Australian Government

Department of Sustainability, Environment, Water, Population and Communities

Lake Albacutya

Ramsar Wetland

Ecological Character Description

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All photos except those of birds and those otherwise specified are of the Lake Albacutya Ramsar site; all bird photos by Ian Morgan are of birds recorded at Lake Albacutya.

Introductory Notes

This Ecological Character Description (ECD Publication) has been prepared in accordance with the *National Framework and Guidance for Describing the Ecological Character of Australia's Ramsar Wetlands* (National Framework) (Department of the Environment, Water, Heritage and the Arts, 2008).

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) prohibits actions that are likely to have a significant impact on the ecological character of a Ramsar wetland unless the Commonwealth Environment Minister has approved the taking of the action, or some other provision in the EPBC Act allows the action to be taken. The information in this ECD Publication does not indicate any commitment to a particular course of action, policy position or decision. Further, it does not provide assessment of any particular action within the meaning of the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), nor replace the role of the Minister or his delegate in making an informed decision to approve an action.

The *Water Act 2007* requires that in preparing the [Murray-Darling] Basin Plan, the Murray Darling Basin Authority (MDBA) must take into account Ecological Character Descriptions of declared Ramsar wetlands prepared in accordance with the National Framework.

This ECD Publication is provided without prejudice to any final decision by the Administrative Authority for Ramsar in Australia on change in ecological character in accordance with the requirements of Article 3.2 of the Ramsar Convention.

Disclaimer

Note: There may be differences in the type of information contained in this ECD publication, to those of other Ramsar wetlands.

  

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GLOSSARY

Biogeographic region - A scientifically rigorous determination of regions as established using biological and physical parameters such as climate, soil type, vegetation cover, etc (DEWHA, 2008a).

Biological diversity - The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species (genetic diversity), between species (species diversity), of ecosystems (ecosystem diversity), and of ecological processes (DEWHA, 2008a).

Catchment - The total area draining into a river, reservoir, or other body of water (DEWHA, 2008a).

Change in ecological character - The human-induced adverse alteration of any ecosystem component, process, and/or ecosystem benefit/service (Ramsar Convention Secretariat, 2006).

Community - An assemblage of organisms characterised by a distinctive combination of species occupying a common environment and interacting with one another (DEWHA, 2008a).

Community composition - All the types of taxa present in a community (DEWHA, 2008a).

Community structure - All the types of taxa present in a community and their relative abundances (DEWHA, 2008a).

Conceptual model - Wetland conceptual models express ideas about components and processes deemed important for wetland ecosystems (DEWHA, 2008a).

Ecological character - The combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time (Ramsar Convention Secretariat, 2006).

Ecological community - Any naturally occurring group of species interacting with each other especially through food relationships, and which inhabit a common environment and is relatively independent of other groups. Ecological communities may be of varying sizes, and larger ones may contain smaller ones (DEWHA, 2008a).

Ecosystems - The complex of living communities (including human communities) and nonliving environment (ecosystem components) interacting (through ecological processes) as a functional unit, which provides, inter alia, a variety of benefits to people (ecosystem services) (DEWHA, 2008a).

Ecosystem components - Include the physical, chemical and biological parts of a wetland (from large scale to very small scale, e.g. habitat, species and genes) (DEWHA, 2008a).

Ecosystem processes - Dynamic forces within an ecosystem. They include all those processes that occur between organisms and within and between populations and communities, including interactions with the nonliving environment, that result in existing ecosystems and that bring about changes in ecosystems over time. They may be physical, chemical or biological (DEWHA, 2008a).

Ecosystem services - Benefits that people receive or obtain from an ecosystem. The types of ecosystem services include

- cultural services - the benefits people obtain through spiritual enrichment, recreation, education and aesthetics
- provisioning services - such as food, fuel and fresh water
- regulating services - the benefits obtained from the regulation of ecosystem processes such as climate regulation, water regulation and natural hazard regulation
- supporting services - the services necessary for the production of all other ecosystem services such as water cycling, nutrient cycling and habitat for biota. These services will generally have an indirect benefit to humans or a direct benefit in the long term.

Endorheic - Referring to a surface drainage not reaching the sea (http://fishbase.mnhn.fr/Glossary).

Limits of acceptable change - Variation that is considered acceptable in a particular component or process of the ecological character of the wetland without indicating change in ecological character that may lead to a reduction or loss of the criteria for which the site was Ramsar listed (DEWHA, 2008a).

Monitoring - Collection of specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing management (DEWHA, 2008a).

Population - A group of individuals of one species in an area, though the size and nature of the area is defined, often arbitrarily, for the purposes of study being undertaken (Begon et al., 1990)

Ramsar criteria - Criteria for Identifying Wetlands of International Importance, used by Contracting Parties and advisory bodies to identify wetlands that qualify for the Ramsar List on the basis of representativeness or uniqueness or of biodiversity values (Ramsar Convention Secretariat, 2006).

Ramsar sites - Wetlands designated by the Contracting Parties for inclusion in the List of Wetlands of International Importance because they meet one or more of the Ramsar Criteria (Ramsar Convention Secretariat, 2006).

Significant impact - A ‘significant impact’ is an impact which is important, notable, or of consequence, having regard to its context or intensity. Whether or not an action is likely to have a significant impact depends upon the sensitivity, value, and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts (Department of Environment & Heritage, 2006).

Subterminal lakes - Bodies of water that are located upstream of terminal lakes in closed or endorheic watersheds where the topography prevents their drainage to the oceans. Subterminal lakes have distinct shorelines and when full, overflow into downstream subterminal or terminal lakes (Timms, 2001). Subterminal lakes remain substantially fresh due to occasional flushing of salts (Timms, 2001).

Terminal lakes - Bodies of water that are located at the end of closed or endorheic watersheds where the topography prevents their drainage to the oceans. True terminal lakes have indefinite shorelines, they do not overflow and outflow pathways are chiefly evaporation and seepage (Timms, 2001). Terminal lakes are saline as salts become trapped (Timms, 2001).

Wetlands - Areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres (Ramsar Convention Secretariat, 2006).

Abbreviations

CAMBA	China-Australia Migratory Bird Agreement
CEPA	Communication, Education, Participation and Awareness
CMA	Catchment Management Authority (in 2011, likely to become Natural Resource Catchment Authority)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEWHA	Department of Environment, Water, Heritage and the Arts (Commonwealth) (Later changed to SEWPaC)
DSE	Department of Sustainability and Environment (Victoria)
EC	Electrical Conductivity
ECD	Ecological Character Description
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)*
EVC	Ecological Vegetation Classes
FFG Act	*Flora and Fauna Guarantee Act 1988 (Victoria)*
GL	Gigalitres
JAMBA	Japan-Australia Migratory Bird Agreement
LAC	Limit of Acceptable Change
MDBC	Murray-Darling Basin Commission
ML	Megalitres
PPM	Parts Per Million
ROKAMBA	Republic of Korea-Australia Migratory Bird Agreement
SEWPaC	Department of Sustainability, Environment, Water, Population and Communities
WMSDWSS	Wimmera Mallee Stock and Domestic Water Supply System

EXECUTIVE SUMMARY

Introduction

Site description

Lake Albacutya is located in semi-arid Victoria, approximately 400 km northwest of Melbourne. The site is managed by Parks Victoria as part of the Lake Albacutya Park. It is a large subterminal lake of the internally draining Wimmera River. The 5659 ha lake fills intermittently when prolonged high rainfall in the upper catchment creates large flows in the Wimmera River, allowing water to reach Lake Albacutya. With a full capacity of 290 GL, Lake Albacutya retains water for several years when full, emptying slowly through evaporation and seepage if no further inflows are received. Lake Albacutya is characterised by alternating wet and dry phases and is capable of supporting climax communities in both states. When dry, the lake supports grasslands and terrestrial fauna. When the lake holds water, an aquatic community develops which may support breeding waterbird populations. There is an extensive Eucalypt woodland surrounding the lake, dominated by River Red Gum which are maintained by the lake's unique hydrological regime and provide habitat for waterbirds and the nationally vulnerable Regent Parrot which occurs at the site.

Ramsar criteria

Lake Albacutya was designated as a Wetland of International Importance under the Ramsar Convention in 1982. The site meets the following criteria for listing as a Wetland of International Significance:

Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

> Lake Albacutya is a representative near-natural example of a 'seasonal intermittent freshwater lake over 8 ha' within the Murray-Darling Drainage Division. It is also representative of a subterminal lake which fills from a north-flowing endorheic river, rare within the Murray-Darling Drainage Division.

Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.

> Lake Albacutya supports breeding populations of the nationally vulnerable Regent Parrot (*Polytelis anthopeplus monarchoides*). This subspecies has a restricted distribution confined to arid south-eastern Australia, and the lower Wimmera River including Lake Albacutya is one of three key population and breeding areas. Up to 3 % of the entire population of this subspecies has been recorded at Lake Albacutya and breeding has been known to occur there several times. The Eucalypt woodland at Lake Albacutya provides ideal breeding habitat for the species, especially when the lake holds water.

Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.

When full the lake supports regionally, nationally and internationally significant waterbirds. It is part of one of the key population areas for the nationally vulnerable Regent Parrot. Lake Albacutya also supports a genetically unique population of River Red Gum which has the highest known drought and salinity tolerance of all varieties tested in Australia.

Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.

Lake Albacutya supports very high numbers of waterbirds during its intermittent wet phases. When holding water, Lake Albacutya has been known to support in excess of 20 000 waterbirds in 1993 and at least 10 000 to 100 000 waterbirds in 1982-83. Records prior to this time are deficient but expert opinion suggests that the lake would again support in excess of 20 000 when it receives sufficient flows.

Criterion 6: A wetland should be considered internationally important if it regularly supports 1 percent of the individuals in a population of one species or subspecies of waterbird.

Lake Albacutya has supported in excess of 1 % of at least three waterbird species. Between 1981-1983 Lake Albacutya supported up to 5 % of the national population of Freckled Duck. In 1983 over 10 000 banded stilt were recorded which represents at least 4.5 % of the Australian population. In 1993 1000 Australasian Shoveler occurred at the lake meeting the 1 % threshold.

Purpose of the Ecological Character Description

In order to effectively manage any wetland ecosystem and maintain the key wetland values, it is essential to first understand the ecological character of the site. This Ecological Character Description aims to:

- describe the ecological character of the Lake Albacutya Ramsar site including critical components, processes and benefits and services;
- develop a conceptual model to describe the ecosystem function of the site and relationships between components, processes and benefits;
- quantify the limits of acceptable change for the critical components, processes and services of the wetland; and
- identify the current and potential threats to the ecological character of the site.

The ecological character of Lake Albacutya

The key wetland values of Lake Albacutya are supported by its ecological character which is comprised of the critical components, processes and benefits and services.

Components and processes

Ecosystem components are the tangible physical, biological and chemical entities that comprise a wetland, such as communities and species, while ecosystem processes are the dynamic forces which contribute to the functioning of the wetland, such as interactions among organisms and their environment. Table E1 summarises the critical components and processes of Lake Albacutya.

Table E1 Summary of the critical components and processes of Lake Albacutya

Component	Processes	Description summary
Morphology	Geomorphology	Subterminal lake of up to 5732 ha, full capacity 290 GL, flood capacity 320 GL, up to an average of 6 m deep. Underlying clays of the lakebed enable the lake to hold water for long periods of time. One of only 3 major subterminal lakes in the Murray-Darling Basin Drainage Division which fill from northern flowing rivers.
Surface Water	Hydrology	Receives flows from the Wimmera River during sustained periods of high upper catchment rainfall. Extended dry periods occur between inflow events. When full, retains water for several years emptying slowly by evaporation and seepage. No comprehensive historical data is available on hydrology at the lake but limited records, anecdotal evidence and modelling suggest a decrease in the frequency and extent of flooding of Lake Albacutya to the time of listing. There is a long history of high levels of regulation of the Wimmera River for rural and urban water supply to which the altered hydrology of Lake Albacutya has been attributed. Models analysed prior to installation of the Wimmera-Mallee Pipeline predicted the average overflow frequency to be once in 49 years, reduced from natural conditions (once in 4 years) due to river regulation. These results showed that the lake was expected to be shallow or empty about 80 % of the time compared with only about 20 % of the time naturally. Hydrology driven ecology includes waterbird arrival and breeding, Eucalypt woodland recruitment and survival and aquatic ecosystem development.
Flora - Eucalypt woodland	Recruitment Regeneration	Extensive Eucalypt woodland fringes the lake, dominated by River Red Gum (*Eucalyptus camaldulensis*). Provides habitat, particularly nesting hollows, for waterbirds and nationally vulnerable Regent Parrot. Lake Albacutya River Red Gum population is genetically unique having very high drought and salinity tolerance. The Eucalypt woodland at Lake Albacutya is suffering some degree of dieback probably due to the altered hydrological regime.
Fauna - Waterbirds - Threatened species	Migration Reproduction	High waterbird abundance of many waterbird species during wet phases. Capable of supporting more than 20 000 waterbirds in total and ≥1 % of populations of at least 3 waterbird species. Breeding recorded for 12 waterbird species. Key population area for nationally vulnerable Regent Parrot with at least 50 individuals (at least 2 % of the national population) and several breeding events recorded at the site.

Besides these critical components and processes, which are the primary determinants of ecological character and contribute directly to the Ramsar criteria, there are several essential elements which support the critical components and processes thereby contributing to the ecological character. These include:

- Climate: low rainfall and high evaporation at the site coupled with variable rainfall in the upper catchment contribute to the lake's intermittent hydrological cycle.

- Landforms: the land surrounding Lake Albacutya is mostly flat, however crescent shaped lunettes of wind blown sediment have formed on the eastern shoreline, contributing to the evolving geomorphology of the site.

- Water quality: there is limited data on the surface water of Lake Albacutya, indicating that it is relatively clear and fresh after long lake-full events but may be more turbid and brackish during small inflow events and in the final recession stage.

- Groundwater: groundwater in the Parilla Sands Aquifer was found to be approximately 9 m beneath the surface at Lake Albacutya, with salinity of around 20 000 µS/cm.

- Flora: an aquatic plant community develops in the lake when it holds water (including species such as water milfoils, watermat and algaes), which provides food and habitat for aquatic fauna and some waterbirds. During dry phases the lakebed is colonised by terrestrial grasses and shrubs which provide habitat and nutrients for the aquatic community when submerged.

- Aquatic fauna: when the lake holds water an aquatic community forms including a variety of aquatic invertebrates, and eventually fish. These provide food for many waterbirds.

- Terrestrial fauna: many terrestrial species of the surrounding Mallee and woodland communities utilise Lake Albacutya, especially birds and some mammals, reptiles and invertebrates.

Benefits and services

Benefits and services are defined as the benefits that people receive from ecosystems, including items such as food, water, recreational and economic opportunities as well as services such as supporting biodiversity.

Table E2 summarises the critical benefits and services provided by the Lake Albacutya Ramsar site that contribute to its international importance.

Table E2 Summary of the critical benefits and services of Lake Albacutya

Benefit/service	Description
Near-natural wetland-representativeness	Lake Albacutya is a representative example of a near-natural intermittent subterminal lake within the Murray Darling Drainage Division. As a gazetted Park under the *Victorian National Parks Act 1975*, its key land-based values are protected.
Waterbird habitat	Lake Albacutya is capable of supporting more than 20 000 waterbirds particularly ducks, Banded Stilt and Eurasian Coot when full.
Waterbird habitat	Capable of supporting more than 5 % of the south-eastern Australian population of Freckled Duck, more than 4.5 % of the Banded Stilt population and 1 % of the Australasian shoveler population.
Supports threatened species	Supports breeding populations of nationally vulnerable Regent Parrot. At least 2 % of the national population has been recorded at the site.

In addition to these critical benefits and services, there are a variety of other benefits and services which the lake provides. Although these supplementary benefits are not critical to the ecological character of the site they are significant and are outlined below.

- Food: fish, crustaceans and waterbirds provide a potential food source. In the past this has also led to economic benefits through commercial fishing.
- Agricultural grazing: sheep grazing licences occupy about 2000 ha of the lakebed which provides good fodder during dry phases.
- Genetic material: The Lake Albacutya provenance of River Red Gum is internationally renowned for its salt and drought tolerance and is widely used in forestry.
- Flood mitigation: As the second largest sub-terminal lake of the land locked Wimmera River system, Lake Albacutya plays a minor role in flood mitigation, by receiving and storing excess run-off.
- Tourism/recreation: Lake Albacutya provides excellent recreational opportunities when the lake is full, including camping, nature appreciation, bushwalking, fishing, hunting, boating and waterskiing. By attracting visitors, Lake Albacutya contributes to the local economy.
- Indigenous values: the Wotjobaluk people of the Wimmera River area value the lake for practical and spiritual reasons and this is recognised in a native title determination over the area. There are 17 registered heritage sites within the Ramsar site.
- Scientific/educational: Lake Albacutya provides an opportunity for scientific research as it is relatively undisturbed and intact. The site also provides opportunities for visitor education and awareness raising within the local and wider community.
- Supporting biodiversity: over 500 aquatic and terrestrial native plant and animal species have been recorded at the site and it provides habitat for numerous threatened species at a state and national level.

Changes since listing

Lake Albacutya was first listed under the Ramsar convention in December 1982. Unfortunately there is limited data available on the ecological character of the site at that time, with most available data being recorded since then. It is difficult, therefore to quantify any changes in the ecological character of the site since the time of listing, however there are potential changes in some elements, particularly related to hydrology, that may have implications for the ecological character of Lake Albacutya.

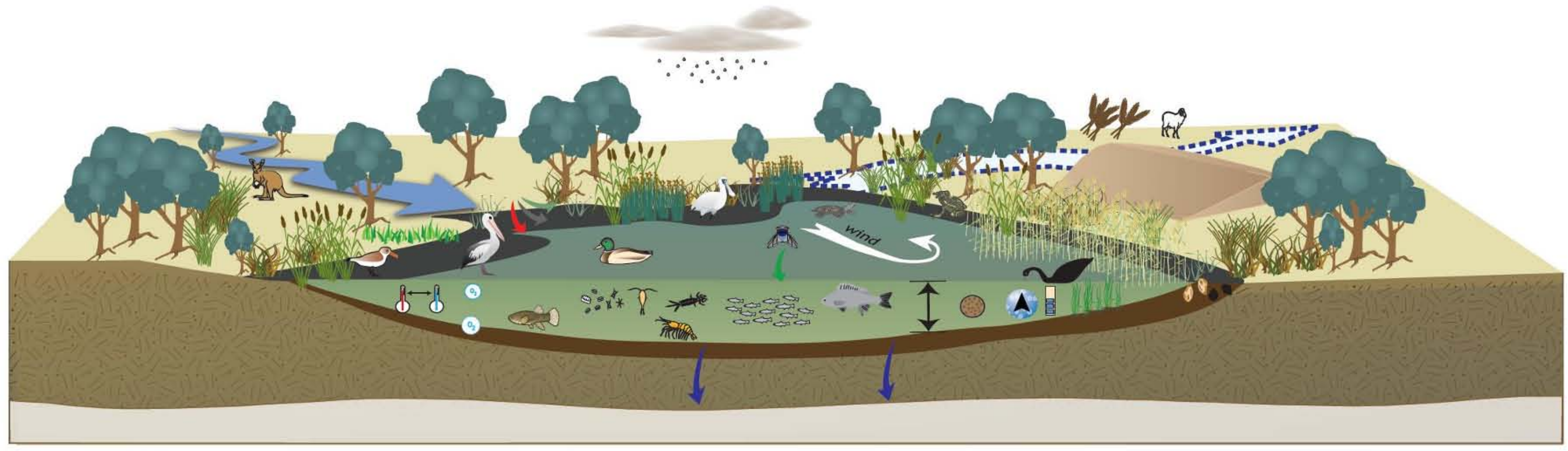
In 1982, at the time of listing, the hydrology of the lake had been altered from its natural condition due to river regulation for water supply. This had reduced the frequency, duration and extent of flooding of Lake Albacutya. At the time of listing Lake Albacutya held water from the previous large flood event of 1974 as a result of above average rainfall in the late 1970s. Since the mid 1990s, however, rainfall in the Wimmera Catchment has been well below the long term average. This has been attributed at least in part to anthropogenic climate change, and if so, this trend is likely to continue, exacerbating the altered hydrology caused by river regulation. Water diversion has decreased since the time of listing (though this has partly been a result of low river flows caused by low catchment rainfall). Since the time of listing work commenced on a pipeline to replace inefficient open channels of the water supply system. This has resulted in a proportion of the water savings being allocated to environmental flows for the Wimmera River, but benefits to Lake Albacutya are dependent on catchment rainfall and the amount and timing of environmental releases.

Conceptual model

The conceptual model aims to depict the key elements and drivers of the ecological character of Lake Albacutya including components, processes, benefits/services and threats. It assists in understanding how these interact to contribute to ecosystem functioning and determine the ecological character of the site.

