied. To assist in collating all relevant information on each wetland it is important to capture and record information from the local community. In many cases adjoining landholders have had a long association with a wetland and have developed good understanding that is useful to include in the development of the plan. This is particularly important if only limited monitoring records exist.

This process is also useful to increase community ownership and acceptance of the EWP, particularly if ongoing work involves onground works.

These plans are required to be developed over a relatively short timeframe (6–8 weeks). To achieve the best result, a targeted community/agency engagement process was developed where a list of people with a good technical understanding of the wetland was developed by the technical working group.

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

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

The information is captured in brief dot point form and only technical information and observations have been noted that will add value to the development of the plan.

A list of participants has been recorded; however, comments for each wetland have been combined so individual comments are not referenced back to individuals.

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:

Information provided to participants

We are currently completing a study for NVIRP Northern Victoria Irrigation Renewal Project. It involves completing plans for, Lake Murphy, Lake Elizabeth and Johnson Swamp.

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 is recognised that these wetlands have been altered significantly since European settlement and the expansion of irrigated agriculture.

Providing information on these changes and how they 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 influence the floodplains and wetland.
- What connection does the wetland have to the floodplain in providing floodwater or local catchment runoff?
- To what extent does the current irrigation supply channel impact the water regime over time?

- During more recent times (i.e. last 50 years) 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 (box thorns, willows, cumbungi, etc.)
- What influence – both positive and negative – has grazing domestic stock had on reserve?
- 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?

List of community and agency participants

- Ernie Moore (landholder)
- Colin and Jeff Gitsham (landholders)
- Robin Algie (G-MW water bailiff)
- Tom Lowe (field naturalist, Birds Australia representative)
- Murray Rohda (DSE Senior Wildlife Officer)

Comments and feedback from participants for Lake Elizabeth

- Lake Elizabeth has been kept constantly full over a long period of time.
- Large quantities of outfall water escaped into the lake for a very long period.
- The Conservation Department also added water, on top of outfall, to keep it full.
- There has always been good waterbird numbers present on the lake.
- There were probably more ducks on the lake when it was fresher.
- Outfall has reduced significantly over the past 12 years and there is hardy any outfall water presently entering the lake.
- The lake may need to be kept dry into the future as there is a big shortage of water.
- It may be useful to link the filling of the lake to wetter weather cycles when more water is available.
- Since going saline, Lake Elizabeth has developed blue clear water that is very scenic.
- The lake is one of the few wetlands that people visit and drive completely around the perimeter.
- The fencing and revegetation works completed over the past 12 years have been very successful and improved the frontage attracting a host of different birds.
- The vegetative corridors planted on the farms that link back to Lake Elizabeth make the whole area more attractive and environmentally improved.
- Historically, drovers would hold their stock on the Lake Elizabeth frontage and overgraze the area.
- The vegetation that is currently growing around the frontage areas might require some controlled grazing in the future since total exclusion of stock has occurred.
- The wetland is almost dry and will need a water supply; however; it's important not to overfill the lake.
- There is a large area of farmland that naturally drains back into Lake Elizabeth. It's important not to overfill the lake to ensure it retains enough 'air space' to accept the local catchment runoff, particularly in wet years
- Overfilling the lake may be increasing the groundwater and soil salinity levels on nearby adjoining farmland.

- There are areas of farmland to the south of the lake where landholders pump water into the channel and it outfalls into the lake.
- Last Spring, around the 16th October, there was a large outfall event as water over-topped the G-MW channel.
- Automation of the channels isn't always reliable and mistakes happen.
- Lake Elizabeth almost went dry in 1929 where there was a large fish kill. This seemed to be caused by a heavy thunderstorm and resulted in a significant amount of dirty water flowing into Lake Elizabeth, which was very low at the time. This dirty water flowing off the surrounding land killed large Murray Cod present in the lake.
- Roy Gitcham (father of Geoff and Colin) was only a small boy in 1929 and present in a photograph showing the fish kill. These fish were very large, which suggests Lake Elizabeth had been kept full for a long period of time prior to the 1920s.
- In 1975, there were 42 fishing boats present on the Lake Elizabeth one weekend when the Redfin were biting
- The Redfin disappeared soon after the mid 1970s as the salinity levels rose.
- European Carp then dominated the lake through the late 1970s until the lake became too saline even for them.
- The Murray Hardyhead was discovered after all of the Carp and larger fish died when the lake became too salty.

