# DEMONSTRATING ENVIRONMENTAL WATER NEEDS IN A CLIMATE OF CHANGE

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Efficient and accountable management of water resources in Northern Victoria has become a critical issue for the future of irrigation, communities and the environment, both north and south of the Great Dividing Range. To increase efficiencies and enhance accountability for water resource use, the Victorian Government is investing $1 billion through the Northern Victoria Irrigation Renewal Project (NVIRP) to upgrade ageing irrigation infrastructure across the Goulburn-Murray Irrigation District. The upgrade is expected to generate an additional 225 GL of water that will be distributed equally between irrigators, the environment and Melbourne. Whilst there are significant potential benefits for the environment as a whole from the water savings initiatives, there may also be adverse impacts from altering the hydrology of the diverse array of wetlands and rivers which are directly linked to the irrigation delivery network. The NVIRP Environmental Referrals process has investigated these potential impacts and identified ten wetlands and four rivers of high environmental value that require the development of environmental watering plans. These plans are the primary means by which the NVIRP commitment to 'no net environmental loss' will be achieved and assets of high environmental value will be protected. Three Environmental Watering Plans (EWPs) were completed prior to the operation of NVIRP works in the 2009-2010 irrigation season. These are for Johnson Swamp, Lake Elizabeth and Lake Murphy. The paper will describe the development of the Lake Elizabeth EWPs by the North Central Catchment Management Authority (NCCMA), within the context of uncertain climatic conditions, the recent long drought and the need to demonstrate accountability and efficiency in the use of a scarce and finite resource.

*Key words*: Environmental Watering Plans, Torrumbarry Irrigation System, modernisation, NVIRP, wetlands, environmental water

THE Northern Victoria Irrigation Renewal Project (NVIRP) is a large scale water savings project that has the potential to impact on environmental assets located in the Goulburn Murray Irrigation District (GMID) (NVIRP 2009).

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.

The NVIRP Environmental Referrals process aims to ensure mitigation of the potential impacts of irrigation modernisation on high environmental value assets. The process assesses operational impacts on:

- natural waterways via changes in the delivery patterns of irrigation water;
- natural waterways via the reduction in channel outfalls to these waterways;
- regional groundwater via improved system efficiency (reduced leakage and seepage) and;
- wetlands in the GMID via the reduction in channel outfalls to these wetlands (SKM 2008).

The NVIRP Environmental Referrals process prioritised 10 wetlands and four rivers with significant environmental values that may be impacted by the NVIRP. The 10 wetlands (Lake Elizabeth, McDonald Swamp, Johnson Swamp, Lake Yando, Lake Leaghur, Lake Meran, Little Lake Meran, Lake Murphy, Little Lake Boort and Round Lake) are located within the GMID and require the development of Environmental Watering Plans (EWPs) prior to any changed operation of the irrigation system (HydroEnvironmental 2009).

The NVIRP commissioned the North Central Catchment Management Authority (NCCMA) to complete three of the Wetland EWPs: Lake Elizabeth, Johnson Swamp and Lake Murphy - prior to the operation of NVIRP works in the 2009-2010 irrigation season (NCCMA 2009a, 2009b, 2009c).

The EWPs are intended to identify the water required to protect the environmental values of the wetlands; define the environmental watering regime and the sources of water; identify the infrastructure requirements; outline draft protocols for ongoing water supply and; identify management responsibilities (NVIRP 2009).

## DEVELOPMENT PROCESS

The EWPs were developed in collaboration with key stakeholders i.e. Goulburn-Murray Water (G-MW), Department of Sustainability and Environment (DSE), Parks Victoria (PV) and the Department of Primary Industries (DPI). A number of tasks were undertaken to develop each EWP (Fig. 1) (NCCMA 2009a), as follows:

- Wetland watering requirements: the relationships between the various wetland values described by relating ecological objectives to hydrological objectives.
- Hydrology assessment: quantifying the volumes of water required to provide the recommended watering regime for each wetland.
- NVIRP mitigation water: calculation of the proportion of the outfall water required to maintain the environmental values of the wetland that were historically supported by irrigation water.
- Potential risks associated with the recommended watering regime: the potential risks or limiting factors and impacts that may result from the implementation of the recommended watering regime.
- Infrastructure requirements: assessment to ensure that delivery of water can occur at appropriate times and in the required quantities.
- Adaptive management framework: an adaptive management approach (assess, design, implement, monitor, evaluate and adjust) has been incorporated into each EWP to ensure that it is responsive to changing conditions.
- 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 environmental watering plans.

## WATER SAVINGS VERSUS ENVIRONMENTAL VALUES

The three EWPs completed prior to the 2009 winter works program are the first of their kind and were developed prior to the Victorian Government's water savings policy (NCCMA 2009a, 2009b, 2009c).

A key component of the EWPs is the quantification of 'mitigation' water. Mitigation water is defined as the water required to ensure that there are no net negative impacts on high environmental values due to NVIRP works. It is the primary means through which no net environmental loss will occur due to the 85% reduction in the channel outfall water source to the wetland.