The critical components and processes in Table E1, along with other essential elements, and the links and interactions between them, are depicted in several key conceptual models in Figures E1 and E2.

Lake Albacutya



Components/Features

Soil mainly made up of aeloian and fluvial sands and clays to considerable depth.

Substrates: inner lakebed is usually clay wih sandier substrate at outer lakebed.

At least two lunette dunes present mainly at east and north east as a result of deflational processes.

Water depth may be shallow to deep (up to 8 m) depending on the flood characteristics of the inundation phase.

Water Quality

Water temperature is temporally and spatially variable, and more responsive to air temperature in shallow areas.

Dissolved oxygen concentrations are temporally and spatially variable. Decomposition of organic matter during flooding may lead to low dissolved oxygen.

pH is generally alkaline but may vary depending on inundation phase and production.

Water is fresh but may become partly saline when drying. Small inflows may also be saline.

Turbidity levels generally low, depending on depth, wave action and wind mixing. European Carp may contribute to future turbidity.

Fauna

Aquatic invertebrates: A diverse and abundant invertebrate community comprised of micro and macroinvertebrates occurs. Early invertebrate colonisers are dessication-resistant species that emerge from egg banks and resting stages. Other freshwater invertebrates colonise via aerial (wind and bird) and aquatic dispersal. Community composition and abundance varies depending on factors including inundation phase, water quality and food and habitat availability. Invertebrates represent an important link in the food chain as they convert primary production into animal biomass that represents a food resource for fish and birds with different species of life stages providing food for different predator species.

Fish colonise the lake from upstream and their abundance depends on factors including inundation phase, water quality and food and habitat availability. Few endemic species occur and introduced native and pest species are common.

Frogs and turtles are likely to disperse from local farm dams and also from upstream. As the lake dries, the development of lake bed vegetation provides an important habitat and food resource for terrestrial animals such as kangaroos, emus and lizards. Sheep graze about 54% of the dry lake bed.

Waterbirds

A variety of waterbirds including herbivores, piscivores, waders, shorebirds, ducks and grebes, may be absent or present in low to high abundances depending on food and habitat availability. The major determinants of habitat are depth and vegetation. In general feeding habitat is shallow while deep water is required for successful breeding. Eucalypt woodland including River Red Gum, and other fringing vegetation provide important breeding sites.

Herbivores

Shorebirds

Ducks and grebes

Large wading birds

Piscivores

Processes

Inputs from the single inflowing creek (Outlet Creek) and minor local runoff are the most important inputs of water , sediments , nutrients , and allochthonous (externally sourced) material . Lakebed dry-phase community adds nutrients and organic matter.

Biota disperse into Lake Albacutya mainly via Outlet Creek and aerial dispersal.

Seed and egg banks within the lake sustain communities through internal regeneration and recruitment.

Groundwater recharge.

Rare and episodic overflow discharge via Outlet Creek.

Episodic lakes undergo major changes with inundation phase that lead to changes in the major source of primary production with macrophytes, attached algae and phytoplankton making significant contributions at different times. Lake Albacutya fills infrequently and the dry phase may last for periods of up to 30 years. The flood-mediated wet phase may last from months to many years. Winter rainfall, while low, can still benefit some water-dependent species.

Flora

Fringing vegetation: Lake margin is fringed by Eucalypt woodland (River Red Gum, Blackbox, Lignum) which persists through the wet-dry cycle. Understory varies with inundation phase, and is made up of shrubs, herbs, and grasses. River Red Gum is affected by dieback, but recruitment is evident.

Emergent macrophytes: Little information is available. Presence , density and composition of emergent macrophytes varies spatially and temporally and is dependent on factors such as frequency of inundation and phase.

Lakebed herbland: As the lake dries a diverse plant community develops comprised of shrubs, grasses and herbs. The community composition is influenced by sediment type and soil moisture. This vegetation represents an important food resource for terrestrial animals and also influences productivity, habitat and water quality when the lake is inundated.

Submerged and floating macrophytes: Little information is available. Submerged macrophytes may be present depending on a variety of factors including presence and composition of viable seed banks, water quality, water depth, and light penetration.

Algae: Algae production is likely to include a diverse range of macro- and microscopic species that occupy all habitats. Macroscopic algae include filamentous algae and species which are attached to the sediments. Microscopic algae includes phytoplankton which predominates in open water and periphyton that grow attached to sediment, plants and other surfaces. Algal production may be the dominant form of primary production depending on variables such as water depth, nutrient loads and the degree of light penetration.

Cereal and other crops in local catchment

Key Threats

River regulation, climate change (reduced rainfall), decline in Eucalypt woodland condition, introduced species and, potentially, recreational activities.

Aquatic Ecology

Lake Albacutya fills episodically to an average depth of around 6m before it overflows, and it can retain water for several years or more, with annual evaporative losses of up to 1.3m. The lake's aquatic ecology is driven by the temporal phase and physical variables such as nutrient load, turbidity, and depth. The first floodwaters carry high organic loads and trigger biochemical interactions in the wet substrate, causing a nutrient pulse which boosts microbial activity after flooding and provides the basis for the lake's food web. On first flooding, inundated terrestrial plants of the inner lakebed also start decomposing and add to the nutrient levels.

Primary production and lake ecology are driven largely by water depth. The shallow littoral zone around the lake edge is characterised by warmer water and coarser sediments. Shrubs and eucalypt woodland plants which colonise the outer lakebed in the dry phase, die after inundation and provide substrate for algae and shelter for early macroinvertebrate colonisers. Species diversity in this zone may be high as emergent and submerged macrophytes also increase habitat complexity for invertebrates and juvenile and small-bodied species of fish which find cover from larger predators. Due to its shallow depth, the littoral zone is also part of the photic zone, the area of light penetration. Photic zone photosynthesis provides most of the organic matter for the lake's aquatic fauna.

In the interior of the lake away from the littoral zone, the photic zone is called the limnetic zone. Here where the water is too deep for rooted macrophytes, primary production is dominated by phytoplankton, and larger fish find protection from waterbird predation. With a maximum depth of around 8m and generally low turbidity, Lake Albacutya has no real profundal or aphotic zone (the zone of little or no light penetration).

Water clarity and nutrient loads are also major determinants of the dominant form of primary production - high levels of turbidity and dissolved nutrients favour phytoplankton dominance. There are reports of high water clarity when Lake Albacutya is full, however when shallow, wind may disturb sediment and increase turbidity. During the last drying stage the lake may become brackish, and eutrophy is also likely.

Figure E1 Ecological character model for Lake Albacutya

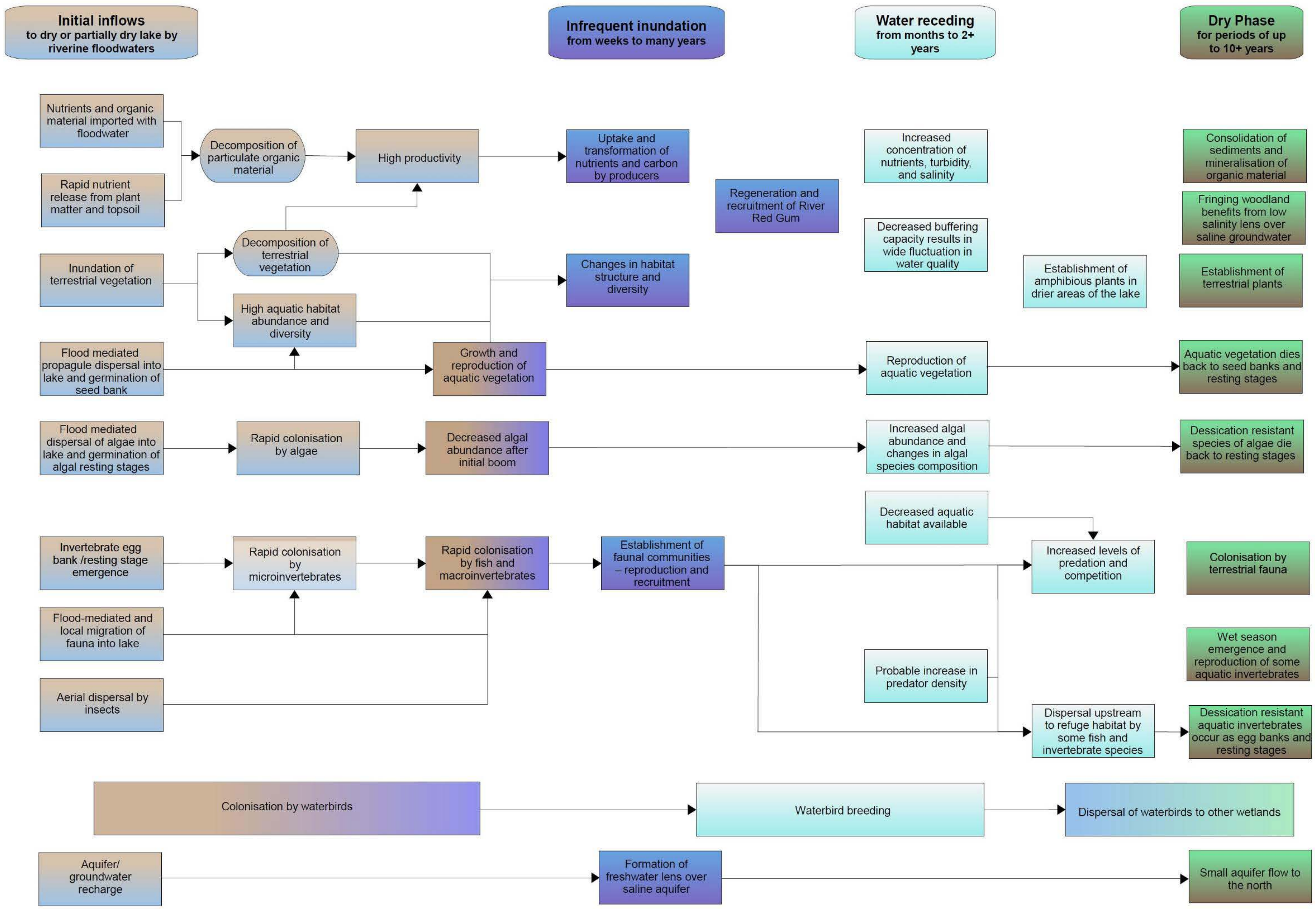


Figure E2 Inundation model for Lake Albacutya (adapted from Price and Gawne, 2000)

Limits of acceptable change

Limits of acceptable change are defined as the variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland. Change in ecological character occurs when the critical parameters of the wetland ecosystem fall outside the range that was normal at the time the site was listed. Setting limits of acceptable change assist in determining if the ecological character is likely to change or has changed and the reasons for this change or likely change.

Exceeding or not meeting a Limit of Acceptable Change does not necessarily indicate that there has been a change in ecological character. While the best available information has been used to prepare this Ecological Character Description and define Limits of Acceptable Change for the site, in many cases only limited information and data is available for these purposes. The Limits of Acceptable Change in Table E3 may not accurately represent the variability of the critical components, processes services and benefits under the management regime and conditions that prevailed in 1982 when site was listed as a Ramsar wetland.

Lake Albacutya experiences an extremely high degree of variability, largely due to a naturally episodic hydrological regime which has been altered by regulation and extraction of water for agricultural purposes. There are limited data to describe the normal variation in the attributes of Lake Albacutya at the time of listing. The series of anthropogenic changes over the past 150 years further complicate the establishment of limits of acceptable change variation.

Limits of acceptable change have been set for those components and processes, and benefits and services, identified as critical in maintaining the ecological character relevant to the Ramsar listing. However, confidence levels on the limits set are generally low due to the reasons discussed. Limits of acceptable change are discussed below and are summarised in Table E3.

Morphology

Morphological attributes rarely change significantly as a result of natural processes in the short to medium term. Human intervention, however, can result in significant change within years or decades. The natural elements of the morphology of Lake Albacutya include the size and shape of the lakebed and margins, its structure and composition, its ability to hold water and inflow and outflow points. Morphology at Lake Albacutya has not apparently changed appreciably over the short or long term, however future potential activities such as filling, excavating, channel construction, bed lining, human-induced erosion, and bank works could pose a threat to lake morphology.

In order to preserve the ecological character, the following limit of acceptable change in relation to morphology is established:

- the significant morphological features of Lake Albacutya (lake banks, lakebed, single natural inlet creek, single natural discharge creek, depth from outlet sill to lakebed) must be retained without significant change as a result of human interference.

Hydrology

Lake Albacutya's unique hydrology relies on extended above average upper catchment rainfall which causes periodic flooding of the lake which then dries over several years due to high evaporation. Between floods the lake experiences extended dry periods. There is great variation in annual rainfall in the Wimmera River catchment making the hydrology of Lake Albacutya episodic and unpredictable. Extensive water diversions of the Wimmera River over the past two centuries had reduced flows into Lake Albacutya at the time of listing.

The hydrological regime underpins the ecological character of Lake Albacutya, with floods of both short and long duration playing a role in supporting flora and fauna. Recent records show that even small inflow events in which the lake does not overflow are able to support large numbers of waterbirds. Modelling suggests that under natural conditions overflow periods of 6 months occur about every 8 years and overflow periods of 24 months occur about every 10 years, however this had been modified at the time of listing by reduced river flows.

The following limits of acceptable change for hydrology have been set, however a lack of knowledge constrains their confidence limit.

- A 24 months duration lake-full overflow event should occur every 20 years on average.
- A shallow flood of at least 9 months duration should occur every 8 years on average.

Waterbirds

Waterbirds can appear in large numbers when the lake holds water. Little long term waterbird data exists, however records from recent inflow events in 1993 and around 1974 to 1983 indicate that waterbirds including predatory guilds have arrived in large numbers.

Up to 60 species of waterbird are known to use the lake when it holds water, and up to 12 species breed at the site. Three species have met the 1 % population level relevant to the Ramsar criteria - Freckled Duck, Banded Stilt, and Australasian Shoveler. Over 40 000 waterbirds in total were recorded at the lake on one occasion in 1993 and the number of Banded Stilt alone in 1983 was classed at between 10 000 and 100 000, suggesting that over 20 000 waterbirds may also have occurred at that time.

Based on the few existing records, the limits of acceptable change in relation to waterbirds, are:

- supports 20 000 or more waterbirds on one in three occasions when the lake holds water for a period of at least 9 months; and
- supports 1 % of the individuals in a population of at least one species or subspecies of waterbird on one in three occasions when the lake holds water for a period of at least nine months.

Eucalypt woodland

An extensive Eucalypt woodland community fringes the lakebed, occupying 1271 ha of the Ramsar site, and is dominated by River Red Gum. This Eucalypt woodland community provides important roosting and nesting habitat for waterbirds, and the nationally threatened Regent Parrot. The Lake Albacutya River Red Gum population is genetically unique, showing particularly high levels of drought and salt tolerance.

The trees are reliant on regular surface flooding for persistence and regeneration. When assessed in 1993 River Red Gums at Lake Albacutya were suffering from dieback due to reduced flooding over the last century. Regular flooding is also required for recruitment of River Red Gum to replace dead and dying trees and maintain an age structure.

Based on the best information available, and considering the practical limitations of monitoring and analysis, the limits of acceptable change are identified as:

- at least one successful River Red Gum recruitment event occurs every 20 years on average. This matches the hydrology LAC for a major lake-full overflow event;
- at least 75 % of the 1993 extent of River Red Gum is maintained; and
- at least 75 % of the extent of the Eucalypt woodland community is maintained, based on a benchmark established as soon as possible after 1982. This LAC requires the extent to be determined at or as soon as possible after 1982.

Threatened fauna

Regent Parrot is nationally vulnerable and a maximum count of 50 individuals has been recorded at Lake Albacutya or at least 2 % of the total national population size of up to 2500 individuals. This species is also known to breed at the site, with breeding records from 1929, 1992, and 1993. Regent Parrot requires tree hollows for breeding habitat especially those in large River Red Gum and Black Box close to water. Successful nesting also depends on close proximity of large tracts of Mallee vegetation. These habitat requirements are well provided for at Lake Albacutya.

Accurate annual records for Regent Parrot are not available, however based on the available information the following LAC is established.

- A local Regent Parrot population is maintained at Lake Albacutya.
- At least 2 % of the national Regent Parrot population is recorded at Lake Albacutya in one year in ten, at a minimum.

Wetland representativeness

Lake Albacutya represents a near-natural example of the Ramsar wetland category ‘seasonal intermittent freshwater lakes over 8 ha including floodplain lakes’. Lake Albacutya is also a relatively intact representative example of an intermittent subterminal lake of which there are only two greater than 5000 ha within the north-flowing endorheic Wimmera-Avon sub basin.

Lake Albacutya Ramsar site makes up the major portion of the Lake Albacutya Park, which helps to conserve the natural values of the site, as does the proximity of the adjoining Wyperfeld National Park.

Based on the available information the following limit of acceptable change is established.

- Lake Albacutya and the surrounding environment are maintained in a near-natural state.

Waterbird habitat

Of the 18 500 wetlands in the Murray-Darling Basin only 0.53 % were found to support more than 10 000 waterbirds (Scott, 1997). Lake Albacutya also provides habitat for greater than 1 % of populations of at least 3 waterbird species, and for at least 13 migratory species listed on the CAMBA, JAMBA, or ROKAMBA lists.

Waterbird habitat is provided during the flooded phase of the wet-dry hydrological cycle which also supports Eucalypt woodland which some waterbirds require for roosting and nesting. The food to support large numbers of waterbirds feeding and breeding is a result of aquatic fauna and flora communities which develop during flooding and depend on nutrient cycling within and between phases.

Data that describes and quantifies waterbird habitat is extremely limited. Limited information on the extent of River Red Gum in 1993 is available, however no information exists on the components of aquatic waterbird habitat such as mudflats, emergent vegetation, and submerged macrophytes, the specific nesting materials used at Lake Albacutya, and the specific local foods of waders, paddlers and non-piscivorous divers.

Based on the available information the following limits of acceptable change are established.

- Lake Albacutya terrestrial waterbird habitat LAC is as for Eucalypt woodland above.
- Lake Albacutya aquatic waterbird habitat is maintained in a near-natural state.

Supporting threatened species

Lake Albacutya and its surrounding area provide important habitat for the nationally vulnerable Regent Parrot. At least 50 individuals (or at least 2 % of a maximum national population of 2500) have been known to occupy the site and the species has been recorded breeding at the site. The Eucalypt woodland surrounding the lake provides suitable breeding sites in tree hollows, particularly River Red Gum. The close proximity of the Eucalypt woodland at Lake Albacutya to the surrounding Mallee landscape, and water (when the lake is full) adds to the value of the Regent Parrot habitat at Lake Albacutya

Based on the available information the limit of acceptable change for Eucalypt woodland above will also ensure the continuation of an acceptable level of support for threatened species.

Table E3 Summary of the limits of acceptable change for Lake Albacutya

Critical parameter	Limits of acceptable change		Confidence level
	Short term (0 – 10 years)	Medium term (25 to 50 years)	
Morphology	Attribute retained without significant change as a result of human interference.	As for short term.	High
Hydrology	Not applicable	The average return period for shallow floods of at least nine months duration will be no more than eight years. The average return period for lake-full overflow events of 24 months duration will be no more than 20 years.	Low Medium
Eucalypt woodland	River red gum may respond slowly to changes in hydrology; therefore changes in condition are difficult to assess in the short term.	At least one successful River Red Gum recruitment event occurs every 20 years on average. At least 75 % of the 1993 extent of River Red Gum is maintained. At least 75 % of the extent of the Eucalypt woodland community is maintained, based on a benchmark established as soon as possible after 1982	Low Low Low
Fauna - waterbirds	Short term goals not applicable, as waterbirds are present only when the lake holds water.	Supports 20,000 or more waterbirds on one in three occasions when the lake holds water for a period of at least nine months. Supports 1 % of the individuals in a population of one species or subspecies of waterbird on one in three occasions when the lake holds water for a period of at least nine months.	Low Low
Threatened fauna	A local Regent Parrot population is maintained at Lake Albacutya. At least 2 % of the national Regent Parrot population is recorded at Lake Albacutya in one year in ten, at a minimum	As for short term.	High Low
Wetland representativeness	Lake Albacutya and the surrounding environment are maintained in a near-natural state.	As for short term	High
Waterbird habitat	Not applicable - as for Eucalypt woodland above Lake Albacutya aquatic waterbird habitat is maintained in a near-natural state.	Lake Albacutya terrestrial waterbird habitat LAC is as for Eucalypt woodland above As for short term	High High
Supports threatened species	Not applicable, as for Eucalypt woodland above	As for Eucalypt woodland above.	High

Threats

Identifying actual and likely threats to the ecological character of the site helps guide future management planning and action. Those threats that pose a significant risk to the critical components, processes, benefits and services of Lake Albacutya are summarised below in Table E4 and the most significant threats are discussed further in the subsequent text.