Appendix C: Lake Elizabeth – Rating Table (Archard's Irrigation Ltd)

Capacity Summary for Lake Elizabeth

March 2009

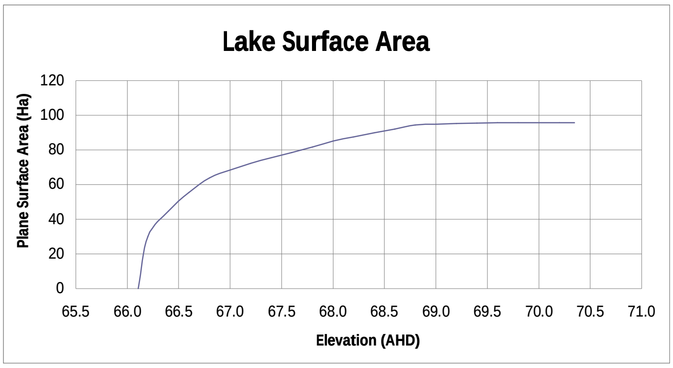
Produced by Dustin Chislett (Archards Irrigation, Cohuna)

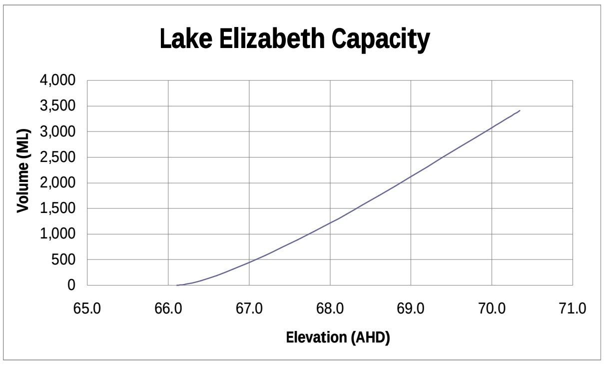
The survey of Lake Elizabeth was carried out using the Kerang Datum.
Usually in this area, one would add 0.45m to heights on the Kerang Datum to convert to AHD heights (this information was obtained from GMW).
However, this method was not used for achieving AHD heights on Contour Plan 95859 since the published heights of permanent survey marks SR-70-D4 and SR-70-D5 did not agree with the computed heights.
All elevations were converted to AHD according to the published AHD elevation of SR-70-D4.

Base Level (AHD) 66.1m

Top (AHD) 68.7m (Estimate)

Elevation (AHD)	Volume (ML)	Plane Surface Area (Ha)
66.1	0	0
66.2	14	30
66.4	90	45
66.6	191	56
66.8	311	64
67.0	444	68
67.2	585	72
67.4	733	76
67.6	887	79
67.8	1,047	82
68.0	1,214	85
68.2	1,387	88
68.4	1,564	90
68.6	1,746	92
68.8	1,934	94
69.0	2,123	95
69.2	2,313	95
69.4	2,504	95
69.6	2,695	96
69.8	2,886	96
70.0	3,078	96
70.2	3,269	96
70.3	3,408	96

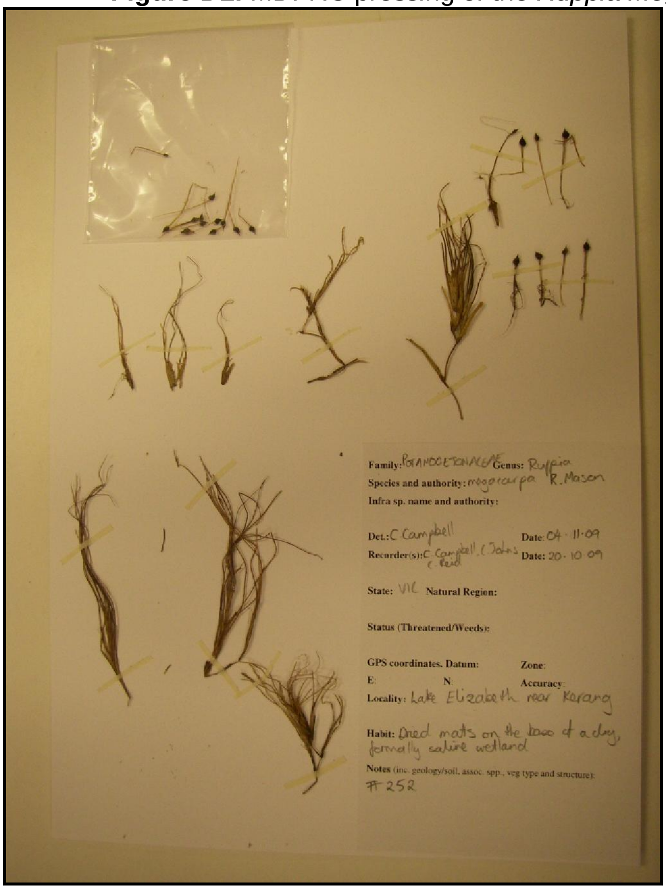




Appendix D: Lake Elizabeth – Wetland characteristics

Characteristics	Description
Wetland Area	94 ha
Conservation Status	Bioregional Important Wetland
Land Status	State Wildlife Reserve
Land Manager	Parks Victoria
Surrounding Land Use	Broadacre dryland cropping
Water Supply	Natural: Wandella & Venables Creeks Current: Terminal Wetland, Channel outfall (28/2) • 300EC • Capacity of 15ML/day
1788 Wetland Category	Permanent Open Freshwater (wet; can have dry periods), >1.0m)
1994 Wetland Category	Permanent Saline (>4,400EC)
Recorded Significant Species	Refer to Table 1 and 2, Section 3.1 (former habitat for Murray Hardyhead)
Wetland Capacity	1264ML, *FSL 73.5 m AHD (Not including wetting up losses, e.g. seepage)* Depth of Wetland (Range): 0-2 metres
Outfall Volumes	401 ML (04/05) 463.5 ML (98/99 to 07/08 median outfall)