There were a number of principles that had been defined by the NVIRP Technical Advisory Committee (based on government policy) for requisite water. These include:

- Water savings are the total volumes saved less the volumes of water required to ensure no net impacts on high environmental values i.e. net savings.
- Using the same baseline years as those used to quantify savings (2004-05), taking into account the long-term average annual patterns of water availability.
- Reliability to match that of the source (outfall water).
- The requisite water should be represented as an obligation in the G-MW bulk entitlement and should be deployed according to the EWP (NVIRP 2009).

Although there were principles surrounding the concept of mitigation water, there was no defined method/guidelines for calculating the volume of outfall water that provides an environmental benefit.

The NCCMA developed a process for calculation of mitigation water, based on the best available information, and applied it to the first set of EWPs (NCCMA 2009a, 2009b, 2009c). This process involved the application of a series of steps:

*Step 1:* Quantifying the hydrological characteristics of the wetland
*Step 2:* Identifying the potential benefits of the outfall water
*Step 3:* Applying a set of criteria to determine whether all or part of the outfall water needs to be set aside to support the environmental values (NVIRP 2009)
*Step 4:* Calculating the volume of mitigation water with respect to the proposed wetland watering regime
*Step 5:* Calculating the net savings (outfall water minus mitigation water)

In the majority (if not all) cases, the actual outfall volumes are less than that required to support the

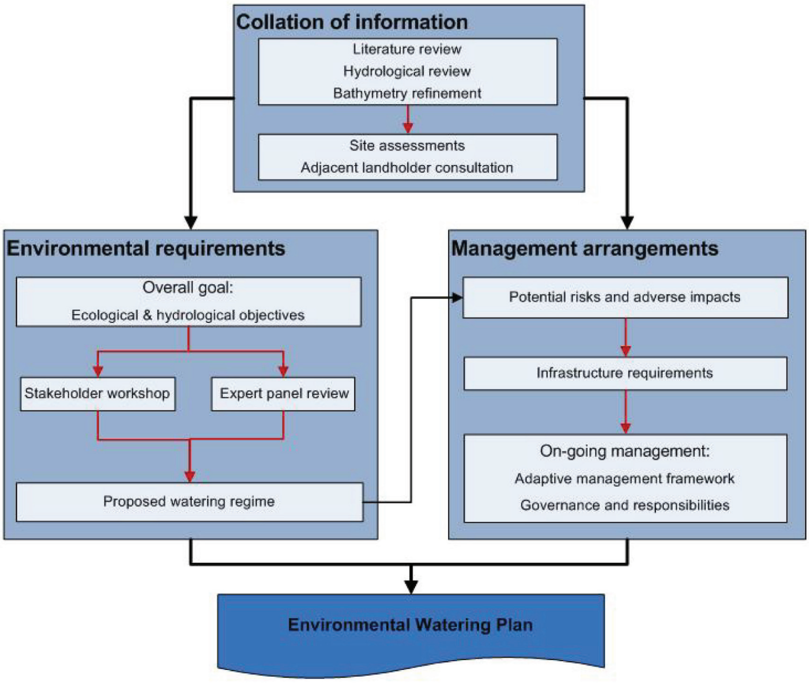


*Fig. 1.* Environmental Water Plan development process (NCCMA 2009a).

environmental values of the wetlands. Therefore, the outfall water only forms part of the overall volume or flow regime of the wetland. It was difficult to quantify what portion of this regime (outfall water) is supporting what portion of the environmental values. Consequently, much of the justification for mitigation water volumes was based on qualitative information.

## CONSULTATION

An important component of developing the Wetland EWPs involved identifying the overall wetland goal and the associated watering regime for each wetland. This required an understanding of the physical attributes, the history and the main biological processes associated with each of the wetlands.

### *Targeted community consultation*

To assist in collating the relevant information on each wetland it was important to capture and record information from the local community. Adjoining landholders who had a long association with a wetland assisted in collating historical information and condition of the wetlands over time. This was particularly important as limited monitoring records exist for the wetlands.

It was found that landholders had developed a good understanding of the wetlands that was extremely useful to include in the development of the plan. Other community and agency people who provided useful technical and historic information included G-MW water bailiffs, duck hunters (Field & Game), bird observers and field naturalists.

### *Formation of a technical advisory committee*

A Technical Advisory Committee was convened by the NVIRP to oversee the development of the EWPs and ensure quality, completeness and practicality. The committee included representation from the CMAs, G-MW, DPI, NVIRP and DSE.

In determining the wetland goal and overall wetland watering regime for each wetland, a workshop was held with key stakeholders and relevant experts to refine the proposed ecological objectives and watering requirements. In addition, key components of the draft plan were presented and reviewed by an independent expert panel that consisted of Brett Lane (Brett Lane & Associates), Terry Hillman (Hillman et al.) and Peter Alexander (HydroEnvironmental).

### *The expert review*

Following their development, the EWPs were reviewed by the independent Expert Review Panel (Jane Roberts, Terry Hillman and Denis Flett) prior to sign-off by the Minister for Water.