Table E4 Summary of key threats to the ecological character of Lake Albacutya

Threat	Potential impacts	Significance of threat	Likelihood of impacts	Timing of impacts
River regulation	Reduced frequency, duration and extent of flooding. Interference with migration, reproduction, regeneration and recruitment processes. Reduced habitat availability and quality for waterbirds. Declining Eucalypt woodland health.	High	High	Short term
Climate change – reduced rainfall	Reduced frequency, duration and extent of flooding. Interference with migration, reproduction, regeneration and recruitment processes. Reduced habitat availability and quality for waterbirds. Declining Eucalypt woodland health.	High	Medium	Short to long term
Decline in Eucalypt woodland health	Reduced habitat for waterbirds and Regent Parrot	High to medium	High to medium	Short to medium term
Recreation	Recreational hunting and human activity may disturb waterbirds and Regent Parrot breeding.	Low	Unknown	Dependent upon hydrology
Pests (carp, birds, bees, rabbits, foxes, cats, dogs)	European Carp reduce habitat quality for fish, aquatic flora and fauna and waterbirds. Pest birds compete with waterbirds and Regent Parrot for food and habitat. Bees compete with waterbirds and Regent Parrot for tree hollows. Rabbits inhibit Eucalypt woodland recruitment. Foxes, cats and dogs may prey on waterbirds and Regent Parrot.	High for carp, medium for other pests	Unknown	Unknown
Weeds	Degradation of Eucalypt woodland. Reduced habitat quality for waterbirds and Regent Parrot.	Medium to low	Medium to low	Short term
Declining surface water quality mainly due to rising saline water tables, salinisation and reduced dilution potential	Reduced habitat quality for waterbirds	Low	Medium during low flow events, Low during high flow events	Dependent upon hydrology

River regulation

River regulation has been impacting on the hydrology of Lake Albacutya since water was first diverted from the Wimmera River system in the mid 1800s. Since then diversion of Wimmera River water to water supplies increased steadily until the early 1980s, peaking at 226 000 ML per year. Modelling has shown that this has resulted in a significant decrease in the frequency and duration of flooding in Lake Albacutya. This reduces the quantity and quality of habitat for aquatic communities and waterbirds, as well as disrupting nutrient cycling and succesional processes. Reduced flooding also impacts negatively on Eucalypt woodland health and recruitment, which further reduces habitat for aquatic and terrestrial fauna. In the long term it is likely that reduced flooding of the lake would result in a significant loss of aquatic and terrestrial biodiversity and habitat quality. This could well reduce the ability of the site to support high numbers of waterbirds and the nationally vulnerable Regent Parrot, for which the site is Ramsar listed.

This threat may be mitigated somewhat through the pipeline for water supply in the Wimmera River catchment replacing inefficient open channels which was completed in 2010 and has produced significant water savings of which an average of almost 40 000 ML/y under historical inflow conditions may be returned to the Wimmera River as environmental flows. Up to 32 400 ML/y of environmental water is also available for the Wimmera River due to water savings from the construction of the Northern Mallee Pipeline which was completed in 2002. Any future benefit to Lake Albacutya, however, is dependent upon adequate catchment rainfall and the actual volume and pattern of environmental water released. Under the the circumstances of rainfall which prevailed in the 1997 – 2010 period and river regulation, actual improvements in the hydrology of Lake Albacutya in the near future are expected to be small.

Climate change

Average rainfall in the Wimmera River catchment over about the last 10 years has been significantly lower than the long-term catchment average. This has been attributed, at least in part, to anthropogenic climate change and is expected to continue. The vast majority of various climate change prediction models, compiled by CSIRO (2007) predict a significant decrease in run-off, with a median estimate of a decrease of 17 % from 1990 to 2030. This poses a severe threat to the hydrological regime of Lake Albacutya which is already impacted by river regulation.

Decline in Eucalypt woodland health

Widespread dieback of River Red Gums, along with a lack of recruitment, has been documented in the lower Wimmera River including Lake Albacutya, and this has been attributed to a reduction of flooding in the area. Deterioration or loss of Eucalypt woodland at the site over the long term will result in habitat loss for waterbirds and Regent Parrot, primarily through a loss of tree hollows as nesting sites.

Additional threats

Several supplementary threats have also been identified which may need to be considered for effective long term management of the site, although they don't currently pose a direct threat to the critical components, processes or benefits/services of the site.

- Agricultural grazing: sheep currently graze lakebed vegetation within about 40 % of the Ramsar site under several grazing licences. This may change the composition and abundance of lakebed vegetation, which in turn may impact upon terrestrial and aquatic fauna.
- Rising groundwater and salinity: groundwater at Lake Albacutya is currently 9 m below the surface and there is no clear evidence that it is rising or becoming more saline. However, due to the large scale land clearance in the Wimmera catchment it is possible that this may occur at some time. This would likely cause widespread tree death and habitat degradation.
- Fire, erosion and flow blockages may also pose some level of threat to Lake Albacutya.

Knowledge gaps

The key knowledge gaps in Table E5 have been identified as being necessary to fully describe the ecological character of the site and set acceptable limits of change for critical components, processes and benefits/services.

Table E5 Summary of key knowledge gaps in the ecological character of Lake Albacutya

Component/process	Identified knowledge gaps
Morphology	Outlet sill elevation in relation to average lakebed elevation
Hydrology	Details on depths, volumes, area inundated, duration of inundation and inflows over time are lacking. Absence of long-term historical flood record.
Impact of climate change	Changes in rainfall and run-off and their impact on the hydrology of Lake Albacutya.
Eucalypt woodland	Changes to health of the community related to area compared to 1993 data. A benchmark for the extent and condition of Eucalypt woodland should be established as soon as possible after 1982 The ability of the Eucalypt woodland to benefit from shorter duration floods, e.g. of at least nine months total duration
Waterbirds	Habitat preferences and preferred depth/extent of inundation required to support key breeding events. Seasonal and annual movement of waterbirds between habitat areas and relative significance of Lake Albacutya.
Threatened species	Comprehensive data on Regent Parrot numbers and breeding at Lake Albacutya. Assessment of other potential threatened species occurring at the site.

Additional knowledge gaps in Table E6 have also been identified and will also assist with the understanding and management of the ecology of Lake Albacutya.

Table E6 Summary of additional knowledge gaps in the ecological character of Lake Albacutya

Component/process	Identified knowledge gaps
Aquatic vegetation	Aquatic vegetation assessments – species composition, density, distribution, succession, changes.
Lakebed vegetation	The impact of the current sheep grazing regime on the ecology of the lakebed vegetation is unknown.
Aquatic fauna	Comprehensive data on the composition and abundance of fish and other aquatic species.
Terrestrial and water-dependent fauna.	Species data for Lake Albacutya is patchy, especially for amphibians and invertebrates.
Surface water quality	Establish a baseline condition for water quality at various inundations stages of the lake.
Groundwater quality and water level	No comprehensive long-term data on the quality and level of groundwater.
Groundwater recharge and dilution	The mechanisms and rates of groundwater recharge and dilution at Lake Albacutya are not well understood.
Ecosystem resilience	Impact of cumulative anthropogenic disturbance on the ecosystem resilience of Lake Albacutya and implications for limits of acceptable change.

Monitoring

To address key knowledge gaps and monitor site condition to maintain the ecological character of the site, the key monitoring activities in Table E7 are recommended.

Table E7 Summary of key monitoring needs for Lake Albacutya

Component/process	Monitoring objective
Morphology	Elevation of the outlet sill in relation to average lakebed elevation, and assessment of morphological attributes – lakebed, inlet sill, outlet sill, lake margins.
Hydrology	Keep a comprehensive record of inflows - flow commencement, depth, volume, extent (area), date, season, duration. Can be used to improve hydrology models and to quantify any changes in hydrology over time and inform release of environmental water allocations. Monitor environmental water releases.
Waterbirds	Rigorously monitor waterbirds to detect any change in numbers, especially in relation to Ramsar criteria. Also monitor impacts of recreation and hunting on waterbird numbers and breeding.
Flora – Eucalypt woodland including River Red Gum	Detect and quantify any changes/trends in the health of the Eucalypt woodland including River Red Gum community (which may assist in determining the exact cause of dieback). Keep records of recruitment events and monitor recruitment and seedling survival.
Threatened species – Regent Parrot	Monitor the Regent Parrot population in terms of numbers, breeding, and movement/migration.
Climate	Monitor catchment and local climate for effects of climate change, especially catchment rainfall and runoff and local rainfall and evapotranspiration.

1. INTRODUCTION

1.1 Background

The *Convention on Wetlands of International Importance Especially for Waterbird Habitat* to which Australia is a signatory, was initially adopted in Ramsar, Iran, in 1971. Commonly known as the Ramsar Convention, this was the first modern inter-governmental treaty between nations with the aim of conserving natural resources.

The original intent of the Ramsar Convention was to protect waterbird habitat, however the convention has broadened its scope to cover all aspects of wetland conservation and 'wise use'.

Australia signed the Ramsar Convention in 1974, becoming one of the first contracting parties, who agreed to a number of actions including to:

- designate sites that meet the Ramsar criteria for inclusion in the Ramsar List
- promote the conservation of the ecological character of listed sites
- report on actions taken to implement the Ramsar Convention

While management of Ramsar wetlands is the responsibility of each individual site manager, the Australian Government, through the Department of Sustainability, Environment, Water, Population and Communities (SEWPaC) works closely with state governments, regional bodies and Ramsar site managers to implement Australia's Ramsar Convention obligations. In accordance with the Ramsar Convention, appropriate management of Ramsar wetlands includes describing and maintaining the ecological character of the wetland and implementing planning processes that promote conservation and wise use. These management principles are supported by national legislation under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Ramsar Convention provides the following relevant definitions:

Ecological character is the combination of the ecosystem components, processes and benefits/services that characterise the wetland at a given point in time.

…change in ecological character is the human induced adverse alteration of any ecosystem component, process and or ecosystem benefit/ service.

Within this context, ecosystem benefits and services are defined as the benefits that people receive from ecosystems.

1.2 Lake Albacutya

Lake Albacutya was designated a Wetland of International Importance in 1982. The criteria which supported this listing included its value to waterbirds, and acknowledgement that it represented a near-natural example of a lake in a terminal lake system. Terminal lake systems receive flows from endorheic river systems which do not flow to the ocean but drain internally into subterminal lakes and/or a terminal lake.

Timms (2001) has reported that true terminal lakes occur at the terminus of endorheic waterways and have no distinct shoreline; outflow is only through seepage and evaporation and terminal lakes are therefore saline due to the trapping of salts. Subterminal lakes occur upstream of true terminal lakes. They have a distinct shoreline and, when full, overflow into a subsequent subterminal or terminal lake; subterminal lakes remain fresh due to occasional flushing of salts (Timms, 2001).

Technically, Lake Albacutya is a subterminal lake as it has a distinct shoreline, and when full, overflows into a series of subsequent sub-terminal lakes and eventually into the true terminal lake in the system (Wirrengren Plain). Lake Albacutya is the second subterminal lake in the Wimmera River system, with Lake Hindmarsh being the first (see Figure 1.1). Sometimes Lake Albacutya may act as a terminal lake of the Wimmera River in an event in which it receives some water but does not fill. In this case it does not overflow but loses water solely by evaporation and seepage.

The Wimmera River originates in the Pyrenees in western Victoria, and with a catchment area of 24 000 km^2, it is Victoria's largest endorheic waterway. The river passes through a dry catchment with significant losses to evaporation and seepage, until it reaches a series of ephemeral lakes that extend north to the Wirrengren Plain in Wyperfeld National Park.

These lakes depend on large, intermittent flows, and so are characterised by contrasting hydrological phases. When dry, the lakes assume many of the characteristics of terrestrial ecosystems, supporting grasslands and terrestrial vertebrate fauna. When flooded, the lakes and their connecting channels become major aquatic ecosystems, retaining water for several years and supporting significant breeding bird and fish populations with extensive aquatic plant communities.

Diversions of river flows to agricultural and urban uses over the past 150 years resulted in a depleted “wet phase” for the Wimmera River terminal lakes system. Instead of overflowing every four years on average, the prognosis for Lake Albacutya was that it was heading towards an overflow return period of around every 50 years, with significantly more time spent empty or shallow than before regulation (Ecological Associates, 2004). Since the mid 1990s, plans have been implemented to replace an extensive but inefficient open channel water supply system fed by water from the Wimmera River with a piped system. When completed the pipeline network has the potential to produce water savings which could make some progress towards restoring the lake's hydrology, and improving the terrestrial and aquatic communities which depend on the flood pulses.

The lake, and the terrestrial and aquatic communities that it supports, are subject to other pressures including from invasive species, catchment clearing, and recreation activities, however these are relatively minor when compared with the overwhelming risk posed by dams and water diversions. Over the longer term, human-induced climate change also poses a threat, with a predicted reduction in catchment rainfall contributing pressure to the already stressed hydrology.

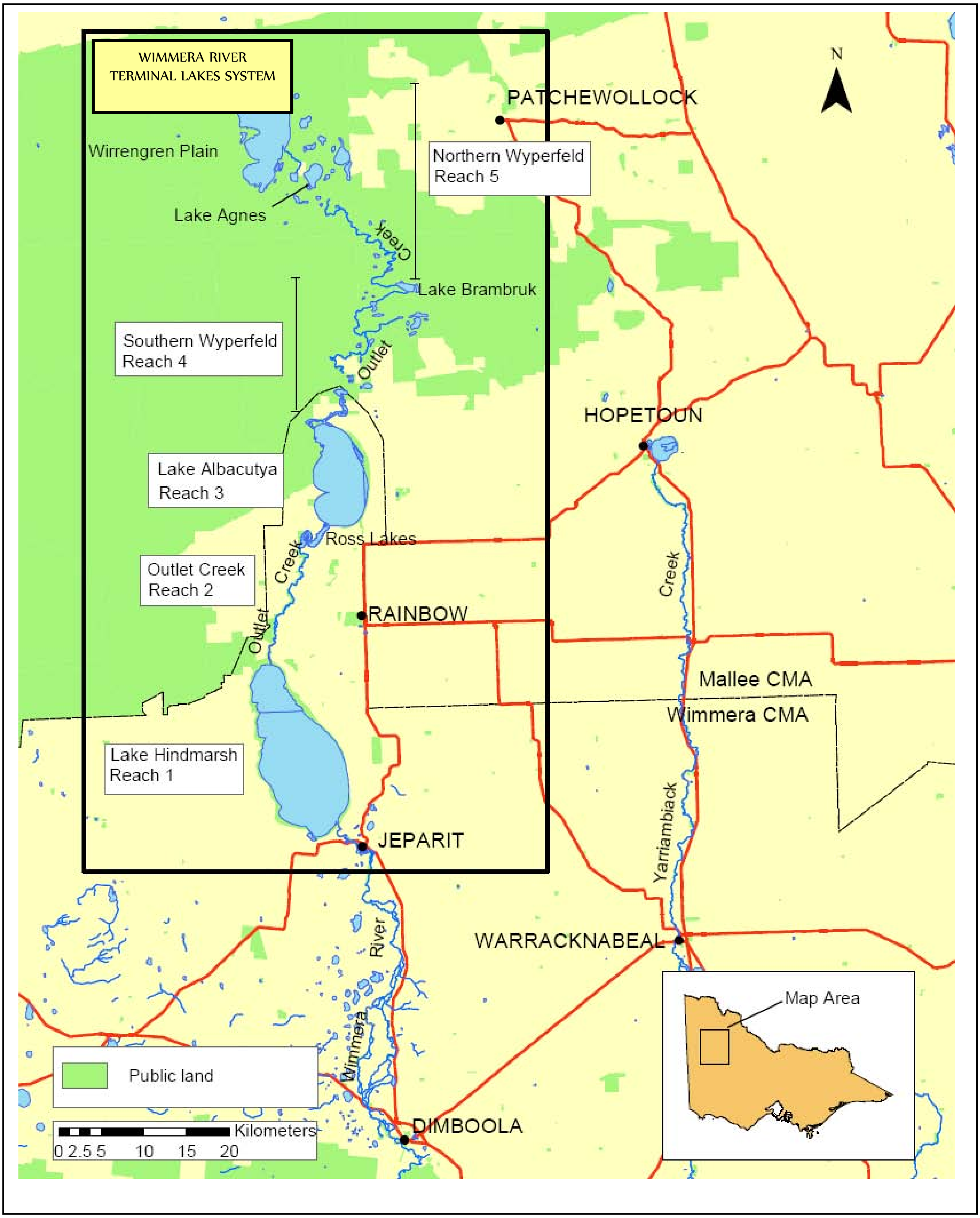


Figure 1.1 The Wimmera River terminal lakes system (Ecological Associates, 2004)

1.2 Site details

Table 1.1 Details of the Lake Albacutya Ramsar site

Name	Lake Albacutya, Victoria
Location in Co-ordinates	Latitude: 35° 45'S Longitude: 141° 58'E
General Location	The site is in north west Victoria, approximately 400 km north west of Melbourne. The nearest town is the town of Rainbow which is approximately 15 km to the south. Lake Albacutya is a subterminal lake of the Wimmera River and is in the Wimmera-Avon River Basin, within the Murray-Darling Drainage Division.
Area	Approximately 5659 ha
Date of Ramsar site designation	15 December 1982
Ramsar criteria met - current (2005)	Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region. Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities. Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region. Criterion 5: A wetland should be considered internationally important if it regularly supports 20 000 or more waterbirds. Criterion 6: A wetland should be considered internationally important if it regularly supports 1 % of the individuals in a population of one species or subspecies of waterbird.
Management authority	Parks Victoria for the Victorian Department of Sustainability and Environment
Date the Ecological Character Description applies	Date of Listing: December 1982
Status of description	This is the first Ecological Character Description compiled for the site.
Date of compilation	2009
Name of compiler(s)	Alan Cibilic & Laura White, WetlandCare Australia
Reference for management plan	Department of Sustainability and Environment (2003) *Lake Albacutya Ramsar Site Strategic Management Plan* Department of Sustainability and Environment, East Melbourne, Victoria. Website: http://www.dse.vic.gov.au

1.4 Purpose of this ECD

Development of an Ecological Character Description (ECD) for the Lake Albacutya Ramsar site has several aims.

1) To assist in implementing Australia's obligations under the Ramsar Convention, as stated in Schedule 6 (Managing wetlands of international importance) of the *Environment Protection and Biodiversity Conservation Regulations 2000*:

   a) to describe and maintain the ecological character of declared Ramsar wetlands in Australia

   b) to formulate and implement planning that promotes:
      i) conservation of the wetland
      ii) wise and sustainable use of the wetland for the benefit of humanity in a way that is compatible with maintenance of the natural properties of the ecosystem.

2) To assist in fulfilling Australia's obligation under the Ramsar Convention, to arrange to be informed at the earliest possible time if the ecological character of any wetland in its territory and included in the Ramsar List has changed, is changing or is likely to change as the result of technological developments, pollution or other human interference.

3) To supplement the description of the ecological character contained in the Ramsar Information Sheet submitted under the Ramsar Convention for each listed wetland and, collectively, to form an official record of the ecological character of the site.

4) To assist the administration of the EPBC Act, particularly:

   a) to determine whether an action has, will have or is likely to have a significant impact on a declared Ramsar wetland in contravention of sections 16 and 17B of the EPBC Act, or

   b) to assess the impacts that actions referred to the Minister under Part 7 of the EPBC Act have had, will have or are likely to have on a declared Ramsar wetland.

5) To assist any person considering taking an action that may impact on a declared Ramsar wetland whether to refer the action to the Minister under Part 7 of the EPBC Act for assessment and approval.

6) To inform members of the public who are interested generally in declared Ramsar wetlands to understand and value the wetlands.

In order to maintain the ecological character of a declared Ramsar wetland it is important to know the ecological conditions at the time of listing. As a result the ecological character is described at a particular point in time, and contracting parties are expected to notify the Ramsar Secretariat if the ecological character changes.

Every attempt has been made to document the ecological character of Lake Albacutya at its time of listing in 1982, in part by interpolating from existing data or extrapolating from more recent data. However, identifying the natural variability and defining limits of acceptable change (LACs) for some of the Ramsar site's critical components, processes and benefits and services has not been possible. Dates have been used to identify where a more recent baseline has been established for specific components, processes and services.

This ECD has been compiled using the methods outlined in the National Framework for describing the Ecological Character of Australian Ramsar wetlands (DEWHA, 2008a).

1.5 Relevant treaties, legislation, and regulations

The following have been identified as most relevant to the site, or to species and communities related to the site.