Figure D1: MDFRC pressing of the *Ruppia Megacarpa* from Lake Elizabeth



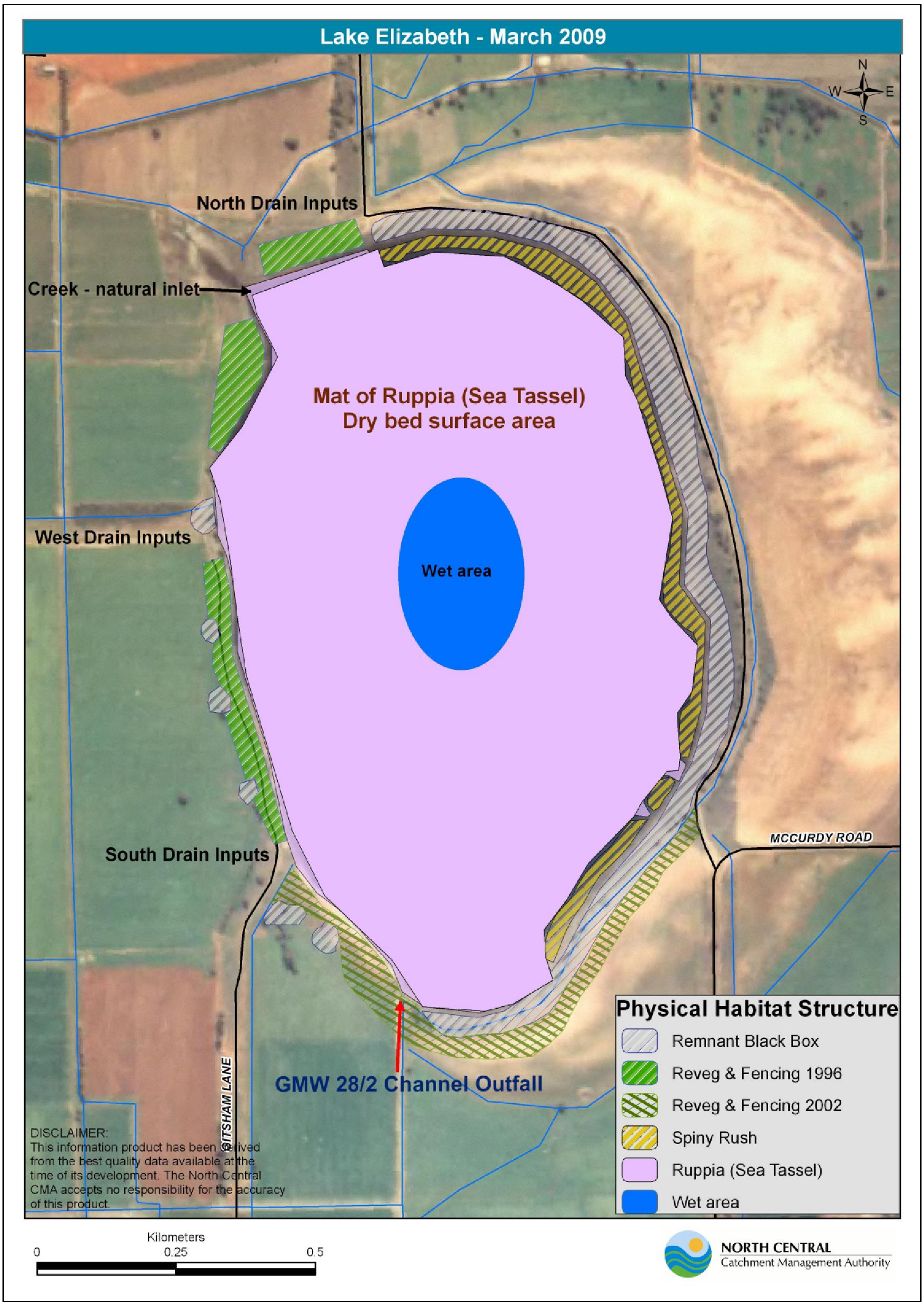
Appendix E: Flora and fauna species list