## ESTABLISHING WETLAND MANAGEMENT GOALS

Long term sustainable water management is important for all stakeholders (e.g. NVIRP, rural landholders and the environment). The key focus of the Victorian Government is to achieve water savings and encourage efficient and effective water use while seeking opportunities for multiple benefits (DSE, 2008).

To enable the effective use of environmental water, the process for determining the wetland management 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 wetland goals needed to be achievable and that the watering regime needed to support the values in the long-term (i.e. ensure viability of species and habitats in the long term).

## QUANTITATIVE, QUALITATIVE AND ANECDOTAL INFORMATION

In collating information for the EWPs, quantitative information was available for the previous 10 years of water resource management, while qualitative and anecdotal information was used to assess the key knowledge gaps.

Environmental values (i.e. plant and animal communities, species, processes and habitat dependant on flow) were identified from species records and anecdotal information.

The wetland surface hydrology was assessed via recorded outfall (since 1998) and anecdotal information provided by water bailiffs and the local community. This information provided an estimate on the duration, frequency and seasonality (timing) of the hydrological regime for the wetlands. It was also found that the hydrology information provided further insight into the environmental values.

## LAKE ELIZABETH ENVIRONMENTAL WATERING PLAN

The completed EWPs document the approach to mitigating against the potential impacts of the NVIRP due to automation of the Torrumbarry Number 2 Channel which outfalls into Lake Elizabeth, Johnson Swamp and Lake Murphy. The main components of the EWPs are described below, using Lake Elizabeth as the example.

### *Lake Elizabeth*

Lake Elizabeth is a 94 ha wetland situated approximately 10 km north-west of Kerang (Fig. 2). It is a terminal lake located within the Wandella Creek subcatchment of the Loddon River basin. The wetland is listed as being of bioregional significance and is a State Wildlife Reserve under the *Crown Land (Reserves) Act 1978* and is managed by Parks Victoria under the *Wildlife Act 1975*.

Prior to European settlement, Lake Elizabeth was a permanent open freshwater lake (DSE 2009a). A change to the hydrology of the area, most notably the development of the Torrumbarry Irrigation System in the 1920s and associated changing land use, caused the wetland to become more saline (Macumber 2002) and it is now classified as a permanent saline lake (DSE 2009b). 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.

Lake Elizabeth occurs in the Victorian Riverina bioregion. The surrounding land use in the catchment (approximately 1304 ha) is agriculture, consisting primarily of annual pasture (SKM 2004).

Lake Elizabeth is directly connected to the Torrumbarry Irrigation System via the 28/2 Channel located to the south of the wetland (Fig. 2). A number of drains also enter the lake from the surrounding land providing water from surface drainage. Following the planned modernisation of irrigation infrastructure by the NVIRP, the efficiency of the irrigation delivery system will improve, reducing the volumes of outfall water received by the wetland by approximately 85%.

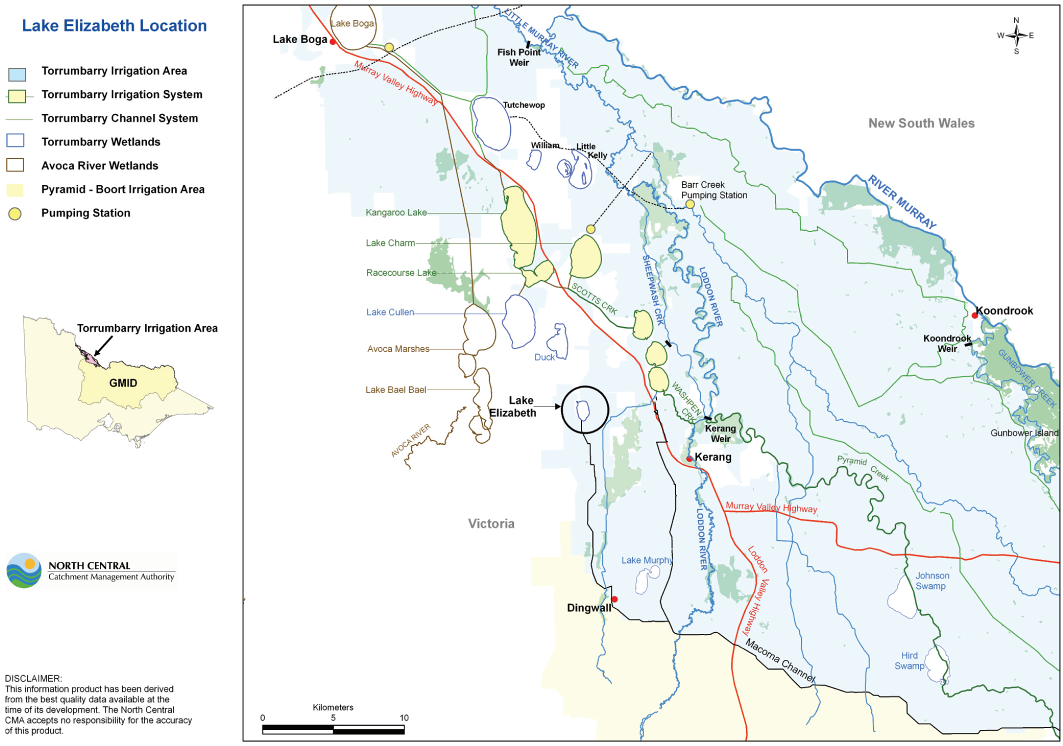


*Fig. 2.* Location of Lake Elizabeth (NCCMA 2009a).