1.5.1 International

- The Ramsar Convention - an intergovernmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources.
- The Agreement between the Government of Australia and the Government of Japan for the Protection of Migratory Birds in Danger of Extinction and their Environment (JAMBA).
- The Agreement between the Government of Australia and the Government of the People's Republic of China for the Protection of Migratory Birds and their Environment (CAMBA).
- The Agreement between the Government of Australia and the Republic of Korea for the Protection of Migratory Birds and their Environment (ROKAMBA).
- The Convention on the Conservation of Migratory species of Wild Animals (the Bonn Convention).
- The Convention on Biological Diversity was signed by 150 government leaders at the 1992 Rio Earth Summit and is dedicated to promoting sustainable development.

1.5.2 National

- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) - the Australian Government's central piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, and ecological communities, including Ramsar sites.
- *Water Act 2007 -* establishes the Murray-Darling Basin Authority (MDBA) with the functions and powers, including enforcement powers, needed to ensure that Basin water resources are managed in an integrated and sustainable way. The Act requires the MDBA to prepare the Basin Plan - a strategic plan for the integrated and sustainable management of water resources in the Murray-Darling Basin. The Act also establishes a Commonwealth Environmental Water Holder to manage the Commonwealth's environmental water to protect and restore the environmental assets of the Murray-Darling Basin, and outside the Basin where the Commonwealth owns water
- *National Strategy for the Conservation of Australia's Biological Diversity 1996* - fulfils Australia's obligations under the international Convention on Biological Diversity. This National Strategy for the Conservation of Australia's Biological Diversity aims to bridge the gap between current activities and the effective identification, conservation and management of Australia's biological diversity.
- *National Local Government Biodiversity Strategy 1998* encourages biodiversity conservation through catchment and regional planning, and the establishment of a nationally coordinated information and monitoring system.

1.5.3 Victorian legislation and strategies

- *The Flora and Fauna Guarantee Act 1988* (FFG Act) - is the key piece of Victorian legislation for the conservation of threatened species and communities and for the management of potentially threatening processes.
- *The National Parks Act 1975* - creates national, state, wilderness and other parks in Victoria for the preservation and protection of the natural environment, indigenous flora and fauna and features of scenic, archaeological, ecological, geological, historic or other scientific interest.

- *The Water Act 1989* - provides the framework for allocating surface water and groundwater throughout Victoria. It details the Crown's entitlements to water and private entitlements to water from all rivers, streams and groundwater systems in Victoria.
- *The Heritage Rivers Act 1992* - identifies 18 heritage river areas in Victoria and protects public lands in specific parts of heritage rivers or river catchment areas which have significant recreation, nature conservation, scenic or cultural heritage attributes. The Act prohibits some land and water-related activities which may significantly impair the area's recreation, nature conservation, scenic or cultural heritage attributes.
- *Crown Land (Reserves) Act 1978* - the principal legislation dealing with the reservation and management of Crown lands in Victoria
- *Victorian Environmental Assessment Council Act 2001* - the purpose of this Act is to establish the Victorian Environmental Assessment Council to conduct investigations and make recommendations relating to the protection and ecologically sustainable management of the environment and natural resources of public land.
- *The Environment Protection Act 1970* - enables the EPA to improve air, land and water environments by managing waters, controlling noise and controlling pollution.
- *The Victorian River Health Strategy 2002 -* provides the framework in which the Government, in partnership with the community, makes decisions on the management and restoration of Victoria's rivers.
- *The Catchment and Land Protection Act 1994* sets up a framework for the integrated management and proterction of catchments and encourages community participation in the management of land and water resources.
- *The Fisheries Act 1995* provides a framework for the regulation, management and conservation of Victoria's fisheries.
- *The Planning and Environment Act 1987* establishes a framework for planning the use, development and protection of land in Victoria.
- *The Wildlife Act 1975* promotes the protection and conservation of wildlife and the sustainable use and access to wildlife.
- *Victoria's Biodiversity Strategy 1997* provides the framework for managing biodiversity in Victoria.

1.5.4 Regional plans and strategies

- Department of Sustainability and Environment, 2003, *Lake Albacutya Ramsar Site Strategic Management Plan,* Department of Sustainability and Environment, East Melbourne, Victoria.
- Mallee Parks Management Plan, 1996, Dept Natural Resources and Environment, Vic.
- Environmental Operating Strategy for the management of the Wimmera-Glenelg Environmental Water Reserve, 2007, Wimmera CMA & Glenelg Hopkins CMA.
- Wimmera Weed Action Plan, 2000, Wimmera CMA.
- Wimmera Rabbit Action Plan, 2000, Wimmera CMA.
- Wimmera Waterway Health Strategy, 2006, Wimmera CMA.
- Wimmera Regional Catchment Strategy, 2003, Wimmera CMA.
- Wimmera Catchment Salinity Management Plan, 2005, Wimmera CMA.
- Hindmarsh Shire Strategic Statement, Hindmarsh Shire Council.

2. DESCRIPTION OF THE SITE

2.1 Lake Albacutya

Lake Albacutya is the second in the series of subterminal lakes of the Wimmera River (Victoria's largest internally draining waterway). The Wimmera River rises in the Pyrenees Range near Ararat and flows north-west over 200 km to reach Lake Hindmarsh, the largest natural body of fresh water in Victoria. Occasionally, during prolonged periods of high rainfall, Lake Hindmarsh overflows, draining into Lake Albacutya via Outlet Creek. When river flows are sufficient Lake Albacutya also fills and overflows, and water drains via the next section of Outlet Creek into a series of smaller lakes in Wyperfeld National Park, finally terminating in the Wirrengren Plain in the very wettest of periods.

Lake Albacutya fills only intermittently when significant flows reach the lake from the Wimmera River. This occurs when high rainfall periods result in large amounts of run-off in the upper catchment. Due to this intermittent filling regime, Lake Albacutya is characterised by contrasting hydrological phases. The lake is located in the low rainfall semi-arid zone of north-western Victoria and when dry, it assumes many of the characteristics of terrestrial ecosystems, supporting lakebed vegetation including grasses and shrubs which support terrestrial fauna. The lakebed is comprised of underlying clays which give the lake its ability to hold water for several years while possibly also recharging the groundwater aquifer.

A significant aquatic ecosystem establishes when flows reach the lake, especially when it retains water for long periods. During lake-full phases, the lake is capable of supporting aquatic invertebrate and fish populations and extensive aquatic plant communities which provide a food source that attracts large numbers of waterbirds, some of which breed at the lake. An extensive community of Eucalypt woodland (primarily River Red Gum) surrounds the lake, occupying the lake margins which are periodically inundated. This woodland community provides breeding habitat for various waterbirds, as well as the nationally vulnerable Regent Parrot which also utilises the site. Areas of Mallee and Pine-Buloke woodland also occur within the Ramsar site.

2.2 Site location

Lake Albacutya is located 400 km north west of Melbourne, and approximately 150 km north of Horsham. The nearest small town is Rainbow, which is located approximately 15 km south of the lake. Lake Albacutya is adjacent to the extensive Wyperfeld National Park which adjoins the eastern boundary of Lake Albacutya Park. The Lake Albacutya Ramsar site is located within the Lake Albacutya Park. The Ramsar site boundary contains the entire bed of Lake Albacutya and the lake margins, including most of the area of maximum inundation of the lake which can be determined approximately by the maximum extent of Eucalypt woodland at the lake margin. The site also includes 531 ha of Mallee vegetation. The boundary does not include an area of mainly open grassland and seasonal herbland in the north-east which lies eastward of the first rise in the lakebed and which would be subjected to inundation in lake-full overflow events, or the Eucalypt woodland on the eastern margin of this open herbland. In the southern third of the lake, the boundary falls between 100m and 200m inside the boundary of the Lake Albacutya

Park. The boundary in the north-eastern third of the lake does not include the lunette dunes, and lies between 200m and 1100m inside the boundary of the Lake Albacutya Park. In the north-western two-thirds, the boundary of the Lake Albacutya Park extends more than 2 km beyond the boundary of the Ramsar site and so cannot be used as a guide.

2.3 Drainage division

The Lake Albacutya Ramsar site is located in the Wimmera-Avon River Basin within the Murray-Darling Drainage Division according to the Australian Drainage Divisions System.

The Murray-Darling Drainage Division occupies 1 060 000 km^2, extending from Roma in Queensland to Goolwa in South Australia and incorporating three quarters on New South Wales and half of Victoria (Murray-Darling Basin Commission (MDBC), 2005). It is one of the most developed drainage divisions in Australia accounting for 34 % of the nations gross value of agricultural production and contains 75 % of the nation's area of irrigated agriculture (MDBC, 2005). The waters of the drainage division provide drinking water for over three million people, about a million of which are located outside the division (MDBC, 2005). The Murray-Darling Drainage Division sustains approximately 30 000 wetlands, 16 of which are Ramsar listed. Run-off in the region is highly variable, though many of the river systems within the drainage division are highly regulated (MDBC, 2005).

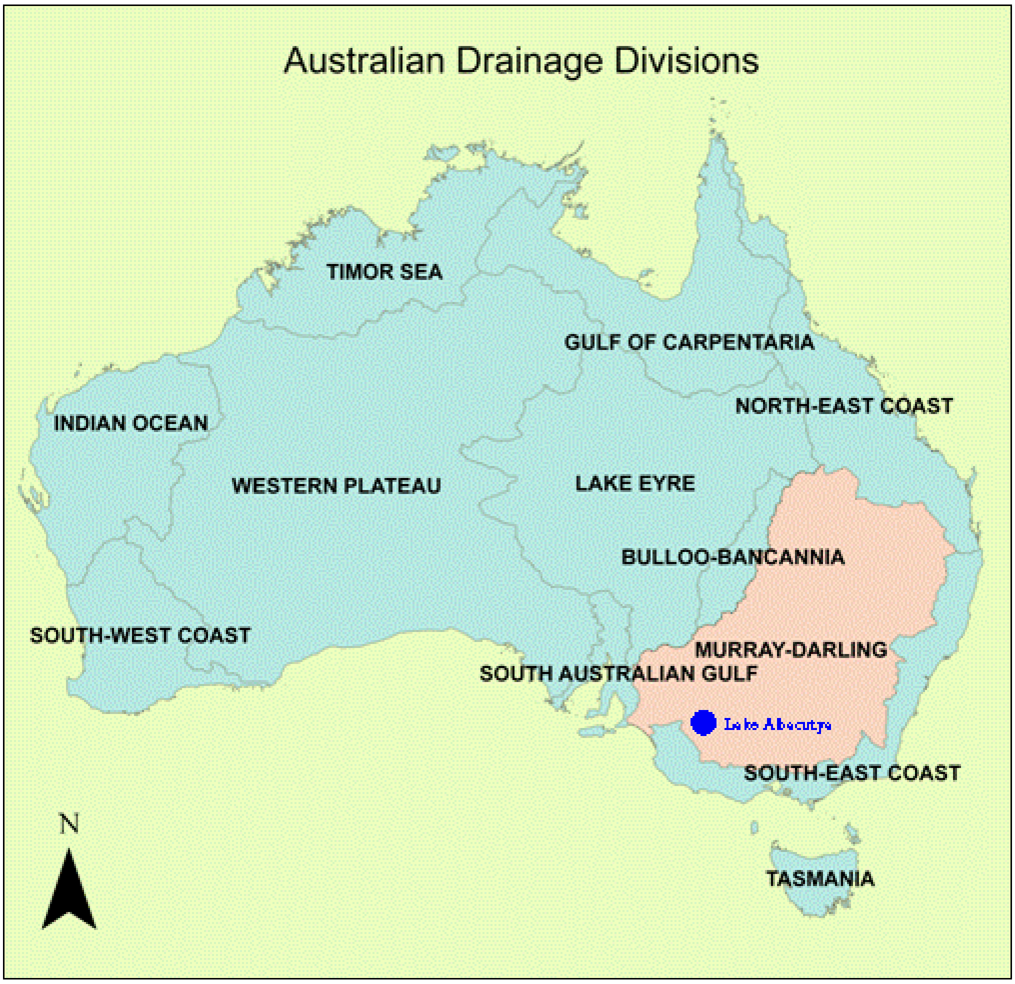


Figure 2.1 Drainage divisions (biogeographic regions) of Australia showing the location and extent of the Murray-Darling Drainage Division (shown in pink), and the approximate location of Lake Albacutya (blue circle)

2.4 Catchment

The Wimmera-Avon River Basin covers approximately 30 400 km^2, which comprises catchments of both the Wimmera and Avon Rivers. It has a population of approximately 48 000, and its major towns are Horsham and Stawell. This basin is highly modified, with land use composed primarily of crops and pasture with small remaining areas of woodland and forest. Woodland and forest make up 7.5 % of the basin area but contribute 18 % of the basin runnof. Main consumptive water uses in the basin are rural stock and domestic use, irrigation and residential. An environmental water reserve has been defined for the basin in a Bulk Entitlement which means a set share of inflows is provided to the environment under different water resource situations.

Most of the basin's water originates in hills in the south, comprising the Southern Pyrenees and the Grampian Ranges. The flat Wimmera Plains then extend north over most of the basin. These plains have an elevation of between 100 to 200 m above sea level and consist of finely-textured unconsolidated deposits which become an extensive dune complex nearer the Murray River. Runoff from this area is low with most of the water being lost through evaporation and deep seepage.

The Wimmera River, the major river within the Wimmera-Avon Basin, is the largest land-locked drainage system in Victoria. It does not flow into the sea or the Murray River, but instead flows into a terminal lakes system. The Wimmera River Catchment covers an area of about 24 000 km^2 (Glenelg Hopkins CMA & Wimmera CMA, 2007). Primary land use in the catchment is dryland agriculture, with wheat, oats and barley the major crops, and sheep grazed for both meat and wool production. Urban and industrial development, conservation, forestry and irrigated agriculture make up the remaining land uses in the catchment.

Table 2.1 Land use, with average annual precipitation and run-off across the Wimmera-Avon River Basin (adapted from Australian Government, 2009)

Land Use Type	Area (sqkm)	Precipitation (ML)	Runoff (ML)
Closed Forest	100	86,285	7,068
Open Forest	624	343,595	7,508
Plantation	6	4,379	116
Woodland	1,532	925,333	52,983
Woody Pasture	2,258	899,662	14,729
Shrubby Pasture	772	370,706	24,540
Pasture	8,135	3,720,511	179,631
Irrigated Pasture	9	3,613	117
Winter Crops	13,097	5,334,217	58,590
Summer / Fodder Crops	3,178	1,241,490	4,817
Irrigated Crops	22	10,071	187
Sugarcane	0	0	0
Irrigated Sugarcane	0	0	0
Cotton	0	0	0
Irrigated Cotton	0	0	0
Horticulture	43	22,742	395
Irrigated Horticulture	0	0	0
Bare Ground	75	29,316	1,955
Intensive Use	63	26,221	1,268
Water	460	197,984	13,826
Entire Basin	30,374	13,216,125	367,730

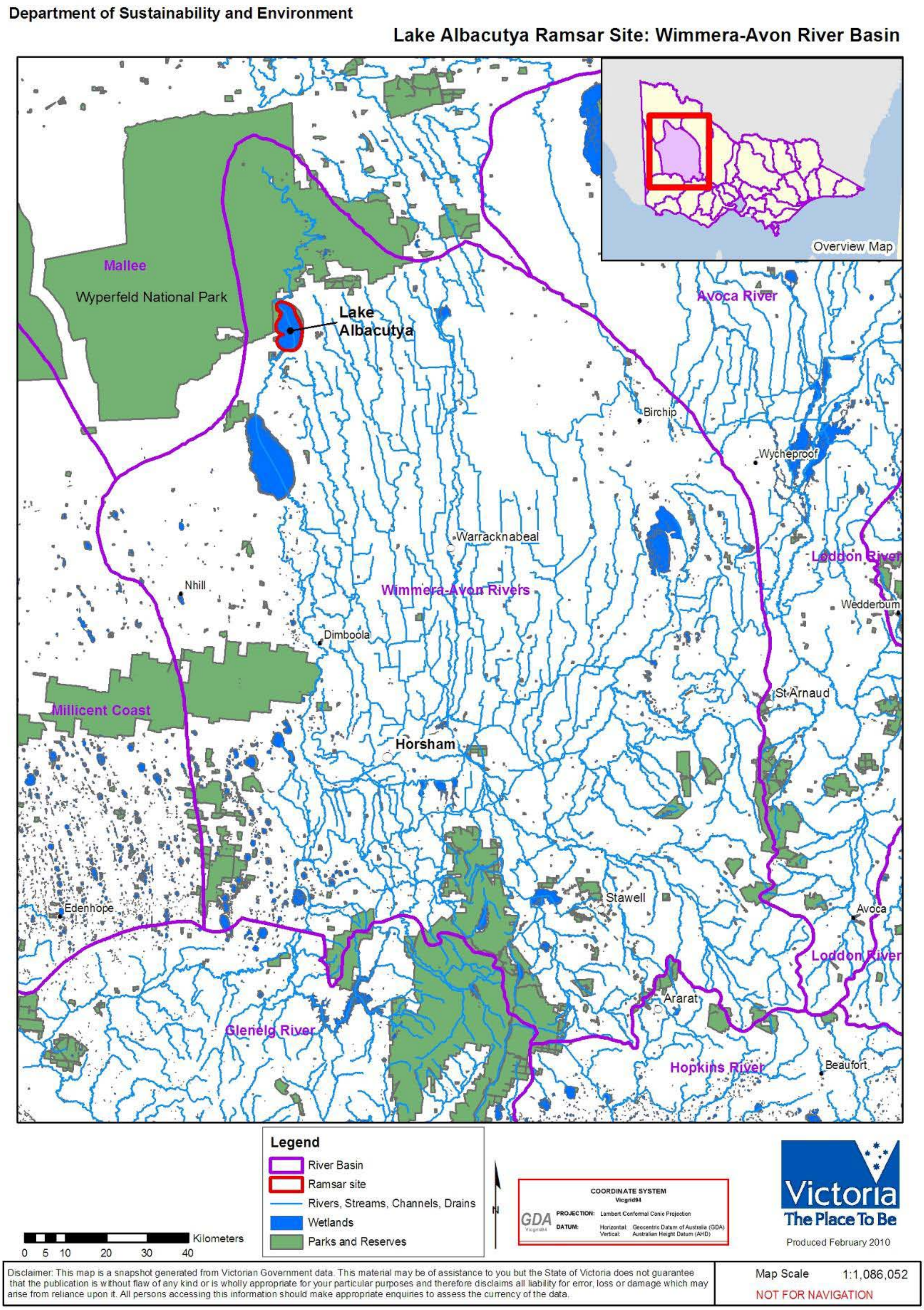


Figure 2.2 Wimmera-Avon River Basin (provided by the Department of Sustainability and Environment, Victoria)

2.5 Climate

Lake Albacutya lies within the semi-arid region of Victoria. Rainfall at Lake Albacutya is low and unreliable. Annual rainfall in the Wimmera-Avon Bason is highly variable from around 200 mm to 700 mm per year, with an average of 365 mm per year (Figure 2.3). The winter months from May to October are generally the wettest months, receiving 60 % of the yearly total (Figure 2.4). Winters are generally mild with several frosts usually occurring. Summers are hot and potential evaporation is very high, averaging 1300 mm annually (Morton & Heislers, 1978) (Figure 2.4). The majority of flows in the Wimmera River originate from the ranges in the upper catchment which has much higher rainfall, generally from 400 mm to 600 mm and up to 1000 mm per year (Figure 2.5).