Common name	Scientific name	Dates recorded
Australasian Grebe	*Tachybaptus novaehollandiae*	1988, 1989-1990, 1995, 1999, 2000, 2006
Australasian Shoveler	*Anas rhynchotis*	1987, 1988, 1989, 1990, 1991, 1992, 1994, 1997, 1999
Australian Magpie	*Gymnorhina ribicen*	1989-1990
Australian Pelican	*Pelecanus conspicillatus*	1989-1990
Australian Saltmarsh Grass	*Puccinellia stricta*	1990
Australian Shelduck	*Tadorna tadornoides*	1977, 1989-1990, 2004
Australian Wood Duck	*Cheninetta jubata*	1989-1990
Berry (creeping) Saltbush	*Atriplex sembiccata*	2004
Black Box	*Eucalyptus largiflorens*	1990, 2004
Black Falcon	*Falco subniger*	Likely to occur (ARI 2009)
Black Swan	*Cygnus atratus*	1/01/1989
Black-seeded Glasswort	*Halosarcia pergranulata spp. pergranulata*	1990
Black-tailed Native-Hen	*Gallinula ventralis*	1987, 1988, 1989, 1993
Black-winged Stilt	*Himantopus himantopus*	1989-1990
Blue-billed Duck	*Oxyura australis*	1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994
Bonefruit	*Osteocarpum spp.*	1990
Cane Grass	*Eragrostis australasica*	1990
Chestnut Teal	*Anas castanea*	1989-1990
Climbing Saltbush	*Einadia nutans*	1990, 2004
Common Greenshank	*Tringa nebularia*	1989-1990
Crested Pigeon	*Ocyphaps lophotes*	1999
Curlew Sandpiper	*Calidris ferruginea*	1989-1990
Curly Windmill Grass	*Enteropogon acicularis*	1990
Dillion Bush	*Nitraria billardierei*	1990
Double-banded Plover	*Charadrius bicinctus*	1989-1990
Eastern Great Egret	*Ardea modesta*	Likely to occur (ARI 2009)
Eurasian Coot	*Fulica atra*	1985, 1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2004, 2006
Five Spined Roly Poly	*Sclerolaena muricata*	1990
Freckled Duck	*Stictonetta naevosa*	1989, 1991
Fuzzweed	*Vittadinia sp*	1990
Great Cormorant	*Phalacrocorax carbo*	1989-1990
Great Creasted Grebe	*Podiceps cristatus*	1989-1990, 1988, 1989, 2001
Great Egret	*Ardea alba*	1985, 1989-1990
Grey Copper Burr	*Sclerolaena diacatha*	1989-1990
Grey Teal	*Anas gracilis*	1989-1990
Halosarcia	*Halosarcia spp.*	2004
Hardhead	*Aythya australis*	1989, 1990, 1991, 1992, 1999, 1999
Hoary-headed Grebe	*Poliocephalus poliocephalus*	1989, 1992, 1999
Little Black Cormorant	*Phalacrocorax sulcirostris*	1989-1990
Little Pied Cormorant	*Phalacrocorax melanoleucos*	1989-1990
Masked Lapwing	*Vanellus miles*	1989-1990, 1999
Murray Hardyhead	*Craterocephalus fluviatilis*	1971, 1989,

Common name	Scientific name	Dates recorded
Musk Duck	*Biziura lobata*	1987, 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1996, 1997, 1998, 1999, 2000
n/a	*Ruppia megacarpa*	1990
Pacific Black Duck	*Anas superciliosa*	1989-1990
Pied Cormorant	*Phalacrocorax varius*	1988
Pink Bindweed	*Convolvulus erubenscens*	1989-1990
Pink-eared Duck	*Malacorhychus membranaces*	1989-1990
Purple Swamphen	*Porphyrio porphyrio*	1990, 2003
Red Sandspurrey	*Spergularia rubra*	1990
Red-capped Plover	*Caradrius ruficapillus*	1989-1990
Red-kneed dotterel	*Erythrogonys cinctus*	1989-1990
Red-necked Avocet	*Recurvirostra novaehollandiae*	1989-1990
Red-necked Stint	*Calidris ruficollis*	1989-1990
Rosinweed	*Cressa cretica*	1990, 2004
Royal Spoonbill	*Platalea regia*	1988, 1995
Ruby Saltbush	*Enchylaena tomentosa*	1990, 2004
Saloop Saltbush	*Einadia hastata*	2004
Salt Bush	*Atriplex prostrata*	1990
Sea Tassel	*Ruppia maritima*	1990
Sharp-tailed Sandpiper	*Calidris acuminta*	1989-1990
Short Rat-tail Grass	*Sporobolus mitchellii*	1990, 2004
Short-Leaf Bluebush	*Maireana brevifolia*	2004
Silver Gull	*Larus novaehollandiae*	1989-1990
Silver Mulga	*Acacia argyrophylla*	1990
Slender Fissure Weed	*Maireana pentagona*	1990
Slender-fruit Saltbush	*Atriplex leptocarpa*	2004
Snow-wort	*Abrotanella nivigena*	1974, 1990
Spiny Flat-sedge	*Cyperus gymnocaulos*	1990, 2004
Spiny Saltbush	*Rhagodia spinescens*	1990, 2004
Stonewort	*Chara sp.*	1990
Straw-necked Ibis	*Threskiornis spinicollis*	1989-1990
Stubble Quail	*Coturnix pectoralis*	2001
Sweet Swamp Grass	*Poa fordeana*	1990
Tall Groundsel	*Senecio runcinifolius*	1990
Tangled Lignum	*Muehlenbeckia cunninghammii*	1990, 2004
Variable Spear Grass	*Stipa variabilis*	1990
Wallaby Grass	*Danthonia spp.*	2004
Wallaby Grass	*Danthonia caespitosa*	1990
White-bellied Sea-Eagle	*Haliaeetus leucogaster*	Likely to occur (ARI 2009)
White-faced heron	*Egretta novaehollandiae*	1989-1990
White-necked Heron	*Ardea pacifica*	1989-1990
Windmill grass	*Chloris truncata*	1990
Yanga Bush	*Maireana brevifolia*	1990
Yellow-billed Spoonbill	*Platalea flavipes*	1989-1990
Exotic		
African Boxthorn	**Lycium ferocissimum*	1990
Annual beard-Grass	**Polypogon monspeliensis*	1990
Barley-grass	**Critesion murinum*	1990, 2004
Burr Medic	**Medicago polymorpha*	1990
Capeweed	**Arctotheca calendula*	1990
Common Heliotrope	**Heliotropium europaeum*	1990
Common Sow-thistle	**Sonchus oleraceus*	1990, 2004