*Environmental values*

Lake Elizabeth provides habitat for a diverse range of native flora and fauna species and supports high numbers of waterbirds. 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*. As wetland habitat for a number of protected species, Lake Elizabeth is required to be protected and conserved in accordance with international migratory bird agreements (DEWHA 2009).

From 2002 to 2006–07, Lake Elizabeth was managed as a permanent wetland to protect habitat for native waterbird and fish species, particularly the nationally listed Murray Hardyhead *Craterocephalus fluviatilis* (DSE 2006). The salt tolerant aquatic plant Sea Tassel *Ruppia* spp. 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).

The environmental values of Lake Elizabeth have been impacted by the current drying phase. Elevated salinity levels are evidenced by a mat of dead and dying *Ruppia* spp. covering the bed of the lake and chenopod shrubland vegetation colonising the drying areas. The revegetation works around the fringes of the wetland remain in good health, while the stand of Black Box *Eucalyptus largiflorens* (western boundary) exhibits poor health (a combination of dead trees and live trees displaying varying levels of stress). Salt tolerant weeds, including an extensive infestation of Spiny Rush *Juncus acutus*, dominate the understorey along the high water mark of both the eastern and southern boundaries. Appendix E in the EWP illustrates the generic vegetation composition of Lake Elizabeth surveyed in March 2009 (NCCMA 2009a).

*Wetland hydrology*

Duration, frequency and seasonality (timing) of water supply are the most important components of the surface hydrological regime for maintaining wetland condition and environmental values. Lake Elizabeth's natural water supply originates from a series of interconnecting creeks (Wandella and Venables Creek) and anabranches that break away from the Loddon River approximately 30 km upstream (south). Prior to irrigation, the natural hydrological cycle of Lake Elizabeth would have consisted of flooding in winter and spring, with drawdown due to evaporation and leakage to the groundwater system (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).

*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 *Ruppia* spp. established and thrived. In the 1970s, Murray Hardyhead were discovered in Lake Elizabeth and management of the lake's hydrology subsequently focused on maintenance of this species.

Outfall data for Lake Elizabeth has been recorded by G-MW since 1998 (Fig. 3). 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.

Channel outfalls to the wetland decreased significantly due to a combination of increased channel efficiency, lower water allocations and reduced rainfall and local catchment runoff. Reduced inflows resulted in lower lake water levels and increased salinity levels (O'Brien et al. 2009). To counteract the potential impacts that rising salinity levels would have on the Murray Hardyhead, environmental water was regularly allocated from the Murray Flora and Fauna Bulk Entitlement from 2002 onwards (Fig. 3) to maintain salinity levels below 45 000 EC units (or µS/cm) (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 together with dry climatic conditions and the reduced availability of environmental water, meant that the lake began to dry in 2007 and is now almost completely dry (Figs. 4, 5).

*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 40 000 EC or µS/cm) (DPI 2004).

Lake Elizabeth is a through-flow lake, meaning that groundwater generally enters at one end and leaves at the other with losses to groundwater from the lake itself, which leaks (Macumber 2002). This was demonstrated particularly by the consistent correlation between lake salinity and lake level.

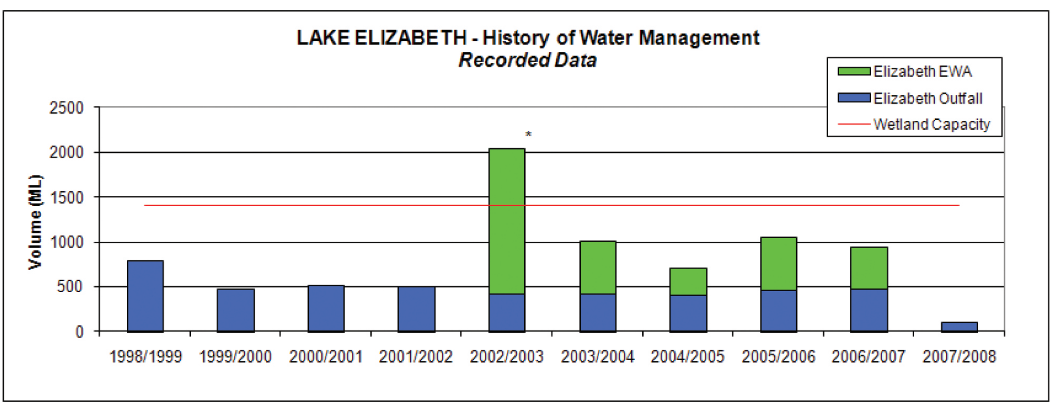


*Fig. 3.* Lake Elizabeth watering regime (1995-2008). Notes: Outfalls recorded by G-MW are from 1998 only. EWA = Environmental Water Allocation. * 2002-2003 included top-up volumes to counter evaporation losses.

*Fig. 4.* Lake Elizabeth wet phase (date unknown).