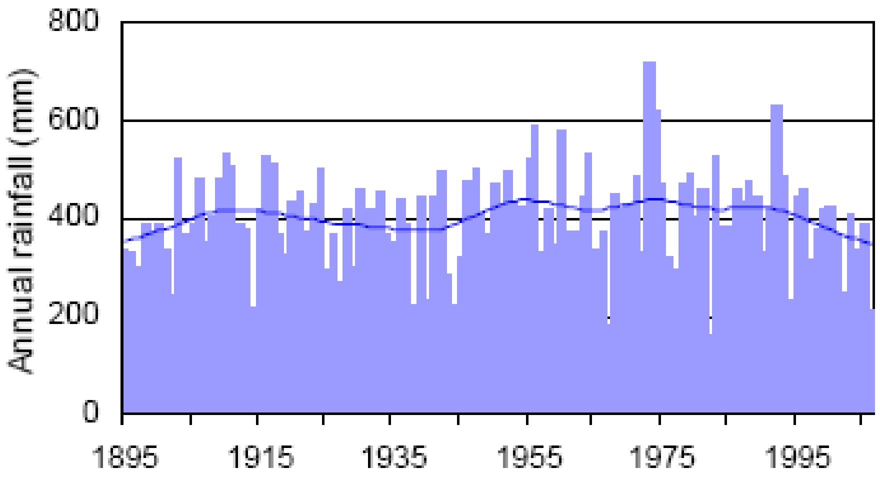


Figure 2.3 Historical rainfall averages for the Wimmera-Avon Basin (CSIRO, 2007)

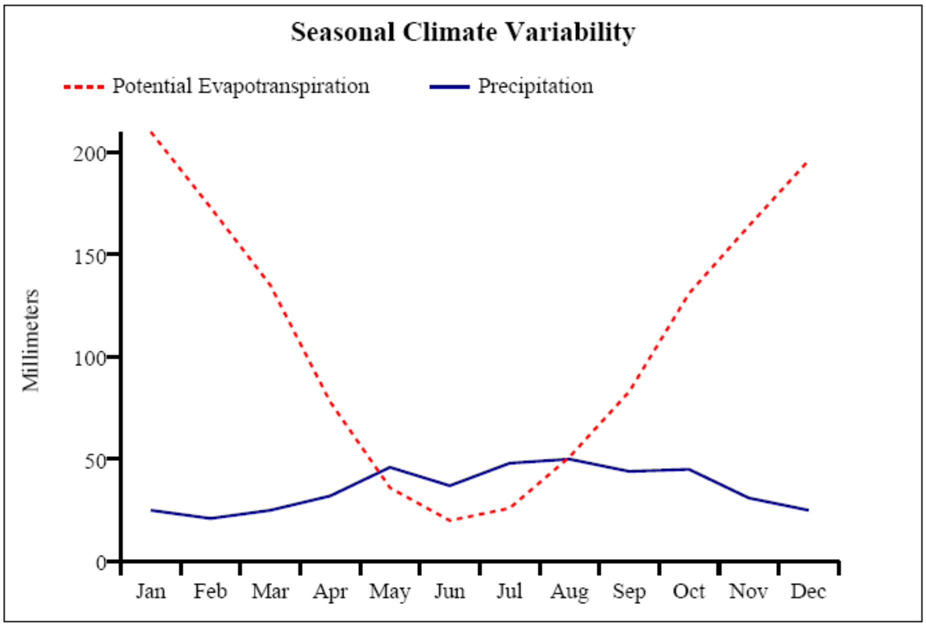


Figure 2.4 Average monthly rainfall and evapotranspiration in the Wimmera-Avon Basin (Australian Government, 2009)

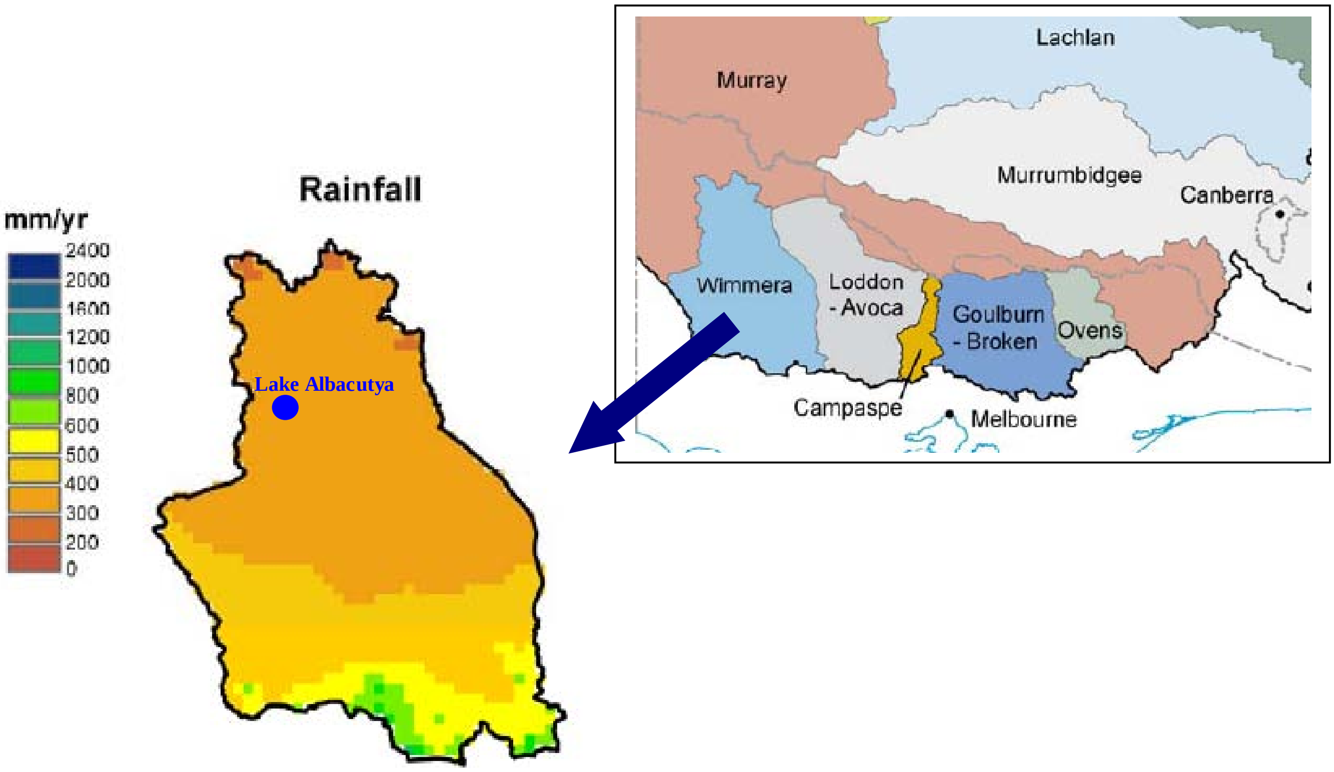


Figure 2.5 Distribution of average annual rainfall in the Wimmera-Avon Basin (CSIRO, 2007)

Average maximum temperatures at the nearest recording station at Rainbow range from 14.4°C in July to 30.8°C in January. Average minimum temperatures range from 3.8°C in July to 14.1°C in February (Table 2.2). Temperatures of up to 46°C have been recorded during summer. Several frosts usually occur during the cooler months of the year. Optimum temperatures for plant growth occur mainly in early autumn and late spring when conditions are less severe.

Table 2.2 Mean monthly temperature (1912-1970) and rainfall (1901-2009) near Lake Albacutya – blue numbers indicate minimum and red numbers indicate maximum (Rainbow* Post Office – nearest measuring station to Lake Albacutya) (Bureau of Meteorology, 2009)
* Rainbow is 14 km south of Lake Albacutya

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature													
Mean maximum temperature (°C)	30.8	30.4	27.6	22.3	18.0	14.7	14.4	16.1	19.3	22.7	26.0	29.2	22.6
Mean minimum temperature (°C)	13.7	14.1	12.2	9.1	6.6	4.5	3.8	4.4	5.9	7.9	10.2	12.5	8.7
Rainfall													
Mean rainfall (mm)	20.7	27.0	21.0	25.2	37.4	35.2	37.3	36.2	35.0	33.7	28.4	27.4	364.4
Mean number of days of rain ≥ 1 mm	2.3	2.5	2.5	3.8	6.1	6.5	8.0	7.4	6.5	5.6	4.2	3.1	58.5

2.6 Land tenure and management framework

2.6.1 Lake Albacutya Park

The Lake Albacutya Park was reserved in 1980 under Schedule 3 ('Other Parks') of the *Victorian National Parks Act 1975*. The Lake Albacutya Park is slightly larger than the Ramsar site, taking in a small strip of land surrounding the lake as well as adjacent sections of Outlet Creek (see Figure 2.6). When full, the lake covers 5850 ha of the 8300 ha park. Parks Victoria is responsible for the management of the Lake Albacutya Park and the Lake Albacutya Ramsar site.

Under the *National Parks Act 1975*, Parks Victoria is required to manage the site in accordance with the following objectives:

a. ensure that Lake Albacutya Park is controlled and managed in accordance with the objects of this Act in a manner that will, insofar as is appropriate to the park-
    i. preserve, protect and re-establish indigenous flora and fauna in the park;
    ii. preserve and protect features in the park of scenic, archaeological, ecological, geological, historic or other scientific interest;
    iii. enable the park to be used by the public for the enjoyment, observation and study of the countryside and its pursuits, its flora and fauna, its ecology and geology and other features; and
    iv. control exotic flora and fauna in the park;
b. ensure that proper and sufficient measures are taken to protect Lake Albacutya Park from injury by fire;
c. promote and encourage the use and enjoyment of Lake Albacutya Park by the public; and
d. prepare a plan of management in respect of Lake Albacutya Park.

There are three current grazing licences within the Lake Albacutya Ramsar site granted by the Department of Sustainability and Environment under the *National Parks Act 1975*. Together the three licences cover 2,117.6 ha of the lakebed. Licensees are entitled to graze sheep providing they keep the land in good condition which includes undertaking pest and weed control.

Lake Albacutya Park (photo M. Krelle)

2.6.2 Heritage river

The Wimmera River is a nominated heritage river under the *Heritage Rivers Act 1992* for 229 km of its corridor from Polkemmet Bridge to Wirrengren Plain, including Lake Albacutya, for its high conservation, cultural heritage and recreation values. This Victorian Act provides protection for rivers and natural catchment areas, in the case of the Wimmera River specifically to:

- preserve cultural heritage
- provide opportunities for recreation, education and landscape appreciation
- improve water quality
- manage flow regimes
- prevent dieback in the riparian vegetation
- conserve flora and fauna.

Parks Victoria is also responsible for the management of heritage river areas.

The Wimmera Heritage River is regarded as being of conservation significance as it:

- is part of the largest land-locked drainage system in the state of Victoria
- provides a vital and unique wildlife corridor in an otherwise cleared landscape
- supports a broad range of fauna threatened at state and federal level
- contains a wetland of international importance under the Ramsar Convention (Lake Albacutya)
- links two major parks systems
- supports a suite of endangered vegetation types and species
- has significant Aboriginal association with the area evidenced by numerous middens and scar trees, and
- provides opportunities for recreation of high local significance.

The heritage river section of the Wimmera River extends from Polkemmet Bridge 20 km west of Horsham to Wirrengren Plain in Wyperfeld National Park, including Lake Albacutya and its margins. Twenty eight kilometres of the Wimmera Heritage River is contained within the Lake Albacutya Park which includes sections of Outlet Creek to the north and south of the lake (Parks Victoria, 2000).

2.6.3 Native title

A native title determination exists for areas of the Wimmera River including Lake Albacutya. This determination was made in December 2005 after an application for a determination of native title for the region by the traditional owners the Wotjobaluk, Jaadwa, Jadawadjali, Wergaia and Jupagulk Peoples (collectively referred to as the Wotjobaluk People) began in 1995. The determination gives the traditional owners non-exclusive rights to hunt, fish, gather and camp for personal, domestic and non-commercial communal needs. The native title rights are held in trust by the Barengi Gadjin Land Council Aboriginal Corporation on behalf of the Wotjobaluk people and the corporation administers the determination on their behalf. The determination is such that any other rights and interests held prevail over the native title rights and interests but do not extinguish them.

Campfire at Lake Albacutya during a lake-full event (photo M. Krelle)

2.6.4 Local Government

Lake Albacutya is located within the Hindmarsh Shire and it is zoned as Public Conservation and Resource Zone. This zoning aims to:

- protect and conserve the natural environment and natural processes for their historic, scientific, landscape, habitat or cultural values
- provide facilities which assist in public education and interpretation of the natural environment with minimal degradation of the natural environment or natural processes
- provide for appropriate resource based uses.

The Hindmarsh Planning Scheme contains an Environmental Significance Overlay, Schedules 5 and 6 of which apply to Lake Albacutya. Schedule 5 provides protection for wetlands of conservation value from land use and development that would degrade their condition, and schedule 6 similarly protects the primary catchments of these wetlands. A Land Subject to Inundation Overlay also applies over the known flood prone land of Lake Albacutya, to ensure that development proposals are compatible with the flood hazard and local drainage conditions and to protect water quality in accordance with the provision of relevant State Environment Protection Policies.

2.6.5 Other agencies

Parks Victoria is responsible for the on-ground management of the site, however numerous other agencies are involved in specific management components and broader regional management, and in ensuring that management complies with all relevant legislative requirements.

Successful management of the site relies on constructive partnerships between the managing bodies. For example, the Department of Sustainability and Environment is responsible for legislation involved in managing flora and fauna, Grampians Wimmera Mallee Water (GWMWater) manages water diversions for urban and rural use, the Department of Primary Industries manages recreational fishing and hunting and the Wimmera Catchment Management Authority is responsible for strategic natural resource management of the region, waterway health, and management of environmental water allocations. Table 2.3 summarises the key management agencies and their responsibilities.

Table 2.3 Management framework for Lake Albacutya (adapted from DSE, 2003)

Statewide agency	Responsibility	Local agency	Responsibility
Parks Victoria	Management of parks and reserves.	Parks Victoria Mildura	Manage Lake Albacutya and the surrounding Lake Albacutya Park.
Department of Sustainability and Environment (DSE)	Strategic direction for park and reserve management; flora and fauna management and implementation of the Ramsar Convention in Victoria; catchment and water management, forest management, coastal and port management; leasing, licensing and management of public land,	DSE Horsham	Policy advice for the management of Lake Albacutya
Department of Primary Industries (DPI)	Provides strategic direction for recreational hunting, fisheries management and research, agricultural services and sustainable development of Victoria's energy and mineral resources.	DPI Horsham	Manage recreational hunting and fishing for Lake Albacutya Ramsar site in accordance with *Fisheries Act 1995*.
Department of Planning and Community Development (DPCD)	Strategic and statutory land use planning including the administration of the Victorian Planning Provisions.	Regional Development Victoria, Grampians Region.	Develop rural and regional Victoria.
		Hindmarsh Shire	Regulate local development through planning schemes, on-ground works and management of local roads.
Victorian Catchment Management Council	Advise State Government on catchment management, and land and water resource issues and priorities. Encourage co-operation between land and water managers. Promote community awareness on catchment management issues.	Wimmera CMA	Develop and co-ordinate implementation of a Regional Catchment Strategy and Regional Waterway Health Strategy which provides a framework to protect and enhance the waterways of the region. Manage the Environmental Water Reserve for the Wimmera River system. Administer permits for works in the bed and banks of designated waterways.
Environment Protection Authority (EPA)	Co-ordination of all activities relating to the discharge of waste into the environment and the generation, storage, treatment, transport and disposal of industrial waste and the emission of noise and for preventing or controlling pollution and noise and protecting and improving the quality of the environment. Develop State environment protection policies for specified segments of the environment (e.g. SEPP Waters of Victoria).	EPA Bendigo	Licence sewage and other discharges. Monitor water quality.
Rural Water Authorities	Provision of water and sewerage services and the management of urban water supply storages and catchments. Manage and operate the Irrigation Districts and the Stock and Domestic System and administer the diversion of water from waterways and extraction of groundwater.	Grampians Wimmera Mallee Water	Provide water and sewerage services to towns. Manage rural water resources in the Wimmera and Mallee, including headworks and regulation of water extraction for agriculture.

2.6.6 Surrounding lands

Surrounding land use and management of adjacent land areas are significant to the management and condition of Lake Albacutya. Lake Albacutya Park is adjacent to Wyperfeld National Park on the northern and western boundaries, which provides a terrestrial habitat corridor. Adjacent land on remaining sides is freehold and primarily used for sheep grazing and cereal cropping, with some oilseed crops also evident.

2.7 Maps and images

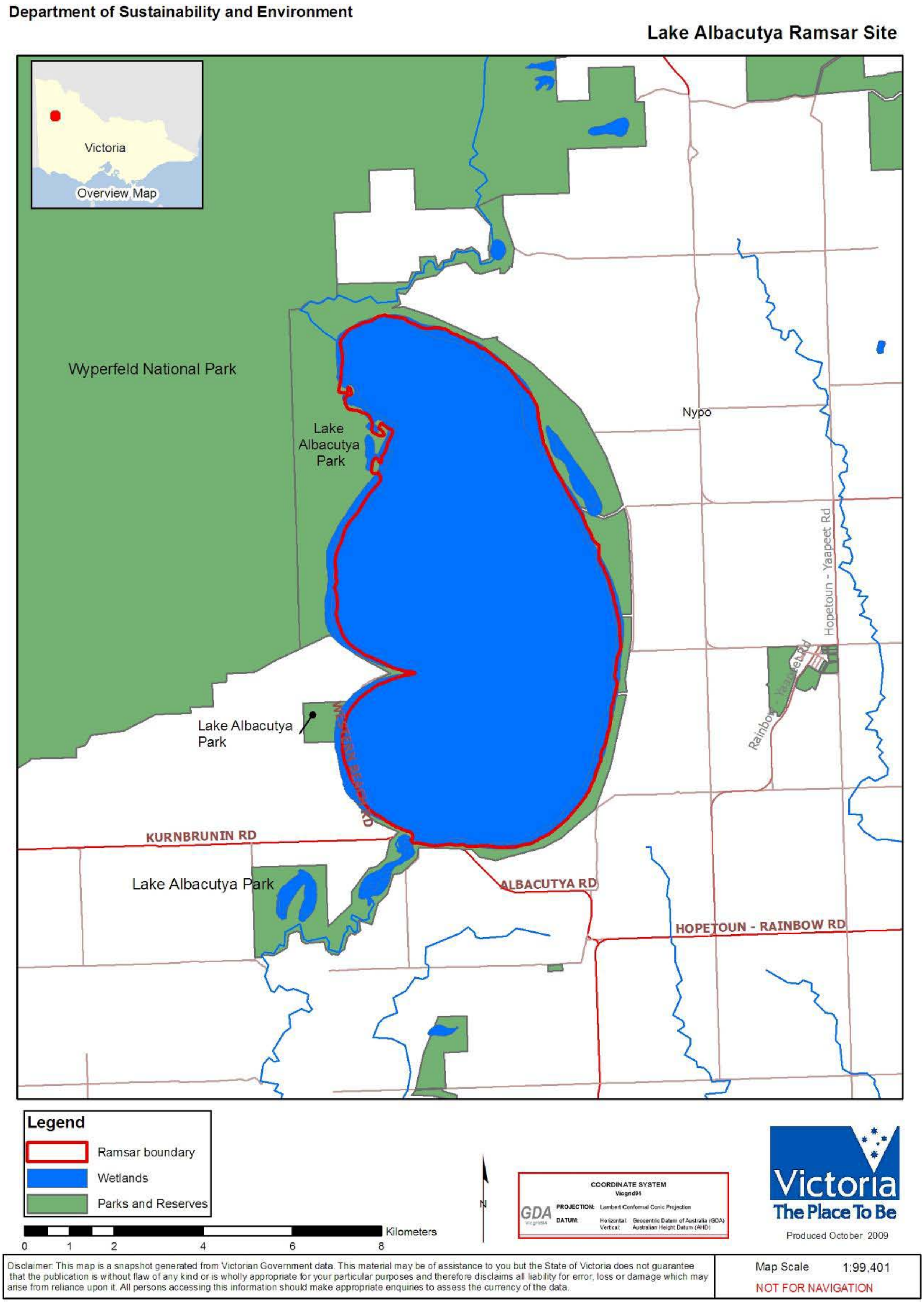


Figure 2.6 Map of the Lake Albacutya Ramsar site also showing Lake Albacutya Park (provided by the Department of Sustainability and Environment, Victoria)