Common name	Scientific name	Dates recorded
Common Starling	**Sturnus vulgaris*	1989-1990
Couch Grass	**Cynodon dactylon*	1990
Curled Doc	**Rumex crispus*	1990
Curly Barb Grass (Curly Rye Grass)	**Parapholis incurva*	1990, 2004
Ferny Cotula	**Cotula bipinnata*	2004
Flat Weed	**Hypochoeris radicata*	1990
Great Brome	**Bromus diandrus*	1990, 2004
Hairy Hawbit	**Leontodon taraxacoides*	1989-1990
Horehoud	**Marrubium vulgare*	1990
House Sparrow	**Passer domesticus*	1989-1990
Madrid Brome	**Bromus madritensis*	1990
Medic	**Medicago spp.*	2004
Mediterranean Barley-Grass	**Critesion hystrix*	1989-1990
Onion Weed	**Asphodelus fistulosus*	1990
Ox Tongue	**Picris echioides*	1990
Ox Tongue	**Helminthotheca echnioides*	1989-1990
Peppercress	**Lepidium africanum*	1990
Prickly Sow-thistle	**Sonchus asper*	2004
Rye Grass	**Lolium spp.*	1990
Scorzonera	**Scorzonera laciniata*	1990
Sharp Rush	**Juncus acutus ssp. Acutus*	1989-1990
Sheep (feral)	**Ovis aries*	1995
Silvery Grass	**Vulpia spp.*	2004
Small Ice plant	**Mesembryanthemum nodiflorum*	2004
Small-flowered Mallow	**Malva parviflora*	2004
Soursob	**Oxalis pres-caprae*	1990
Spear Thistle	**Cirsium vulgare*	1990
Spiny Rush	**Juncus acutus*	1990, 2004
Sweat Melilot	**Melilotus indicus*	2004
Tamarisk	**Tamarix aphylla*	1990
Water Buttons	**Cotula coronopifolia*	1990
Wild Oats	**Avena fatua*	1990, 2004
Wimmera Rye-grass	**Lolium rigidium*	2004
* Exotic species		

Appendix F: Vegetation composition map – March 2009



Appendix G: Hydrology (SWET OUTPUT)

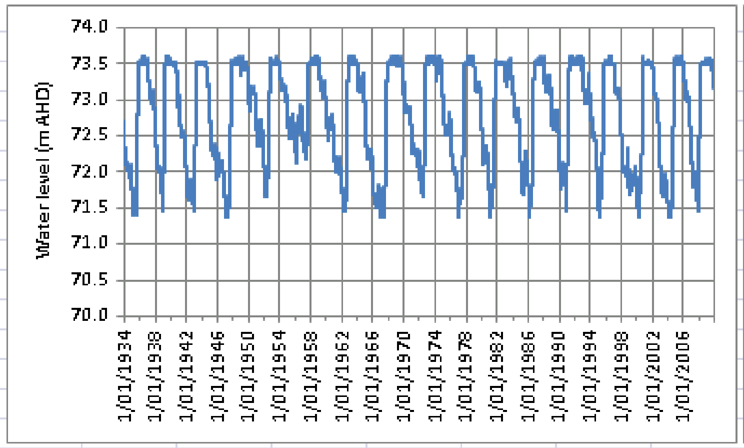
Wetland Name	Lake Elizabeth							
	Degrees	Degrees	Minutes					
Latitude	-35.69721	-35.00	41.8324					
Longitude	143.82102	143.00	49.2614					
	Metres (AHD)							
Altitude	73.59						Runoff coefficient	
	ha	m^2	ML/ha/y	ML/yr	Rainfal	Total (ML)	Mean	Max.
Local contributing catchment area	1304	13040000	0.2	261	332	4332	0.060	0.2
	%area	Depth						
Initial loss to wetland bed parameters	0.25	300						
	Mean	Max						
Assumed average wetland bed runoff coeff	0.150	0.40						
	ML/d							
Notional artificial wetland filling inflow rate	15							
	mm/day							
Maximum artificial filling rate	20							
Management parameters	Day	Month	Start day					
Earliest start to fill	1	8	213					
Latest start to fill	31	12						
Duration wet cycle - includes filling	548	18						
Duration dry cycle - includes drawdown	548	18						
Start condition	Dry		Years					
Maximum wet-dry cycle length			5					
	Day	Month						
Irrigation year start	1	8						
	Elevatio	Volume	Area					
Target level	73.5	1264020	809100					
	Elevatio	Volume	Area					
Wetland spill level	73.59	1337290	818900					
	Elevatio	Tolerance for drying (m)						
Lowest wetland level	71.37	0.1						
		1 = Pan; 2 = Modelled						
Factored Pan evaporation or modelled ET method?		2						