*Fig. 5.* Lake Elizabeth drying phase (2009).

Groundwater levels as at 20 January 2009 were approximately 0.5 m above the lake level (approximately 72 m to 72.1 m AHD). Lack of data and the only very recent and previously unrecorded low lake level, together with 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 continues accumulating salt, an additional threat could arise from relatively high groundwater heads to the south-east generated from episodic flooding of the Wandella Forest and/or Loddon river floodplain (Macumber 2006, 2007; Reid and O'Brien 2009).

*Management objectives*

The new overall goal proposed for Lake Elizabeth is derived from a variety of sources, including historic management goals, local expertise and knowledge, and current climate predictions, and has been appraised by various experts and stakeholders. The goal considers the values the lake supports and potential risk factors that need to be managed, for example, seedbank viability of *Ruppia* spp.

Lake Elizabeth goal

*To provide a watering regime that supports a submerged salt-tolerant aquatic plant assemblage typical of a seasonal brackish/saline lake (dominated by Sea Tassel* Ruppia *spp.).*

The goal for Lake Elizabeth recommends a drier operating regime and hence differs from previous management objectives, which were focused on maintaining the values of a permanent lake.

*Ecological and hydrological objectives*

The ecological objectives for Lake Elizabeth represent the desired ecological outcomes for the wetland and were developed to determine the new optimal watering regime for the lake to protect its remaining high environmental values.

Values (i.e. plant and animal communities, species, processes and habitat dependent on flow) were identified from species records and anecdotal information. Water-dependent species and communities with recognised conservation significance were given highest priority in addition to others that are indicative of integrated ecosystem function, i.e. important for habitat quality.

Hydrological objectives for each of the values were identified. These describe the water regimes required for achieving ecological outcomes (ecological objectives): refer to example in Table 1 (DNRE 2002).

*Proposed water regime*

A wetland watering regime was derived based on the defined ecological and hydrological objectives for Lake Elizabeth. A schematic is provided to illustrate the various components of the wetland (e.g. *Ruppia* spp. and mudflats) that are being targeted by the watering regime (Fig. 6).

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

*Frequency of wetting:* Minimum: one in five years
Optimum: one in three years
Maximum: Permanent

*Table 1.* Example habitat objective for Lake Elizabeth.

| Ecological objective | Justification | Hydrological objective | Limiting factors |
|---|---|---|---|
| 1. Habitat objectives | | | |
| 1.1 Maintain submerged aquatics<br>• *Ruppia* spp. | Food for waterbirds (Objective 2.2 & 2.3, e.g. swans, coots, ducks and waders)<br><br>*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 3–5 yrs to moderate level ≥1.5 m deep and top up to ensure inundation period of 18 months (timing for *Ruppia* spp. to establish and seed). | - Existence of seed bank (e.g. loss through soil loss, predation, herbivory, dessication and failure to replenish)<br>- Residual salt<br>- Turbidity<br>- Filamentous algal growth |

*Duration:* 18 months
*Extent and depth:* ≥1.5 m
*Variability:* Moderate (determined by the response of the aquatic plants)

Overall wetland watering regime:
*Fill wetland to ≥1.5 m one in three years and ensure inundation period at this level is for at least 18 months (may require top-ups).*

The volumes of water required to provide the recommended watering regime for Lake Elizabeth are presented in Table 2. These volumes incorporate evaporation and seepage rates from the water balance calculations.

In year one, Lake Elizabeth is filled to capacity and topped-up with water to counteract evaporation (1455 ML/year). In year two, 851 ML is required to maintain water levels at ≥1.5 m. In the second half of year two, the lake will begin to dry as water is lost to evaporation and seepage.

Other inflows (i.e. surface run-off and rainfall) are not included in Table 2. Surface water inflows to Lake Elizabeth and rainfall will vary considerably from year to year, depending on seasonal conditions. Based on the annual average rainfall, estimates for these are 301 ML/year for rainfall falling directly on the wetland and 261 ML/year for surface run-off (a total of 562 ML). Therefore, in an average year, accounting for all significant inflows and losses, the total volume required to fill and maintain levels in the wetland would be reduced to 2218 ML for 12 months and 570 ML for six months in year two.

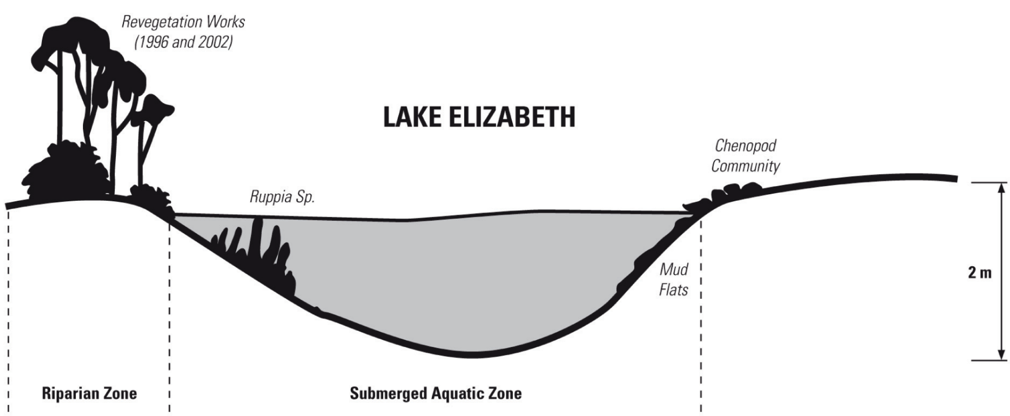


*Fig. 6.* Schematic of Lake Elizabeth (not to scale).