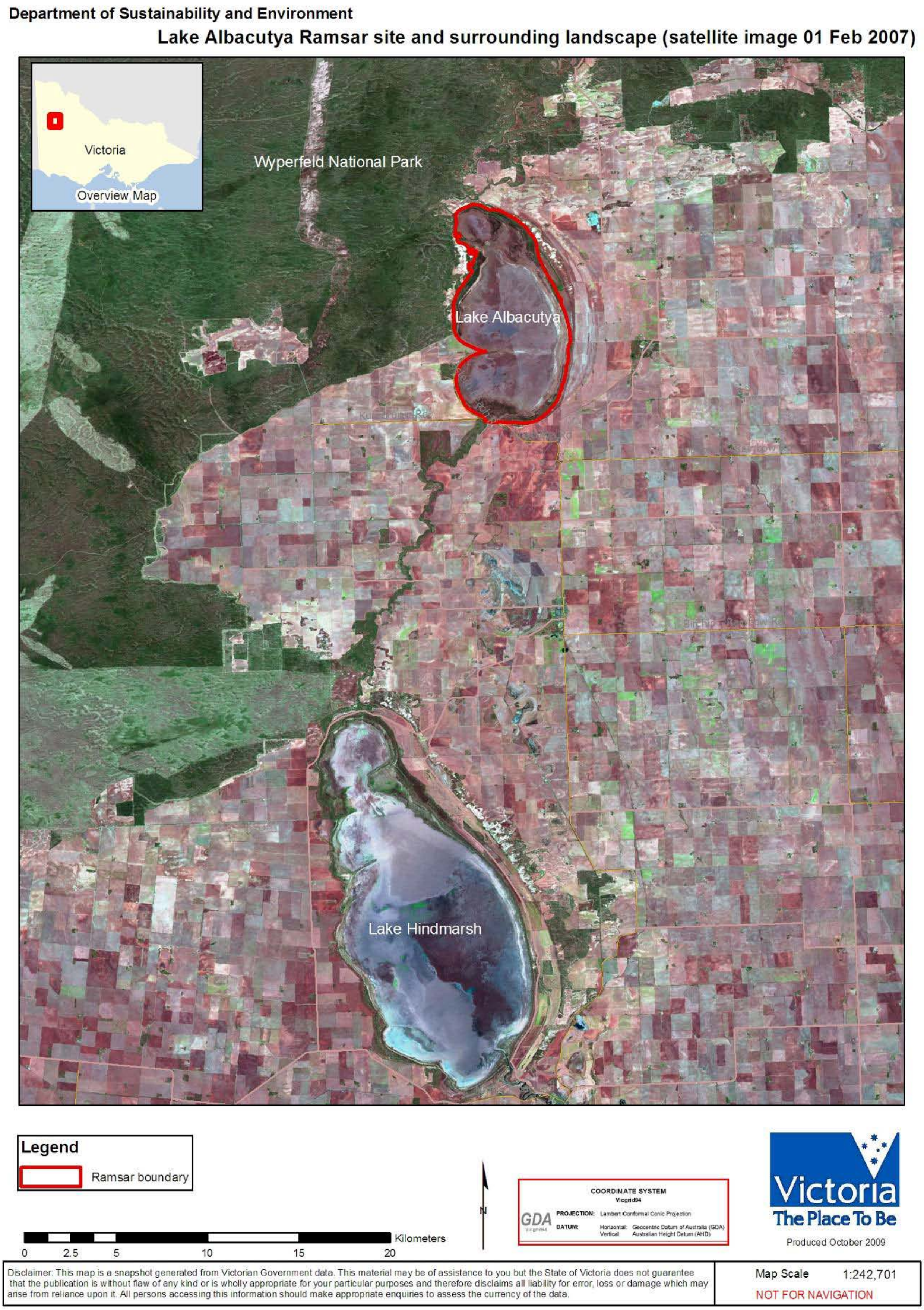


Figure 2.7 Satellite image of Lake Albacutya and surrounding landscape (provided by the Department of Sustainability and Environment, Victoria)

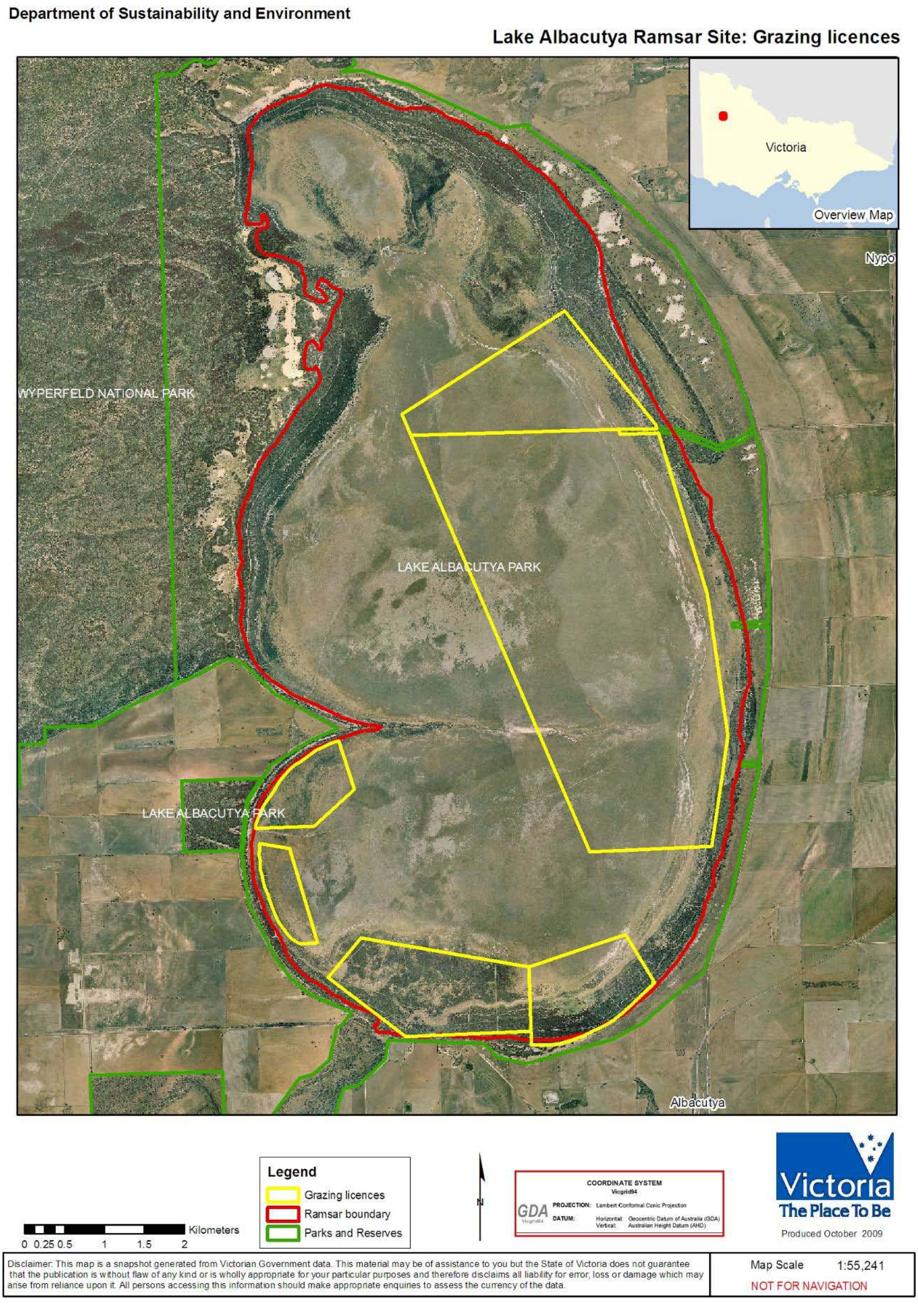


Figure 2.8 Current grazing licences within the Lake Albacutya Ramsar site (provided by the Department of Sustainability and Environment, Victoria)

2.8 Wetland types

Under the Ramsar Convention, Lake Albacutya is classified in the category 'seasonal intermittent freshwater lakes over 8 ha including floodplain lakes'. This category makes up the only wetland type in the site.

Under the Victorian classification system (Corrick & Norman, 1980) Lake Albacutya is classified as a Permanent Open Freshwater wetland. Under this classification, the term 'permanent' is applied because the lake is relatively deep and, when full, holds water for several years.

The Ecological Vegetation Classes (EVCs) mapped by DSE Victoria can be generalised for the Lake Albacutya Ramsar site into five broad community types. These include two wetland or water associated communities (lakebed herbland and Eucalypt woodland) and three terrestrial communities (non-Eucalypt woodland, Mallee and grassland/shrubland).

2.8.1 Wetland/water associated communities

2.8.1.1 Lakebed herbland – wet phase aquatic vegetation

During lake-full periods an aquatic vegetation community develops on the lakebed and lake margins, supporting aquatic vegetation and providing food and habitat for numerous waterbirds. The area of this community varies with the extent of inundation and may extend into and overlap the Eucalypt woodland on the lake margins. There is little data on the species composition of the aquatic vegetation community of Lake Albacutya, however it has been known to support water-milfoils, watermat and algae.

2.8.1.2 Eucalypt woodland

There is an extensive Eucalypt woodland community within the Ramsar site which occurs as a fringe around the edge of the lakebed, occupying approximately 1271 ha. It occupies the area beyond the lakebed itself which becomes inundated during flooding and is dominated by flood dependent or flood tolerant species. This community has a canopy 10-20 m tall, which is dominated by River Red Gum (*E. camaldulensis*) with some Black Box (*E. largiflorens*). The understorey comprises grasses, shrubs or herbs including spear grasses, wallaby grasses, saltbushes (e.g. *Atriplex spp*), wattles (e.g. *Acacia trineura*), Lignum (e.g. *Muehlenbeckia florulenta*), sedges and rushes. The River Red Gum community at Lake Albacutya is genetically unique, in that individuals from this provenance are more drought and salinity tolerant than River Red Gums from any other known location. This community provides important breeding habitat for numerous waterbird species and the nationally vulnerable Regent Parrot.

Eucalypt woodland during dry phase (left), and during wet phase (right) showing encroaching aquatic community (photos A. Cibilic and M. Krelle)

2.8.2 Terrestrial communities

2.8.21. Lakebed – dry phase herbland

This community covers a large portion of the Ramsar site (3769 ha). This community occurs within the bed of the lake between flood periods. It is dominated by species that are adapted to colonising drying mud within the lakebed. It is comprised mainly of grasses (e.g. wallaby grasses *Austrodanthonia spp*, and spear grasses *Austrostipa spp*), small to medium herbs and small shrubs including saltbushes (e.g. *Atriplex spp*) and *Acacia spp* (e.g. three-nerve wattle). During the extended dry phase some woodland species also colonise the lakebed and survive until the next major flooding event.

Lakebed vegetation close up (left) and distant (right) at Lake Albacutya (photos A. Cibilic)

2.8.2.2 Mallee

There is a portion of Mallee community occurring within the Ramsar site, comprising approximately 399 ha. This community generally surrounds the Eucalypt woodland on the landward side away from flooding and is dominated by Mallee Eucalypts *(*e.g. *E. dumosa* and *E. leptophylla)* between 4-10 m tall. The understorey is dominated by shrubs such as *Acacia spp*, saltbushes (e.g. *Atriplex spp*), bluebushes (e.g. *Maireana spp*) with grasses such as wallaby grasses and spear grasses. This community provides foraging habitat for the nationally vulnerable Regent Parrot.

2.8.2.3 Non-Eucalypt woodland

This community occupies only 106 ha of the Ramsar site around the landward edges of the site, away from areas of inundation, particularly in the east. The canopy is generally dominated by pine (*callitris spp)* and Buloke *(Allocasuarina leuhmannii)* up to 12 m tall. Understorey species may include spear grasses, wallaby grasses, saltbushes, bluebushes and *Acacia spp.* This community often occurs on sand ridges.

2.8.2.4 Grassland/shrubland

There are small patches of grasslands and shrublands within the site, covering 19 ha in total. These are areas dominated by grasses or low chenopod shrubs (e.g. *Atriplex spp* and *Maireana spp*). Trees such as Buloke (*Allocasuarina luehmannii*) and pine (*Callitris spp*) may also be sparsely present.

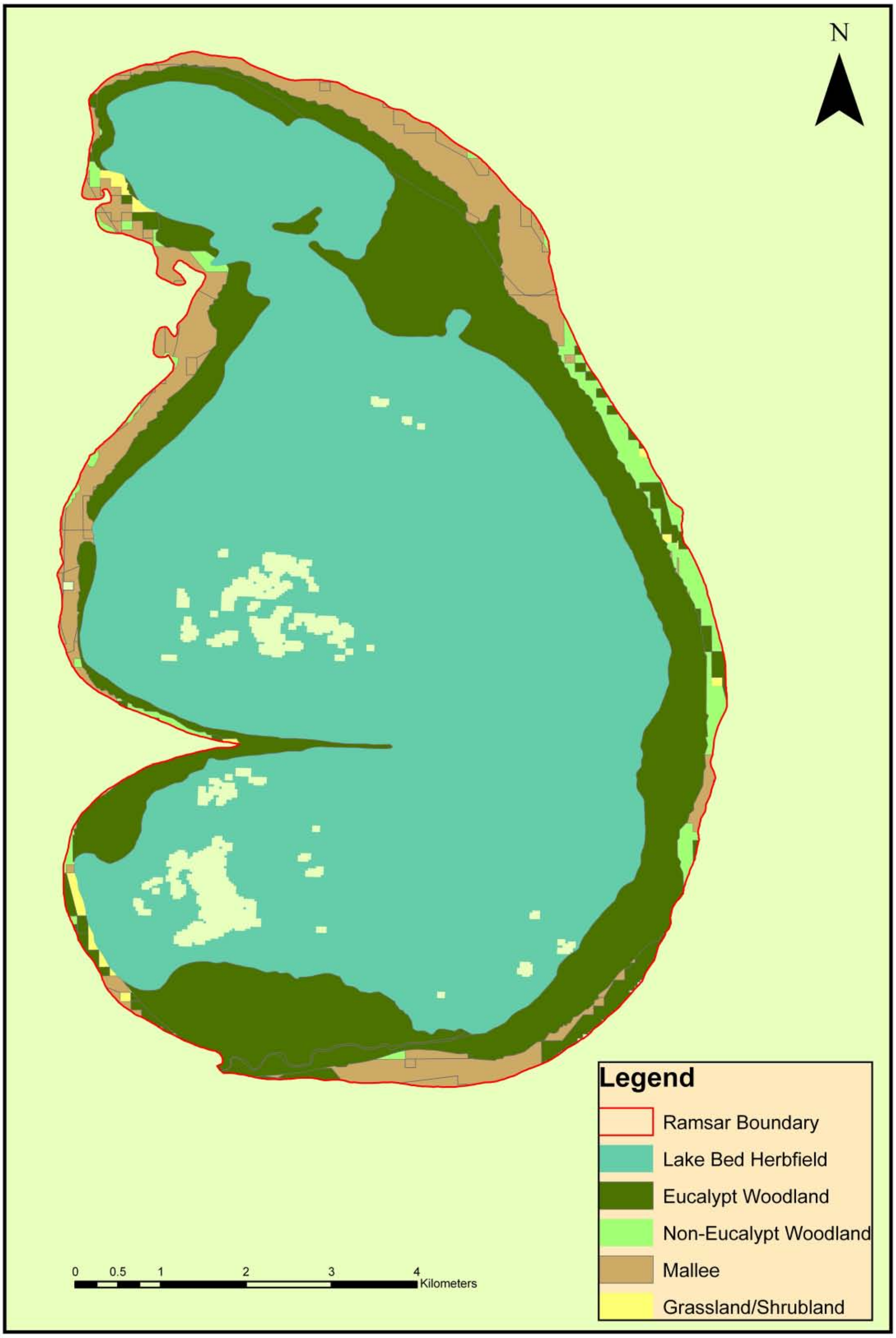


Figure 2.9 Community types in the Lake Albacutya Ramsar site (adapted from DSE, 2009a)

2.9 Overview of the ecological character of the site

The key features of Lake Albacutya are its water holding capacity and hydrological cycle which result in the lake filling intermittently during prolonged episodes of high rainfall in the catchment and holding water for significant periods. This can result in the development of a large, temporary lake located in the semi-arid zone of north-west Victoria. The wet phase of this cycle can provide feeding and breeding habitat for large numbers and species of waterbirds. This flooding regime supports significant floodplain vegetation such as River Red Gum which provides important fauna habitat. The lake, with its signature hydrological cycle and associated terrestrial and aquatic flora and fauna populations, has significant ecological and social values, especially when it retains water for extended periods.

Modelling by Ecological Associates (2004) predicted that under natural conditions Lake Albacutya overflowed every four years on average (not necessarily emptying completely in between) and was shallow or dry for only 19 years in 100. Once full, the lake takes several years to dry if no further inflows are received. The last major lake-full event was between 1974 and 1977. The lake retained water as a result of periodic minor flows until about 1983, with only small flows reaching the lake since then (until the time of writing). At the time of Ramsar listing, therefore, the lake contained water, demonstrated many ecological features of a permanent lake system, and provided habitat for a large variety and numbers of waterbirds. However, by that time the lake was subject to an altered hydrological regime as a result of water regulation and extraction, as described below.

Waters of the Wimmera River have been exploited and regulated from the mid 1800s. Since that time, increasing diversion and regulation of the Wimmera River for the Wimmera-Mallee Stock and Domestic Water Supply System (WMSDWSS) has occurred, and the incidence and duration of Lake Albacutya filling has decreased substantially. Under the regulation regime that was current around the early 2000s, it is estimated that the incidence of overflow from the lake decreased from about 25 times in 100 years with an average of 19 months duration per overflow event under the pre-regulation flow regime, to as rarely as 2 times in 100 years with an average of 11 months duration per overflow event (Ecological Associates, 2004). Models also show that the lake would have been shallow or empty for a maximum period of only five years in any single event with a total shallow or empty period of 19 years in 100 under the pre-regulation flow regime; however under the 2004 regulation regime the model showed a maximum shallow or empty duration of over 30 years and a total of 80 years in 100 spent shallow or empty (Ecological Associates, 2004). The potential impacts on the condition and ecological and social values of Lake Albacutya are significant.

Water diversion to the WMSDWSS peaked in the early 1980s, and pipeline construction to improve the efficiency of the WMSDWSS by replacing the inefficient open water supply channels commenced in the early 1990s. A small section of pipeline known as the Northern Mallee Pipeline was completed in 2002. This produced an annual potential maximum regulated environmental entitlement of approximately 32,400 ML to the Wimmera and Glenelg Rivers, however due to drought since this time, allocations for this entitlement and therefore actual environmental releases were small (Victorian Government, 2003). A larger section, the Wimmera Mallee Pipeline was completed in 2010 creating a potential average water saving of about 83,000 ML per year under historical rainfall conditions. A significant portion of the expected potential water savings has been allocated to environmental flows in the Wimmera River annually, to benefit the hydrology of the heritage river section which includes Lake Albacutya. The lower Wimmera River has been a very high priority for environmental water releases by the Wimmera CMA, but these are dependent on the level of catchment rainfall and runoff. Any environmental water releases are likely to assist to increase water levels in the lower Wimmera River, enabling significant catchment discharge events to flow further towards the terminal lakes than might otherwise have occurred.

More recently the threat of climate change and predictions of reduced catchment rainfall may, if they eventuate, add to the hydrological stresses. An extended drought has been evident since about 1995 which continues at the time of writing, and this has been attributed, at least in part, to the effects of climate change (Steffen, 2009).

River Red Gum at the margins of Lake Albacutya provide important habitat, hollows, and nesting sites for many bird species, however require flooding to trigger recruitment and boost condition after years of drought. Nine years after the Ramsar listing River Red Gum were displaying signs of dieback, possibly resulting from a lack of flooding or the associated increasingly saline water table (Wouters, 1993).

Other issues current at the time of listing include the impact of invasive species such as weeds and rabbits, however rabbit numbers were dramatically reduced after the mid 1990s when the fatal rabbit calicivirus was released in Australia, however more recently numbers appear to be increasing again. Tourism, recreation, duck hunting, fishing, and sheep grazing may also impact on the ecological character of the lake.

The components, processes and values of Lake Albacutya and the interactions between them will be explored in the following sections, along with the condition of the site and likely threats to the condition.

Aerial view of Lake Albacutya during a lake-full event (photo M. Krelle)

Outlet Creek flowing into Lake Albacutya (photo M. Krelle)

3. RAMSAR CRITERIA

The criteria for listing a Ramsar site have changed since the site was listed in 1982. The most recent revision of these criteria was in 2005. The relationship between the old and new criteria, is shown in Table 3.1.

Table 3.1 Ramsar criteria at the time of listing and current Ramsar criteria (DEWHA, 2008a)

Current criteria (2005)	Pre-1999 criteria
Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.	1(a) it is a particularly good representative example of a natural or near-natural wetland, characteristic of the appropriate biogeographical region 1(b) it is a particularly good representative example of a natural or near-natural wetland, common to more than one biogeographical region 1(c) it is a particularly good representative example of a wetland which plays a substantial hydrological, biological or ecological role in the natural functioning of an major river basin or coastal system, especially where it is located in a trans-border position 1(d) it is an example of a specific type of wetland, rare or unusual in the appropriate biogeographical region.
Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.	2(a) it supports an appreciable assemblage of rare, vulnerable or endangered species or subspecies of plant or animal, or an appreciable number of individuals of any one or more of these species.
Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.	2(b) it is of special value for maintaining the genetic and ecological diversity of a region because of the quality and peculiarities of its flora and fauna 2(d) it is of special value for one or more endemic plant or animal species or communities 3(b) it regularly supports substantial numbers of individuals from particular groups of waterfowl, indicative of wetland values, productivity or diversity.
Criterion 4: A wetland should be considered internationally important if it supports plant and/or animal species at a critical stage in their life cycles, or provides refuge during adverse conditions.	2(c) it is of special value as the habitat of plants or animals at a critical stage of their biological cycle.
Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.	3(a) it regularly supports 20,000 waterfowl.
Criterion 6: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterbird.	3(c) where data on populations are available, it regularly supports 1 per cent of the individuals in a population of one species or subspecies of waterfowl.
Criterion 7: A wetland should be considered internationally important if it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.	4(a) it supports a significant proportion of indigenous fish subspecies, species or families, life-history stages, species interactions and/or populations that are representative of wetland benefits and/or values and thereby contributes to global biological diversity.
Criterion 8: A wetland should be considered internationally important if it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.	4(b) it is an important source of food for fishes, spawning ground, nursery and/or migration path on which fish stocks, either within the wetland or elsewhere, depend.
Criterion 9: A wetland should be considered internationally important if it regularly supports 1 per cent of the individuals in a population of one species or subspecies of wetland-dependent non-avian animal species.	None.