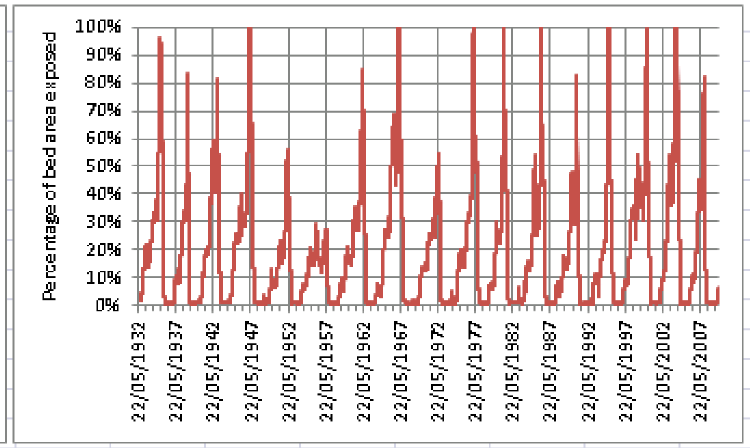
To operate the model

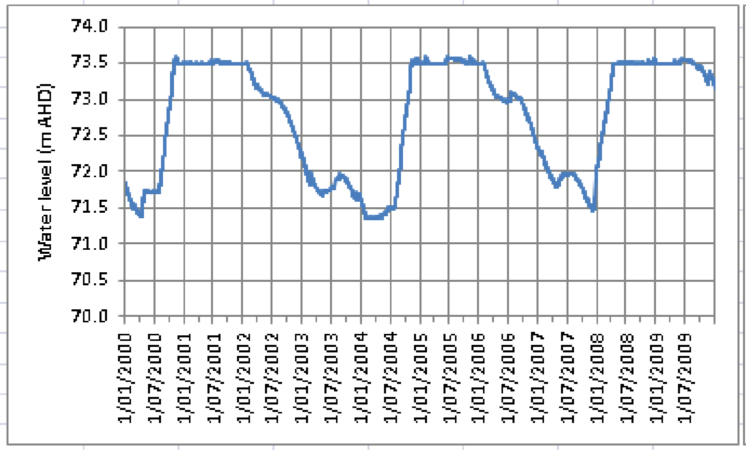
First fill in the required input data cells.
Calculation is set to Manual, so
when ready press Function9 (F9) key
It takes 20 seconds to re-calculate and plot

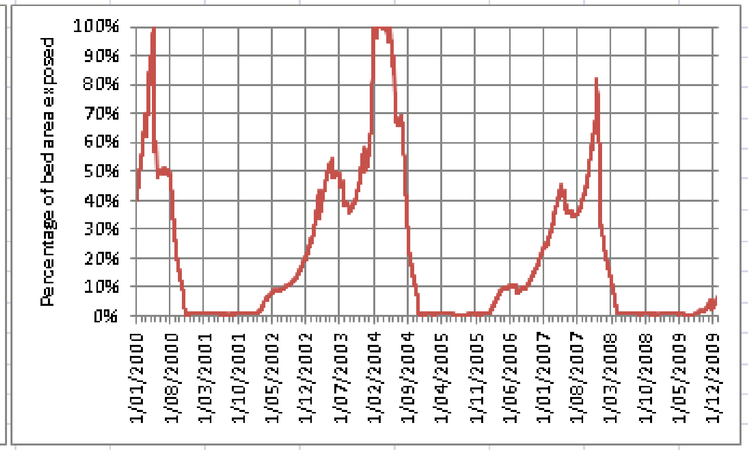
RESULT			
	ML/year	P95 (ML/yr)	ears with no inflo
Mean long-term annual artificial water inflows	556	1,967	64 in 118 years
	ML	No. Period	cord length (yea
Average water inflows for filling periods	2,430	27	118
Drawdowns over record (number of)	27		
Drawdowns not fully dried out (number of)	4		
Drawdowns not fully dried out (percentage)	15%		
95th percentile duration of full period (months)	15.2		
50th percentile duration of full period (months)	14.0		