*Table 2*. Mitigation water volumes required. [1] Area at environmental inundation target (depth of 2 m).

| Year | Area (ha) | Capacity (air space) (ML) | Infiltration (ML) | Evaporation - filling (ML) | Evaporation - full wetland (ML) | Total volume required (ML) |
|---|---|---|---|---|---|---|
| 1 | 81[1] | 1264 | 61 | 143 | 1312 | 2780 |
| 2 | 81 | 1264 | | | 851 | 851 |
| | | | DRYING PHASE | | | 0 |
| 3 | | | DRY PHASE | | | 0 |

*Table 3.* Lake Elizabeth hydrology information.

| Lake Elizabeth | Data |
|---|---|
| Wetland Capacity (Full Supply Level or FSL) | 1264 ML |
| Minimum/maximum volume required for recommended water regime | 2785 to 3631 ML |
| Inflows | |
| Rainfall | 301 ML/year |
| Surface run-off | 261 ML/year |
| Outflows | |
| Estimated seepage (on filling) | 61 ML |
| Annual evaporation | 2 to 7 mm/day averaging 1312 ML/year |
| G-MW Outfall Records | |
| Outfall Volume (2004/05 base year) | 401 ML |
| Outfall Volume (98/99 to 07/08 median calculation) | 464 ML |

However, due to the variability of these inflows, particularly in the 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.

*NVIRP mitigation water*

The baseline water year, 2004–05, was selected to quantify the savings as part of water savings projects. This baseline year is also used to guide the quantification of mitigation water required for wetlands, taking into account the average annual patterns of water availability.

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

Following the planned modernisation of irrigation infrastructure by NVIRP, the efficiency of the irrigation delivery system is expected to reduce the volumes of outfall water received by the wetland by 85%. Using the 2004–05 baseline year for Lake Elizabeth, this would reduce the volume to 60 ML/year. This residual outfall (15%) will continue to reduce the opportunity for the wetland to dry out completely.

A process for calculating mitigation water based on the best available information has been developed and applied to Lake Elizabeth. The total inflows to Lake Elizabeth from rainfall and catchment surface run-off (562 ML/year) and outfalls (400 ML/year) are 962 ML/year. The reduction in outfalls due to NVIRP will mean a reduction in inflows to Lake Elizabeth of, on average, 41%. The impacts of this reduction in inflows have been assessed according to the steps (NCCMA 2009a) and the results presented below.

*Step 1: Define hydrological characteristics of wetland*

The hydrological characteristics of Lake Elizabeth are summarised in Table 3.

*Step 2: Estimate potential benefits of outfall water*

The outfall volumes represent a significant proportion of the total annual inflows to Lake Elizabeth (41%). This outfall water would have provided the following general benefits:

- Top-up flows to maintain water levels within the lake
- Freshening flow (Fig. 7) to maintain salinity levels within the lake
- Counteracting evaporation and seepage (salinity and water level benefits)

As illustrated in Fig. 7, there is a strong correlation between lake levels and salinity in Lake Elizabeth. Consequently the inflow of 400 ML/year from outfalls would help to maintain water levels within the lake and thus would contribute to maintaining or reducing salinity levels.

*Step 3: Applying a set of criteria to determine whether all or part of the outfall water needs to be set aside to support the environmental values (NVIRP, 2009)*

As defined in the Water Change Management Framework (NVIRP 2009), mitigation water is the water required to ensure that there are no net negative impacts on high environmental values due to the NVIRP. Mitigation water is required for a wetland with high environmental values except where the following criteria apply.

*Criteria by which mitigation water may be assessed as zero*

Mitigation water may be assessed as zero where:

- there is no hydraulic connection (direct or indirect) between the irrigation system and the wetland or waterway.
- the water does not reach the wetland or waterway with environmental values (e.g. the outfall is distant from the site and water is lost through seepage and evaporation before reaching the area with environmental values).
- the 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).

Mitigation water may be assessed as zero where the wetland or waterway receives water from the irrigation system:

- 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).
- during a season that is detrimental to the environmental values.
- that is of poor quality (or results in water of poor quality entering a site e.g. seepage that results in saline groundwater intrusions to wetlands) and the removal of which would lead to an improvement in the environmental values.

Mitigation water may be assessed as zero where the environmental values:

- 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 natural flooding).

Mitigation water may be assessed as zero where the removal of the contribution from the irrigation system does not:

- increase the risk of reducing the environmental values (e.g. outfalls from a very small proportion of the water required to support the environmental values and their removal will not increase the level of risk).
- result in the Environmental Water Manager being required to deploy additional water to the wetland or waterway in the future in order to offset the removal of the irrigation system contribution.