3.1 Ramsar criteria at the time of listing (pre-1999)

At the time of listing Lake Albacutya was designated as meeting former Ramsar criteria 1(a), 1(b), 3(a), 3(b) and 3(c).

Criteria 1(a) The wetland is a particularly good representative example of a natural or near-natural wetland characteristic of the appropriate biogeographical region.
and 1(b) The wetland is a particularly good representative example of a natural or near-natural wetland common to more than one biogeographical region.

At the time of listing, Lake Albacutya was considered to be a good example of a terminal lake in the Murray-Darling Depression biogeographic region and in the wider Murray-Darling Basin.

Criteria 3(a) Regularly supports 20 000 waterfowl

Only a small amount of waterbird data exists prior to the time of listing in 1982, with quantitative records dating back only as far as 1981. The nomination statement for the site suggests that the site periodically supported in excess of 10 000 ducks and swans and 10 000 coots. No formal records can be found to verify that Lake Albacutya regularly supported 20 000 waterfowl. Designation of this criteria at the time of listing was based on expert opinion.

Criteria 3(b) Regularly supports substantial numbers of waterfowl from particular groups

Only a small amount of waterbird data exists prior to the time of listing in 1982, with quantitative records dating back only as far as 1981. The nomination statement for the site suggests that the site periodically supported in excess of 10 000 ducks and swans and 10 000 coots. There are few formal records to support his criteria at the time of listing. In 1981 and 1982, prior to the time of listing, up to 1 000 Freckled Duck had been recorded at the site along with almost 400 Red-necked Avocet and almost 200 Red-necked Stint.

Criteria 3(c) Regularly supports 1 % of the individuals in a population of one species or subspecies

In 1981 up to 300 Freckled duck were recorded at Lake Albacutya, and in 1982, prior to the time of listing up to 1000 Freckled Duck were recorded. At this time the Australian population of the species was estimated to be approximately 19 000 individuals. Thus at the time of listing waterfowl records showed that Lake Albacutya had recently supported well in excess of 1 % of the Australian population of Freckled Duck.

3.2 Current Ramsar criteria (2005)

As previously described, since the designation of Lake Albacutya as a Ramsar site the Ramsar criteria for identifying Wetlands of International Importance have been revised. Additionally there have been changes in some elements which potentially affect ecological character of the Lake Albacutya Ramsar site and additional information has become available. The following assessment takes these factors into account to determine if the site continues to meet the criteria for Ramsar listing.

Those criteria met by Lake Albacutya at the time of listing equate to current criteria 1, 3, 5 and 6. Due to the changes in the wording of the revised criteria and in light of new information it is considered that Lake Albacutya now also meets criterion 2. The justifications for Lake Albacutya satisfying criteria 1, 2, 3, 5 and 6 are detailed below.

Criterion 1: A wetland should be considered internationally important if it contains a representative, rare, or unique example of a natural or near-natural wetland type found within the appropriate biogeographic region.

Lake Albacutya is a good example of a near-natural ‘seasonal intermittent freshwater lake over 8 ha’ within the appropriate biogeographic region - the Murray-Darling Drainage Division. Within this wetland category Lake Albacutya is representative of a subterminal lake. There are ten Ramsar listed seasonal intermittent freshwater lakes over 8 ha within the Drainage Division, but Lake Albacutya is the only site comprised wholly of this wetland type. Additionally there are only four major subterminal or terminal lakes of northern flowing endorheic waterways in the Murray Darling Drainage Division, only three of which are over 5000 ha. Two of the others, Lake Hindmarsh and Lake Buloke, are impacted by rising water tables and salinisation. There has been little modification of the lake itself and surrounding environments within the site since the time of listing and it still represents a relatively intact ecosystem within the wider Murray Darling Drainage Division that has been highly modified for agricultural use. However, prior to the time of listing there had been changes to the frequency and duration of flooding.

Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.

Lake Albacutya supports the Regent Parrot (*Polytelis anthopeplus monarchoides*) which is nationally listed as vulnerable under the EPBC Act. This subspecies has a restricted distribution which is estimated to be 140 000 km^2 confined to the semi-arid interior of south-eastern Australia (DEWHA, 2009). The lower Wimmera River catchment from Wyperfeld National Park to Lake Hindmarsh (including Lake Albacutya) is one of the three main areas in Victoria to which populations of the subspecies are restricted, and is also a key breeding area (DEWHA 2009). The total population size for this subspecies has been estimated to be between 1500 and 2495 breeding birds (DEWHA 2009). In 1993 a maximum count of 50 birds was recorded at Lake Albacutya which represents at least 2 % of the population. Breeding of the subspecies at Lake Albacutya has been recorded in 1929, 1992 and 1993 (DSE, 2009b). The Regent Parrot primarily inhabits River Red Gum and adjacent Black Box woodlands with nearby Mallee providing important feeding habitat (DEWHA, 2009). This habitat is provided at Lake Albacutya. The Eucalypt woodland at Lake Albacutya provides nesting habitat for the subspecies which primarily nest in River Red Gum and occasionally Black Box, especially those in close proximity to permanent water (DEWHA, 2009).

The site has also supported the nationally vulnerable plant Ridged Water-milfoil on at least one occasion. Other nationally threatened species which mainly inhabit the adjoining Mallee landscape, but which may also be supported by the Lake Albacutya Ramsar site are Black-eared Miner (endangered), Mallee Emu-wren (vulnerable) and Malleefowl (vulnerable).

Criterion 3: A wetland should be considered internationally important if it supports populations of plant and/or animal species important for maintaining the biological diversity of a particular biogeographic region.

Lake Albacutya is located in the low rainfall semi-arid zone of north-western Victoria. The lake floods as a result of rainfall in the upper catchment of the Wimmera River, and when this occurs it provides significant habitat for water-dependent and aquatic species, many of which disperse from other regions and would not occur in this semi-arid zone location in the absence of significant intermittent freshwater lakes such as Lake Albacutya.

The site also supports populations of genetically unique River Red Gums which are significant for having the highest tolerance to drought and salinity of all varieties tested in Australia.

Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.

In the case of Lake Albacutya, 'regularly' must be interpreted in the context of an intermittent wetland which floods irregularly. This ephemeral subterminal lake is subject to periodic flood events and it is these irregular filling events which support large waterbird numbers. It appears that common waterbirds were rarely recorded prior to the 1990s. Lake Albacutya is known to have supported more than 20 000 waterbirds at times when it received riverine flows. More than 20 000 waterbirds have been recorded at Lake Albacutya on at least one and probably two occasions. When the lake last held a substantial amount of water in 1993 it supported more than 20 000 Grey Teal, more than 3 000 Eurasian Coot, 3 000 Pacific Black Duck, 3 000 Australian Wood Duck, 1 500 Hardhead and 1 000 Australian Shoveler. It also supported between 10 000 and 100 000 Banded Stilt, 1 000 Freckled Duck, 1000 Red-necked Stint and several hundred Red-Necked Avocet, Red-capped Plover, Black-winged Stilt and Sharp-tailed Sandpiper between 1982 and 1983 when the lake last experienced prolonged flooding. It is expected that when the lake again holds a significant depth of water it will again support large numbers of waterbirds in excess of 20 000.

Criterion 6: A wetland should be considered internationally important if it regularly supports 1 percent of the individuals in a population of one species or subspecies of waterbird.

In the case of Lake Albacutya, 'regularly' must be interpreted in the context of an intermittent wetland which floods irregularly. This ephemeral subterminal lake is subject to periodic flood events. It is these irregular filling events which support large waterbird numbers. Reliable, long term waterbird data is lacking but even the limited data available shows that Lake Albacutya has supported in excess of 1 % of individuals in at least three species of waterbird.

The first of these is the south-east Australian population of Freckled Duck. The population size was estimated to be a maximum of 19 000 birds in 1984 (Martindale 1984). Lake Albacutya supported more than 190 Freckled Duck in 1981, 1982 and 1983. On occasions in 1982 and 1983 1000 Freckled Duck were recorded on the lake, potentially representing up to 5 % of the national population estimated to be around 19 000 at that time. These records are from the period when the lake last held water continuously for several years. The most recent Freckled Duck population estimates indicate that the 1 % threshold for the south eastern Australian Freckled Duck population is 250 (Delany & Scott, 2006). Therefore, the next time Lake Albacutya experiences a significant filling event, it is expected that it will again support in excess of 1 % of the Freckled Duck population.

In 1983 Lake Albacutya supported over 10 000 Banded Stilt which represents at least 4.5 % of the Australian population (Delany & Scott, 2006). In 1993 there are records of 1 000 Australasian Shoveler at the lake, which meets the 1 % population threshold which was established at 1 000 in 2006 (Delany & Scott, 2006). Further data will be required to determine if in excess of 1% of the population of other species are regularly supported when water is available.

4. THE ECOLOGICAL CHARACTER OF LAKE ALBACUTYA – COMPONENTS AND PROCESSES

Ecosystem components are the tangible physical, biological and chemical entities that comprise a wetland. This includes items such as the physical size and shape of the wetland, wetland communities, species and genes, soil, water quality, and chemical compounds. There are a large number of components and subcomponents which comprise any ecosystem, all of which are important to ecosystem function (DEWHA, 2008a).

Ecosystem processes are the dynamic forces which contribute to the functioning of the wetland, including the interactions of living organisms with each other and with their environment. They may be physical, chemical or biological actions such as reproduction, predation, decomposition, erosion, nutrient and carbon cycling, evaporation, and hydrology (DEWHA, 2008a).

Processes and components can be considered separately, but in reality various components and processes are inter-related to form a complex ecological system which, together with the benefits and services discussed at Chapter 6, comprises the ecological character of the site. Therefore the components and processes are discussed within the context of the ecological character of the site, rather than individually as either components or processes.

Only some keystone components and processes directly underpin the site's unique ecological character and its ability to meet the relevant Ramsar criteria. Critical ecosystem components and processes are those that will result in a significant change in the system and its ecological character if the component or process itself is significantly altered.

Other components and processes play an indirect role in the wetland's ecological character by supporting these critical components and processes and are termed essential elements. An essential element is defined as a component or process that has an essential influence on the critical components, processes and services/benefits of the wetland. Should the essential element cease, reduce, or be lost, it would result in a detrimental impact on one or more critical component, process and services/benefits. Critical components, processes and services/benefits depend in part or fully on an essential element, but an essential element is not in itself critical for defining the ecological character of the site.

Limits of acceptable change (LAC) are not required to be established in an Ecological Character Description (ECD) for essential elements, but only for those critical components, processes and services/benefits.

This Ecological Character Description aims to describe the ecological character of the site at the time it was designated as a Ramsar site in 1982. Limited or no quantitative data or qualitative information exists for some components or processes at that time, and in those instances more recent data which assists in describing or understanding the ecological character of the site has been included.

4.1 Critical components and processes of Lake Albacutya

These following components and processes have been identified as critical in accordance with the following recommendations.

- They are important determinants of the site's unique character.
- They are important for supporting the Ramsar criteria under which the site was listed.
- Change to which is reasonably likely to occur over short or medium time scales.
- They will cause significant negative consequences if change occurs (DEWHA, 2008a).

Table 4.1 Summary of the critical components and processes of Lake Albacutya

Component	Processes	Description	Justification for identification as a critical component/process
Morphology	Geomorphology	The bed of this subterminal lake covers an area of 3938 ha, with a full capacity of 290 GL and a flood capacity of 320 GL holding water up to 8 m deep.	The lake infrequently holds large amounts of water for long periods of time, creating a unique and representative intermittent wetland habitat. Is one of only four major subterminal or terminal lakes in the Murray Darling Basin Drainage Division which fill from northern-flowing endorheic rivers.
Surface Water	Hydrology - surface water	Lake Albacutya fills intermittently from flows from the Wimmera River during periods of high rainfall in the upper catchment. Under the river regulation regime which was in place at the time of listing, the average overflow frequency of Lake Albacutya is predicted to be once in 49 years, reduced from natural conditions (once in 4 years). When full it usually retains water for several years before evaporation and seepage return it to its dry condition. Small flows may enter the lake between lake-full periods.	The intermittent hydrological cycle drives much of the ecology of the lake including: – stimulating water-bird arrival and breeding; – maintaining Eucalypt woodland health; – stimulating Eucalypt woodland recruitment; – driving the development of the Albacutya provenance of drought-resistant River Red Gum; and – development of a mature aquatic ecosystem capable of supporting predatory guilds.
Flora - Eucalypt woodland	Recruitment Regeneration	Extensive fringing Eucalypt woodland exists around the lake, primarily composed of River Red Gum (*Eucalyptus camaldulensis*).	Provides important habitat for waterbirds and the nationally vulnerable Regent Parrot. The Lake Albacutya provenance of River Red Gum is genetically unique and is adapted to high levels of salinity and drought tolerance.
Fauna - Waterbirds - Threatened species	Migration Reproduction	High waterbird abundance at the site, including: more than 10 000 each of Grey Teal and Banded Stilt, and large numbers of Eurasian Coot, Australian Shelduck, Pacific Black Duck, Australian Wood Duck, Hardhead, Australian Shoveler, Freckled Duck, Red-necked Stint. Twelve waterbird species breed at the site. At least 50 nationally vulnerable Regent Parrot have occurred at the site and are known to breed at the site.	The site supports more than 20 000 waterbirds and greater than 1 % of the populations of Freckled Duck, Grey Teal and Australasian Shoveler. The site supports up to 1 % of this nationally threatened species

4.1.1 Morphology

Lake Albacutya is the second subterminal lake of the Wimmera River. Lake Albacutya is often referred to as a terminal lake, however technically it is a subterminal lake as it has a distinct shoreline and when full it overflows via Outlet Creek to subsequent lakes in the Wimmera terminal lakes system (Timms, 2001).

Lake Albacutya covers an area of almost 6000 ha when overflowing by two or more meters. It is somewhat kidney shaped, about 10 km long and 5 km wide, with its length lying north to south. Lake Albacutya is comprised of a central flat lakebed of approximately 3,938 ha, which rises by 1-2 m within about 1 km of the perimeter of the lake, forming a shallow zone around the edge. At the outer edge of the lake, the bed rises more steeply within 250 m of the lake perimeter. It has a maximum depth of about 8 m (Ecological Associates, 2004) or possibly 12 m (Krelle, M., 2009, pers. comm.), and an average depth of 6 m. Lake Albacutya holds 230 GL when full to the point of overflow into the northern section of Outlet Creek, but has a capacity of up to 320 GL at the point where substantial flow into Outlet Creek occurs (Ecological Associates, 2004).

'Outlet Creek' refers to the creek sections between Lake Hindmarsh and Lake Albacutya and between Lake Albacutya and all downstream lakes in Wyperfeld National Park. The creek has a well defined channel about 20 m wide and continuous banks about 2-3 m high. Water enters Lake Albacutya from Outlet Creek from the south, filling the south-eastern section of the basin first. As the lake fills, water spreads across the remainder of the lakebed (Ecological Associates, 2004) and, when full, exits the lake into the northern section of Outlet Creek. Filling of Lake Albacutya is controlled by stream flows originating in the upper Wimmera River and the level of the sill at the outflow of Lake Hindmarsh. The shore of Lake Hindmarsh forms a sill of approximately 2 m above the bed of Outlet Creek, which is reported to have been deliberately lowered in 1976 to reduce the water level of Lake Hindmarsh (Ecological Associates, 2004). Once full, the flood level of Lake Albacutya is controlled by the level of the Lake Albacutya discharge sill into Outlet Creek, and the capacity of this northern section of Outlet Creek.

The lake morphology results in a wide variety of water depths when the lake is full, including large areas of relatively deep water which provides a variety of habitats for aquatic flora and fauna. Due to this depth, the lake takes several years to dry through the two main water loss mechanisms of evaporation and seepage. Wind action over the large surface area creates turbulence and waves, helping to aerate the water and increase turbidity in shallow areas and at the margins.

Table 4.2 Lakebed morphology at Lake Albacutya – relationships between volume, depth, surface area and flow rate (adapted from SKM, 2003)

Lake Albacutya						**Albacutya Outlet**		
Lake Volume (ML)	Depth (m)		Lake Volume (ML)	Surface Area (Ha)		Lake Volume (ML)	Flow Rate (ML/month)	ML/Day
0	0		0	0		0	0	0
4000	0.1		9970	198		230000	0	0
76000	2		23127	2752		290010	4044	135
170000	4		46256	3658		320000	6592	220
220000	5		69383	3998		330000	9888	330
260000	6		110756	4383		350000	21530	718
290000	6.599		167033	4706		370000	103680	3456
300000	6.61		21289	4986		380000	129600	4320
320000	7.199		260572	5301				
330000	7.4		342804	5852				
370000	8.399							
380000	8.6							

The geology of the wider area is composed of mainly Quaternary alluvial, lacustrine and aeolian sediments and calcareous sand dunes (Ecological Associates, 2004). The soils around Lake Albacutya are Quaternary aeolian sediments while those of the lakebed and shoreline are Quarternary fluvial deposits (National Parks Service, 1980). Some gypsum deposits occur in the soil along the eastern shoreline (National Parks Service, 1980). The underlying soils of Lake Albacutya are generally brown or grey calcareous clays (National Parks Service, 1980). These underlying clays provide a relatively impermeable base, slowing infiltration from surface to groundwaters and allowing the lake to hold water (Wimmera CMA, 2004). Variable depths of grey sands and loams overlay these clays within the top 100 cm (National Parks Service, 1980). The soils of the inner lakebed are comprised mainly of rich organic clays while the outer lakebed generally has courser sandier soils (Robinson et al, 2005), which are less nutrient rich (National Parks Service, 1980) and are more permeable (Ecological Associates, 2004). Surface soils are generally neutral to slightly alkaline, with marked variability in EC and available phosphorus and potassium (Table 4.3). The salinity, alkalinity, and clay content increase with depth (Table 4.4).

Table 4.3 Surface soils at various sites at Lake Albacutya (adapted from National Parks Service, 1980)

Approximate location	Soil description	pH	Electrical conductivity µS/cm	Available potassium PPM	Available phosphorus PPM
Northern end, west	Greyish brown sandy clay	7.6	31	115	3.2
Northern end	Very light grey brown sand	6.8	18	22	0.8
Eastern edge, north	Very light grey brown sand	6.9	16	50	1.5
Eastern edge, north	Dark grey light clay	7.7	119	730	18.5
Eastern edge, north	Greyish brown sandy loam	7.5	23	129	2.9
Eastern edge	Greyish yellow heavy medium clay	8.6	6420	730	15.1
Eastern edge, south	Very light grey brown sand	8.8	328	78	1.5
Eastern edge, south	Light brown yellow grey medium clay	8.9	140	494	2.5
Eastern edge, south	Light yellow grey medium clay	9	227	335	3.3
Southern end, east	Yellowish grey medium clay	8.7	658	850	4
Southern end, east	Light brown yellow grey medium clay	8.9	1480	216	2.0
Southern end	Brownish grey sandy loam	7.9	75	203	5.4
Southern end, west	Very light grey brown sand	7.2	38	50	0.9
Western edge, south	Brown heavy sandy loam	7.1	41	394	1.9

Table 4.4 Soil profile at one site in the middle of the eastern shoreline at Lake Albacutya (adapted from Wouters, 1993)

Depth	Electrical conductivity dSm-1	Soil type	Moisture	Ph
0-10cm	0.099	Sandy Clay Loam (20-30 % clay)	8.4 %	6.8
10-25cm	0.197	Sandy Clay (35-40 % clay)	19.4 %	6.6
25-50cm	0.213	Sandy Clay (35-40 % clay)	16.3 %	6.2
50-100cm	0.385	Sandy Clay (35-40 % clay)	16.7 %	7.4
100-150cm	0.362	Not examined	12.8 %	8.2
150-200cm	0.752	Not examined	13.6 %	9.0

4.1.2 Hydrology - Surface water

The volume of water in Lake Albacutya is mainly a function of streamflow into the lake from the Wimmera River via Outlet Creek, moderated by evaporation from the lake and percolation into the soil profile. Typically, local precipitation and groundwater inflows into Lake Albacutya are negligible and the lake depends on the transmission of large flows along the Wimmera River which originate in the Grampian and Pyrenees Mountain Ranges. The large Lake Hindmarsh (capacity 380 GL when full and 630 GL when significant overflow occurs), upstream of Lake Albacutya, must first fill and overflow, before Lake Albacutya can begin to receive water.

In most years the flow from the Wimmera River is insufficient to replace the annual evaporation and percolation losses from the lower Wimmera River and Lake Hindmarsh so no water reaches Lake Albacutya. In a succession of wet years however, Lake Hindmarsh overflows into Outlet Creek which carries water to Lake Albacutya and sometimes to the lakes beyond. This occurs irregularly and gives the lake its unique wet-dry cycle.