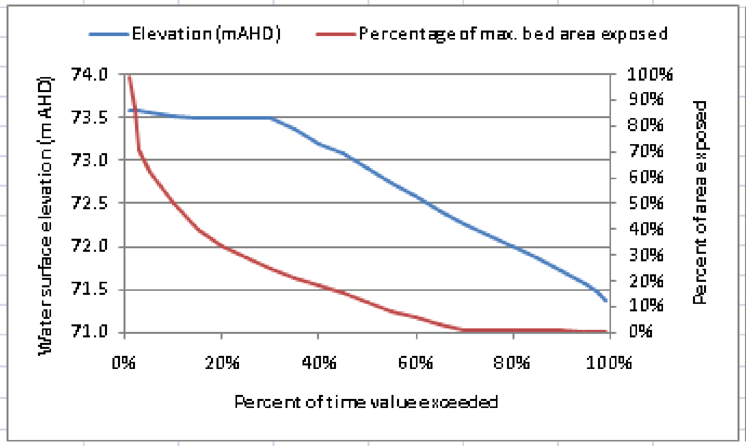
Fill cycle length (yr)	No. cycles
1	
2	
3	2
4	11
5	14
6	
7	
8	
9	
10	

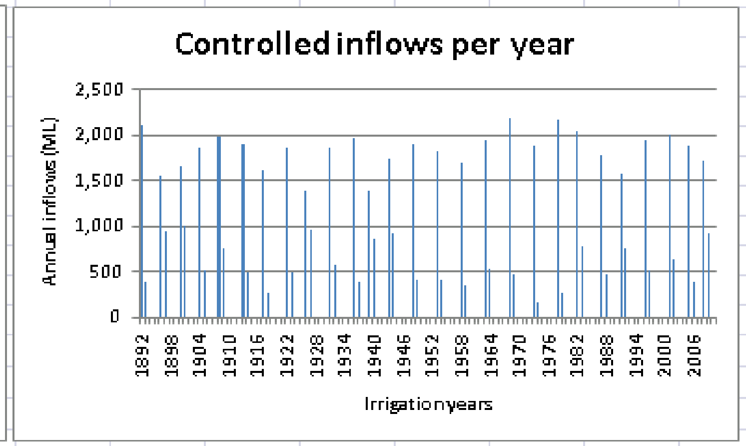












Appendix H: Preliminary leakage and seepage loss contribution calculations

Wetland	Wetland <200 m of main supply channel (Yes/no)	Length of channel (m) <200 m	Channel width (m)	Irrigation channel	Seepage Calculation Figures					Seepage Range (min - max)	
					Channel width category	5 mm/day (ML/yr)	10 mm/day (ML/yr)	15 mm/day (ML/yr)	20 mm/day (ML/yr)	ML/yr (@ 5 mm/day)	ML/yr (@20 mm/day)
Lake Elizabeth	Yes	200	5 to 7	channel 28/2	use 10 m	7	14	20	27	1.4	5.4

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*)

		Seepage Rate in mm/day			
Chanel width (m)	**Chanel half-width (m)**	**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		
Climatic variability	Variability in water availability (e.g. dry season during a planned wetting phase)	Adaptive management of watering regime and delivery options (see above)
Poor water quality (i.e. high salinity and turbidity levels from channel system)	Turbid or saline water reducing establishment of aquatic vegetation	Monitoring of groundwater levels and salinity within wetland. Adaptive management of watering regime.
	Limited regeneration resulting from salinity levels beyond threshold levels (e.g. sea tassel)	
	Unsuitable habitat for waterbirds	
	Filamentous algae	
Groundwater intrusion due to elevated groundwater levels	Failure of *Ruppia megacarpa* to establish	Monitoring of groundwater levels and salinity within wetland. Adaptive management of watering regime.
Lack of connection between wetland and river or floodplain	Altered flow regime - continued lack of flood flows	Lake Elizabeth still receives water from the catchment though its connectivity is considerably reduced.
	Lack of connectivity throughout the landscape	
Flooding of adjacent landholders	Community angst	Monitor rainfall and climate data and adapt water delivery to account for potential flood events.
	Liability	
Ecological response		
Lack of seedbank viability	Limited establishment of submerged aquatic vegetation particularly *Ruppia megacarpa*	Monitoring and adaptive management particularly to address *Ruppia megacarpa.* requirements. Potential to test seed germination (samples taken from wetland bed).
	Emergence of unexpected native or exotic species	
No reliable supply of food/nesting sites	Limited occurrences of waterbirds	Seasonal water delivery, monitoring and adaptive management of watering regime.
Lag time between wetland watering and bird breeding	No successful breeding events	Seasonal water delivery, monitoring and adaptive management of watering regime.
Proliferation of pest plants and animals	Reduced habitat and resource availability	Monitoring, active management (e.g. weed and pest control). Install European carp screens.
	Predation	
	Limited establishment of native vegetation	
High soil salinity	Poor vegetation health	Monitoring and adaptive management of watering regime, Active management (e.g. weed and pest control).
	Limited regeneration and dominance of salt tolerant species e.g. spiny rush	
	Limited habitat availability due to dominance of exotic species e.g. spiny rush	
Other		
Recreational pressures e.g. hunting increases in response to watering event	Loss of non-game species	Monitoring of waterbird numbers and diversity. Reporting of information to relevant bodies including Field and Game Association and DSE.

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 Little Lake Boort. However, recommendations have been made below for variables to be monitored in order to assess the response to the provision of the desired water regime and inform its adaptive management.

It is recommended that an environmental monitoring plan is developed for the site, to ensure planned analysis and reporting of the impacts of the adopted watering regime.