Each of the above criteria was considered with respect to outfall water and Lake Elizabeth. This demonstrated that the outfall water provides significant benefits to Lake Elizabeth and does support the lake's environmental values as follows:

- Outfall water is received directly by Lake Elizabeth and is significant being over 30% (401 ML) of the wetland volume required to fill to Full Supply Level (FSL) (1264 ML) and accounting for over 40% of the lake's total inflows in any one year.
- It provides environmental value due to the outfall occurring at the time of high evaporation rates (over the summer period) and support the environmental values associated with the site, e.g. bird species, through the maintenance of *Ruppia* spp. for feeding. The removal of outfall 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.

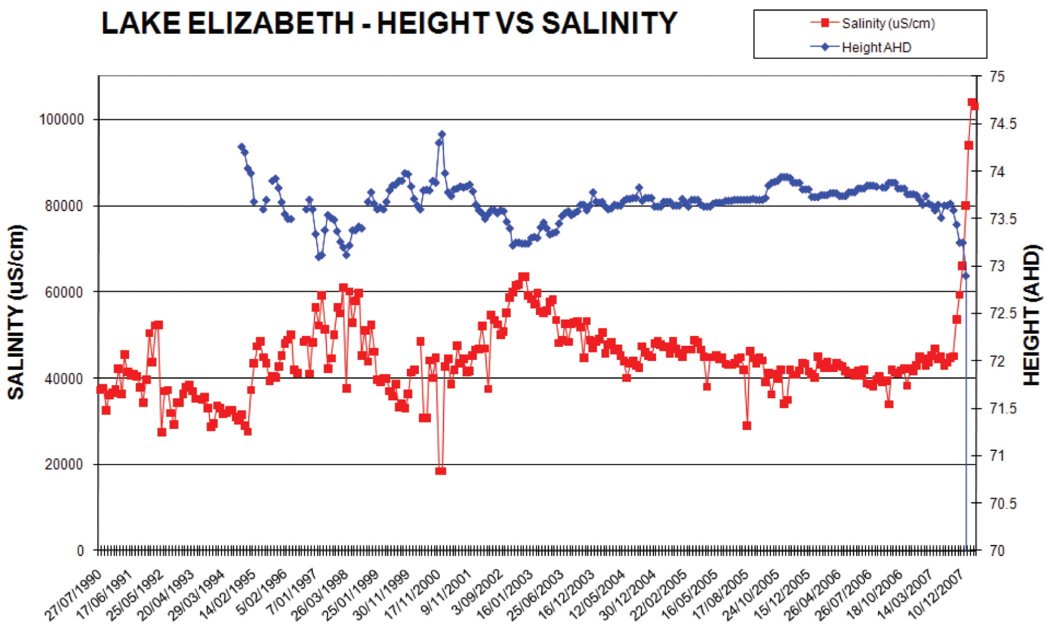


*Fig. 7.* Salinity and water levels at Lake Elizabeth (data sourced from DPI). Note: Extreme right side of graph shows the impact of the start of the lake drying phase.

- If outfall volumes were reduced, additional water would need to be supplied to top-up Lake Elizabeth in the years when it is filled if outfall volumes were reduced.
    - Outfall volumes provide freshening flows, maintaining salinity levels in the wetland. Figure 5 illustrates the interrelationship between water levels in the wetland and salinity). A reduction in outfall water will result in an 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* spp. to complete their life cycle.
    - Outfall volumes counteract seepage and evaporation. Additional water would need to be supplied to wet the bed prior to filling.

*Step 4: Calculating the volume of mitigation water with respect to the proposed wetland watering regime*

The Lake Elizabeth watering regime recommends filling to ≥1.5 m one in three years and ensuring an inundation period of at least 18 months (may require top-ups). Considering the significant contribution that outfall water provides to Lake Elizabeth, the proposed mitigation water is required in the years that Lake Elizabeth is scheduled to be filled or topped-up. Therefore, outfall volumes in these years are equal to the required mitigation water volume. When the wetland is in a dry phase, no mitigation water is required.

*Step 5: Calculating the net water savings (outfall water minus mitigation water)*

The determination and accounting of the resulting water savings will be in accordance with the methodology for outfall losses in the Water Savings Protocol-Technical Manual (DSE 2009c).

*Other water sources*

The calculated mitigation water will form only a small portion of the overall volumes required to support the required watering regime for Lake Elizabeth. Other sources of water will need to be secured in the years that the wetland is scheduled to be filled. The most likely sources for this water will be existing or future environmental entitlements. Existing Victorian Government water recovery commitments to The Living Murray and Snowy River initiatives together with other water recovery projects will provide approximately 900 GL of water to northern Victorian rivers and wetlands.

*Potential risks or adverse impacts*

Identification of the potential risks and limiting factors associated with the provision of the recommended watering regime for Lake Elizabeth is important. Mitigation measures have been recommended to reduce the risk to the wetland's environmental values that may arise from implementation of the NVIRP. For example, one possible undesired outcome from the NVIRP could be groundwater intrusion, which could result in the wetland bed being too saline for *Ruppia* spp. to establish.

*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. 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, recommendations have been made to increase the capacity of the wetland delivery infrastructure to reduce the fill time from 90 days to 30 days.

*Adaptive management framework*

Predicting a wetland's response to watering is difficult, as the interactions between water regimes, processes and biota are extremely complex. The relationships between the various components have been described in the Lake Elizabeth EWP by relating the ecological objectives to hydrological objectives and describing the overall watering regime required to achieve the environmental goal for the wetland.

It is important that an adaptive management approach is undertaken for the implementation of the EWP to ensure that it is responsive to changing conditions.

NVIRP and the G-MW will need to ensure that the mitigation water (volume, timing and quality) is provided to Lake Elizabeth according to the recommendations outlined in the EWP. Therefore, compliance monitoring will need to be undertaken in years that mitigation water is required. This should include monitoring of the volume, timing and quality of the water delivered to the wetland.

In addition, a critical component of the adaptive management of Lake Elizabeth is developing and implementing a monitoring program to determine the effectiveness of the recommended watering regime in achieving the ecological objectives.

It is beyond the scope of the EWP to recommend a detailed monitoring program for Lake Elizabeth. However, two types of monitoring for the wetland were recommended to assess the effectiveness of the proposed watering regime in achieving the objectives and to facilitate adaptive management. These are long-term condition monitoring and intervention monitoring.

Long-term condition monitoring will provide information on whether the watering regime (and other factors) is causing a change in, or maintaining, the overall condition of the wetland (trend over time). Some suggested components for long-term condition monitoring are provided in Appendix G of the EWP (NCCMA 2009a).

Intervention monitoring will assess the response of key environmental values to the provision of water (intervention) and the achievement of ecological objectives, e.g. waterbird feeding and/or breeding. Intervention monitoring may include monitoring of water quality, vegetation and key biota (e.g. waterbirds, fish and invertebrates). Monitoring the response to a watering event will be important to provide feedback on how the system is responding and whether any amendments need to be made to operational management, e.g. top-ups to maintain levels for waterbirds.

It is important to note that previous management reports have provided more detailed guidelines for the monitoring of Lake Elizabeth, particularly relating to salinity levels and groundwater interactions. These, and in particular Macumber (2002), SKM (2004) and Reid and O'Brien (2009) should be referred to before implementation of any monitoring program.

*Governance arrangements*

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 has been developed to describe the decision-making process required to coordinate implementation of the recommended watering regime for Lake Elizabeth.

The main components are:

- assessment of current conditions, e.g. status of wetland, climatic conditions.
- 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.

## CONCLUSIONS AND CHALLENGES

The EWPs have 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 EWPs. These are summarised below.

*Wetlands response to recommended water regime*

The medium to long-term impacts of the proposed wetland watering regimes are unknown (e.g. the impacts of the drying out of Lake Elizabeth for the first time in recorded European history).

The dry climate conditions are impacting on groundwater levels in the Torrumbarry Irrigation Area and there is an inherent difficulty in predicting how the local groundwater configuration will alter assuming continued dry conditions and lack of inflow.

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.

*Mitigation water*

The desired characteristics of mitigation water had not been defined at the time of development of the EWPs (i.e. reliability, carry-over provision etc.). Some of these are particularly important for ensuring that the required watering regime is a viable regime for the wetlands.

Calculation of environmental needs in volumetric terms has been undertaken for Lake Elizabeth but it is unknown how the application of the Long Term Cap Equivalent (LTCE) factor will impact on these estimates (DSE 2009c). It may affect the balance between the proportions of mitigation water and 'other water sources' (Section 5 of the EWP, NCCMA 2009a) that are needed to provide the watering regime.

The fact that the mitigation water forms only a portion of the watering regime for any wetland means that its 'value' will often be dependent on whether other environmental water is allocated to the wetland. Consideration needs to be given to whether the water will be carried over indefinitely until stored volumes equate to volumes required to supply the watering regime of the wetland, or whether alternative wetlands can be supplied (see next point).

It is unclear whether mitigation water will be 'tagged' to a particular wetland, i.e. can only be delivered to the site for which it was originally intended. There is a need to consider the landscape context in terms of gaining the best benefits from environmental water. However, prioritisation processes for environmental water allocations favour higher value wetlands and, with limited water, it is likely that some iconic wetlands (e.g. Gunbower Forest) will be continually prioritised at the expense of other less significant wetlands. This could result in a few isolated healthy wetlands in an otherwise barren landscape. Consequently, there does need to be flexibility in management of the mitigation water to ensure that it is providing the highest environmental benefits possible in any one year. Therefore, it is recommended that a 'hybrid' approach to mitigation water is adopted. This would mean that mitigation water is 'tagged' to the originally intended wetland but with the proviso that it could be 'loaned' to other wetlands within the region.

*Future roles and responsibilities*

The roles and responsibilities of key agencies in the operational management of mitigation water have not yet been clearly defined. A process for calculation and management of mitigation water has been described and is recommended. However, in light of possible significant possible policy changes in Victoria (i.e. Northern Region Sustainable Water Strategy

(DSE 2008)), roles and responsibilities will need to be reviewed.

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