1. Long term condition monitoring

Long term condition monitoring is recommended in order to evaluate any changes to wetland values over time. It should be noted that condition monitoring should be undertaken in conjunction with intervention monitoring to comprehensively evaluate any changes to Lake Elizabeth.

Vegetation condition and distribution

A number of photo points have been established around Lake Elizabeth (Appendix H) to enable the assessment of changes in wetland condition over time (Table G1). 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.

Table J1: Photos points for Lake Elizabeth (GDA94 Zone 55)

Wetland	Photo ID	Easting	Northing	Facing
Lake Elizabeth	PH83	212156.5728	6045630.383	South
	PH85	211984.3787	6045512.228	South
	PH88	211833.52	6045574.045	South east
	PH91	212330.7358	6044155.108	East

It is also recommended that the condition and distribution of vegetation communities, including exotic species, throughout Lake Elizabeth are assessed every five years. Information on vegetation communities gathered on aerial photography during this project has been digitised using GIS to enable comparison in distribution over time (Appendix E) (MDBC 2005).

Additional methods that could also be employed in the evaluation of change to vegetation condition and distribution include:

- Index of Wetland Condition
- Habitat Hectares.

Groundwater monitoring

Long term monitoring of groundwater within the immediate vicinity of Lake Elizabeth is recommended to identify potential risks associated with watering the wetland and for consideration in adaptive management. DPI currently undertakes monthly groundwater monitoring at the wetland. It is recommended that this continues with particular regard to groundwater level and the potential for saline groundwater intrusion.

It is important that the monthly monitoring results are provided by DPI to the North Central CMA and the land manager to facilitate data analysis and inform adaptive management.

2. Intervention monitoring

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

The results of each component of intervention monitoring will be used to reassess and amend the recommended flow regime as required.

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 to the provision of water. Monthly monitoring is recommended and snapshot assessments should incorporate the components outlined in Table G2. A database of historic flora records has been compiled for Lake Elizabeth and should be updated following regular monitoring.

Table J2: Components of snapshot vegetation intervention monitoring

Component	Target	Method	Objective
Vegetation distribution	Submerged aquatic vegetation, chenopod shrubland, availability of open water and mudflat habitat	• Distribution mapping • Photo points • IWC	Habitat objectives, 2.1 - 2.3
Vegetation condition		• Photo points • IWC	1.1, 1.2, 2.1-2.3
Species diversity	Additional species with a focus on submerged saline aquatics	• Species list comparison	1.1, 1.2, 2.2, 2.3

Waterbirds

The diversity and abundance of waterbirds at Lake Elizabeth needs to be monitored following watering in order to assess the success of implementation and achievement of objectives. Monthly monitoring as water levels fluctuate will ensure changes in bird communities are captured (MDBC, 2005). 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 Elizabeth and should be updated regularly following monitoring. Table G3 outlines the recommended components of waterbird monitoring.

Table J3: Components of snapshot intervention monitoring of waterbirds

Component	Target	Method	Objective
Species diversity	All species including those of conservation significance	• Area searches (MDBC 2005)	Habitat objectives, 2.1 – 2.3
Waterbird abundance			Habitat objectives, 2.1, 2.2
Habitat availability	Open water, mudflat, Chenopod shrubland and surrounding Black Box, lignum and chenopod vegetation	• Undertaken in conjunction with vegetation monitoring	Habitat objectives, 2.1, 2.2
Breeding populations	Australian Pelican, Blue-billed Duck, and Black Swan	• Nest surveys (MDBC 2005)	Habitat objectives, 2.1

Fish and macroinvertebrates

It is also recommended that the response of fish and macroinvertebrates is monitored following watering as they are valuable food sources for a number of waterbirds. This will enable variation due to water level fluctuations to be captured. Numerous surveys and records exist to provide baseline data to allow evaluation of the response to watering. A database has also been compiled of all recordings made at Lake Elizabeth and should be updated regularly following monitoring. Table G4 details the components to be incorporated in monitoring fish and macroinvertebrates.

The results of the monitoring should be used to inform the assessment of habitat availability for waterbirds as they provide a significant food source for a number of species. Incidental observations of reptiles and amphibians can also be recorded.

Table J4: Components of intervention monitoring for fish and macroinvertebrates

Component	Target	Method	Objective
Species diversity	All species including those of conservation significance	• Electrofishing, bait trapping, seine and fyke netting (MDBC 2005) • Sweep netting/AUSRIVAS	1.1, 2.1, 2..2, 2.3
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 G5 identifies elements to be considered as part of the water quality monitoring program.

Table J5: Components of intervention monitoring for water quality

Component	Target	Method		Objective
Water quality	Electrical conductivity	Conductivity meter	Water quality meter	1.1, 2.1-2.3
	pH	pH metre		
	Turbidity	Turbidity meter		
	Dissolved oxygen	Oxygen meter		
	Nutrients	Laboratory analysis		

Appendix K: Photo points

LE Photo point 1	LE Photo point 2
	
LE Photo point 3	**LE Photo point 4**
	

NORTH CENTRAL
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