4.1.2.1 Background information – river regulation

Diversions of water from the Wimmera River for domestic and stock supply began in the 1850s. In the early 1850s an earthen dam was constructed across the Wimmera River to divert water into Yarriambiack Creek, a distributary upstream of Horsham. This was soon followed by the construction of various diversion and storage structures to become part of the Wimmera-Mallee Stock and Domestic Supply System (Van Veldhuisen, 2001). After that, regulation of the Wimmera River increased significantly to meet the needs of the ever expanding Wimmera-Mallee Stock and Domestic Water Supply System (WMSDWSS) particularly after the 1950s, until it became one of the largest of its type in the world (Moore, 1988, Sandell, 1996).

The WMSDWSS captures, detains and distributes water in the Wimmera and Glenelg catchments (Ecological Associates, 2004). Water is captured in winter and spring and released to consumers throughout the year. Around 1982 the system comprised 12 main storages with a total capacity of about 770 000 ML, capable of supplying over 200 000 ML per year. The system supplied an area of almost 30 000 km^2 including over 15 000 rural properties and over 50 towns and villages. Water was supplied to users via an extensive system of earthen channels of about 18 000 km in total length. These open channels had very poor water delivery efficiencies with loss through seepage and evaporation as high as 85 % of total diversions (Victorian Government, 2003).

The WMSDWSS is able to capture a significant proportion of high flows in the Wimmera River and its tributaries, reducing the frequency and magnitude of flow events reaching the terminal lakes (Ecological Associates, 2004). The WMSDWSS also utilises water from the Glenelg River to supplement water extracted from the Wimmera River Basin, which may form part of the diversion figures, especially prior to 1976.

Many minor structures also regulate flows in the catchment, such as concrete structures near the mouth of Yarriambiack Creek, a major distributary of the lower Wimmera River. These structures block very low flows and ensure that overtopping occurs below 1 m of water depth, simultaneously allowing water into both Yarriambiack Creek and the lower Wimmera River. Low level flows in the creek may be up to 56 % of flows in the lower Wimmera River (Water Technology, 2009), however the impact of these minor structures is considered to be relatively small compared to the effects of the WMSDWSS.

4.1.2.2 Surface water hydrology at the time of listing

There are several factors which cause difficulty in describing the hydrology of Lake Albacutya at the time of listing in 1982.

Reliable long-term data on the actual inflows or water levels of Lake Albacutya does not exist. A historical record based on incidental and anecdotal evidence has been compiled by Sandell, 1996, from a variety of sources (Figure 4.1) but does not provide a comprehensive picture of the lake's hydrology, and does not include small or short term flood events.

Flood pulses reaching Lake Albacutya have been influenced, over time, by changes including:

- increasing regulation of the Wimmera River since the 1800s which has resulted in reduced frequency and duration of flooding (Ecological Associates, 2004).
- expansion of land clearing which has probably decreased evapotranspiration and increased run-off in the higher rainfall upper catchment (Bond and Cottingham, 2008), although catchment rainfall remained essentially the same (see Figure 2.3).

It is not possible to confirm if a major change in the flooding regime of Lake Albacutya has occurred since the time of listing based on the incomplete available records, and as a result of competing forces and the natural rainfall variability. However, there is a clear indication that very large floods that produce the flooding of lakes downstream of Lake Albacutya had become less frequent by 1982 (Sandell, 1996).

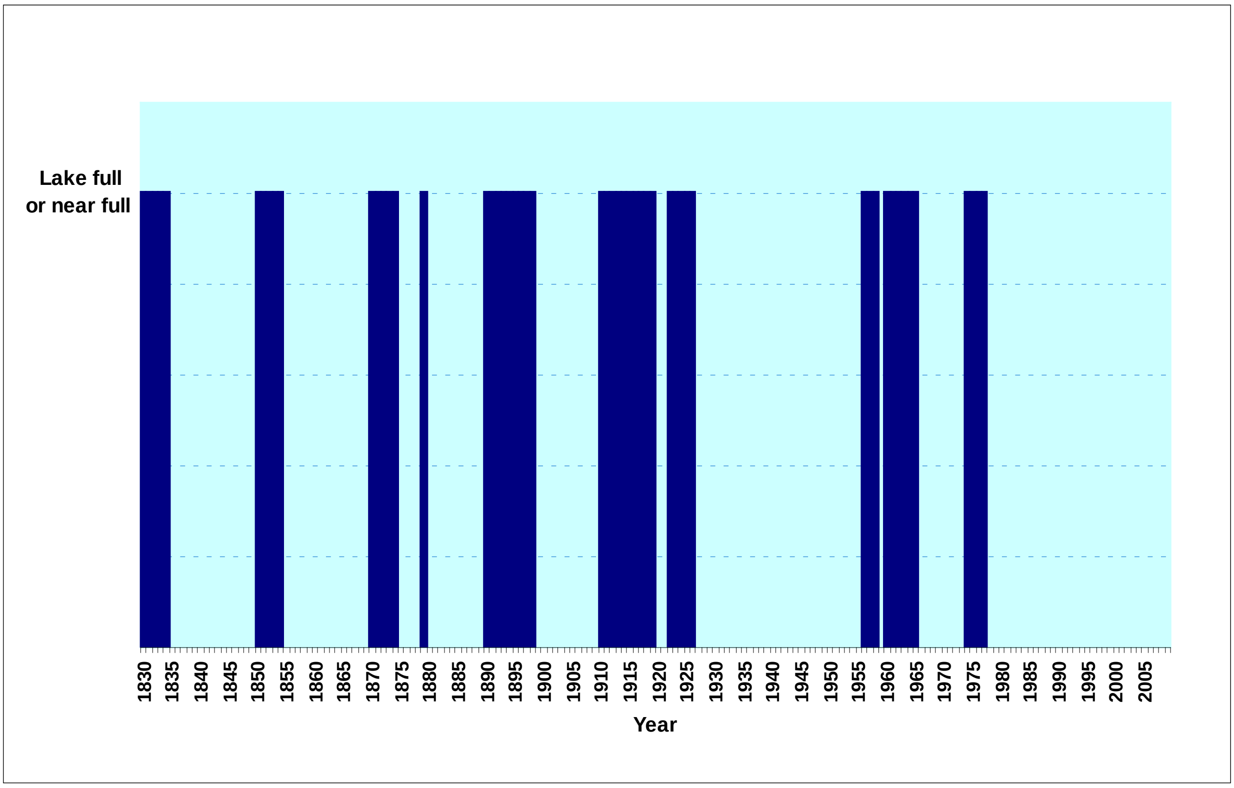


Figure 4.1 Historical flooding events during which Lake Albacutya contained significant volumes of water and overflowed at least once (periods of low volume and small inflows are not shown) (created from data in Sandell, 1996)

Table 4.5 and Figure 4.1 do suggest that, leading up to the time of listing, flood pulses in Lake Albacutya had become increasingly variable as evidenced by the 30 year dry period from 1926 to 1956, and the three floods in relatively quick succession from 1956 to 1974. However the first five and the last five lake-full events have similar average return periods (12 to 13 years) and similar total lake-full period (33 % based on the lake-full minimum periods possible).

Table 4.5 Floods during which at least one overflow event occurred (adapted from Sandell, 1996)

Lake-full event	Year from	Year to	Maximum duration of lake-full event	Minimum duration of lake-full event
1	1830	1834	5	< 4
2	1851	1854	4	< 3
3	1870	1874	5	< 4
4	1879	1879	1	< 1
5	1890	1898	9	< 8
6	1910	1919	10	< 9
7	1922	1926	5	< 4
8	1956	1959	4	< 3
9	1960	1965	6	< 5
10	1974	1977	4	< 3

In the 90 year period between 1830 and 1920 six flooding events were recorded, during each of which Lake Albacutya overflowed at least once. Major flooding, which filled all the terminal lakes downstream of Lake Albacutya, was recorded 4 times within that period, in 1830-34, 1851-54, 1870-74 and 1918. The records show that in more recent times from 1920 to 2009 (almost 90 years) Lake Albacutya only experienced four flooding events in which the lake overflowed at least once (1922-26, 1956-59, 1960-65 and 1974-77), and none of these resulted in major flooding of the terminal lakes downstream of Lake Albacutya. Lake Albacutya last filled in 1974, staying full until 1977 and holding water until about 1983, while small flows entered the lake in 1981, 1983, 1992-3 and 1996 (Sandell, 1996).

Based on the available data it is apparent that in 1982, and in fact from around the 1920s, major flooding of Lake Albacutya had become less frequent and large floods in which water reached the terminal lakes beyond in Wyperfeld National Park were also less frequent. There was no significant downward trend or other change in rainfall for the catchment during this period to explain this pattern.

Over the longer term, this reduced frequency and extent of flooding of the lower Wimmera River system has been attributed to the ongoing uptake of water from the Wimmera River into storage for domestic and agricultural use (Bren & Acenolaza, 2000, Binnie & Partners, 1991).

Water diverted into reservoirs in the Wimmera River catchment includes some water diverted from the Glenelg River catchment. Data provided by GWMWater prior to 1976 has been developed from the Resource Allocation Model (REALM) in the absence of collated hardcopy data, but data after 1976 are based on actual figures (Figure 4.2). These data show that the average annual volume captured in storages from 30 years prior to 1982 was 184 559 ML, ranging from 10 000 ML to 630 000 ML in any one year.

The average annual volume of 176 000 ML captured in reservoirs in the 50 years to 1990 (GWMWater, 2009) is 134 % of the average flows in the lower Wimmera River which averaged 131 000 ML per year at Horsham in this same period from 1940 to 1990 (Bren & Acenolaza, 2000). Clearly, the water diverted to storage reservoirs from 1940 to 1990 (including at the time of listing) regularly exceeded the average annual flows in the lower Wimmera River.

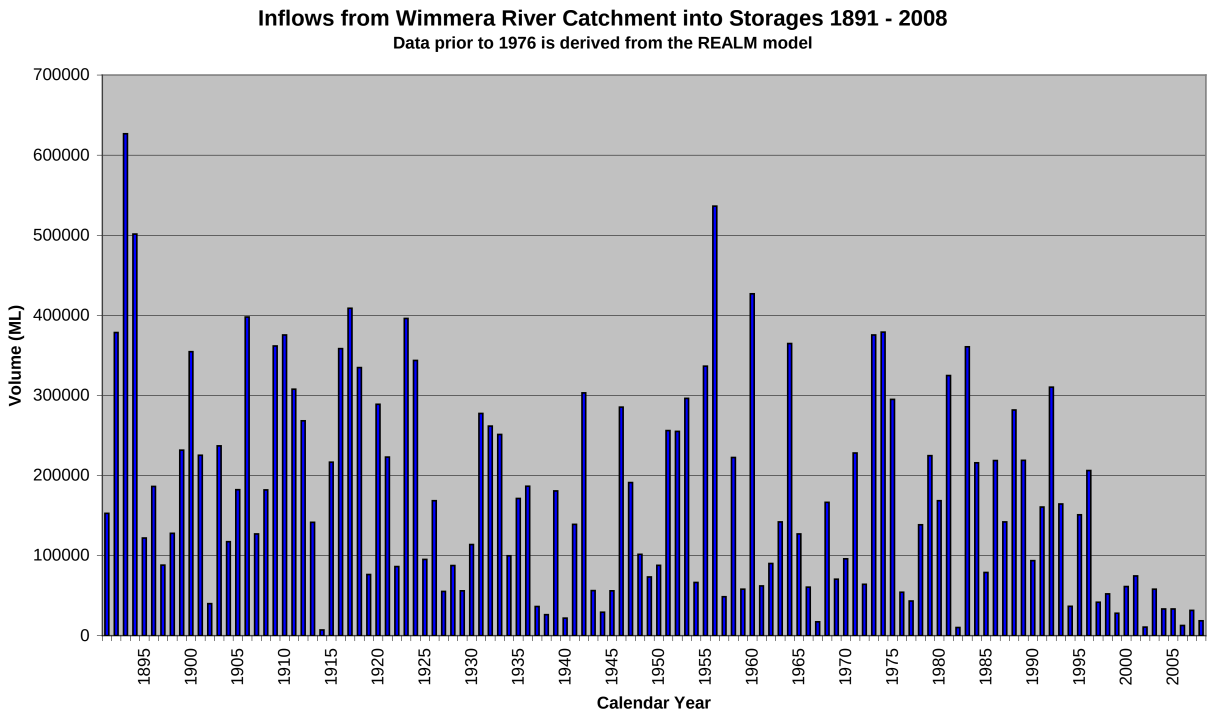


Figure 4.2 Wimmera River catchment inflows to storages 1891 – 2008 (GWMWater, 2009)

Water is captured in storages to supply urban and rural users. As shown in Figure 4.3 from the 1940s to the 1980s deliveries from storages to the supply system increased from under 100 000 ML to approximately 200 000 ML per year (Sandell, 1996). Recent data from Figure 4.4 shows that the average delivery to the supply system between 1976 and 2008 was 176 000ML, peaking in 1982 at 226 000 ML (GWMWater, 2009). Some of the water delivered to and from storages was obtained from the Glenelg River catchment, however volumes are considered relatively minor.

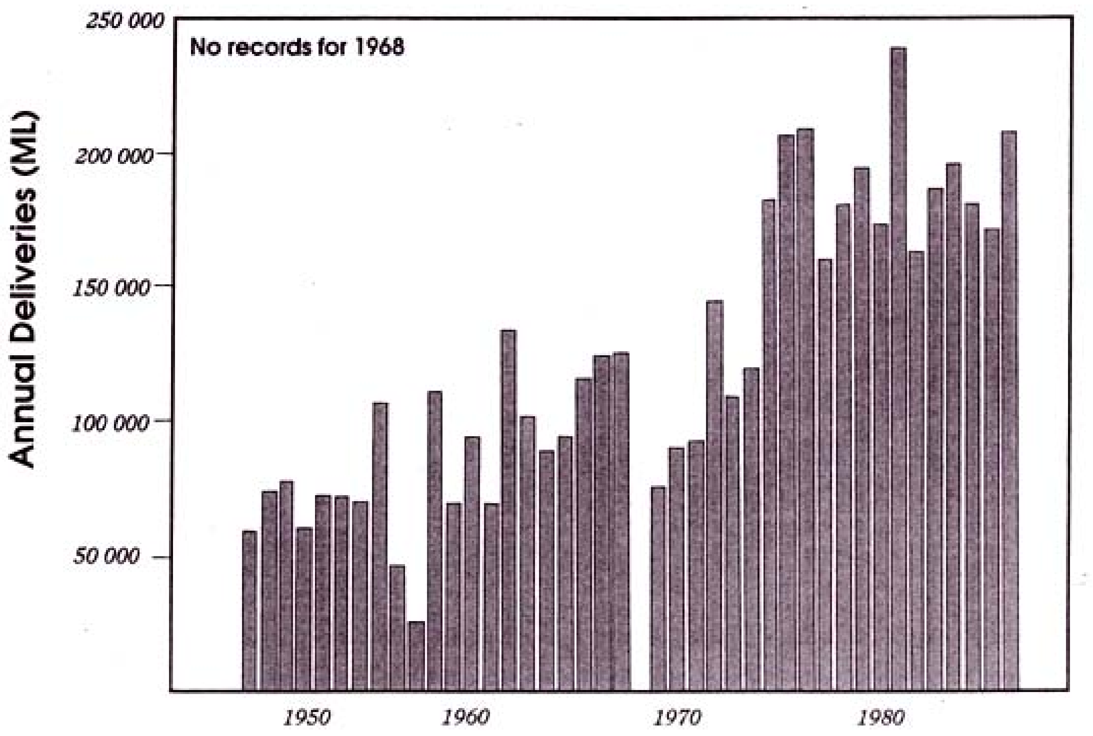


Figure 4.3 Historical diversions to the WMSDWSS (no data is available prior to 1947) (Hydrotechnology, 1993)

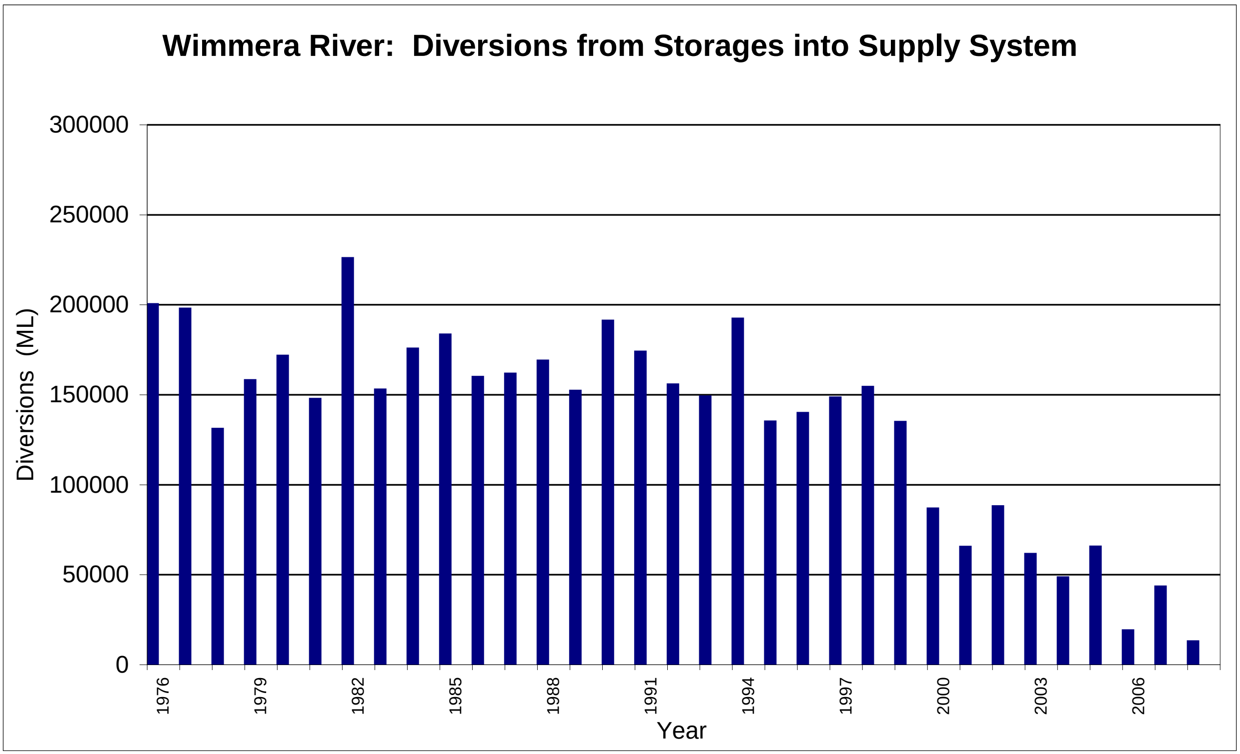


Figure 4.4 Diversions to the WMSDWSS between 1976 and 2008 (GWMWater, 2009)

In order to better understand Lake Albacutya and the impacts of river regulation, several studies were commissioned to investigate the hydrology of the lake including through the use of simulation models to describe and compare wet/dry cycles under both 'natural' and 'regulated' flow regimes. These models provide the most comprehensive indication of how the hydrology of Lake Albacutya has changed as a result of river regulation.

Models were developed and tested using available long-term data, primarily regional rainfall records, Wimmera River streamflow records, regulation and diversion records and historical hydrological records of the terminal lakes. Each of these models depicts a dramatic decrease in the filling frequency of Lake Albacutya as a result of river regulation (Binnie & Partners, 1991, Hydrotechnology, 1993, Bren & Acenolaza, 2000, Ecological Associates, 2004). The most comprehensive and recent model estimated a natural overflow frequency of 1 in 4 years compared with a regulated overflow frequency of 1 in 49 years (Ecological Associates, 2004). This model was developed based on the river regulation conditions current around 2004. In the absence of specific information for the time of listing, the hydrology described by this model represents the best estimate of the situation at the time of listing in 1982. Regulation had not changed significantly between 1982 and use of the model in 2004, although diversions decreased due to declining rainfall since 1995, possibly as a result of climate change (this is further discussed in chapters 5 and 9). The study by Ecological Associates in 2004 examined the hydrological cycle in Lake Albacutya in a 97.5 year period between 1903 and 2000, using the Resource Allocation Model (REALM) to investigate flow regimes in the Wimmera catchment. The REALM package was developed and tested over many years by the Victorian Department of Sustainability and Environment and was adopted as the modeling standard for water resource planning and management in Victoria.

This model demonstrated that under the 2004 regulation scenario, Lake Albacutya would have filled much less often and for much shorter periods than would be the case under natural conditions. The model showed that during the study period Lake Albacutya would have been empty or below 1 m deep for a total of 954 months under the 2004 regulation conditions, compared with only 224 months at or below 1 m deep in a natural or no regulation scenario.

According to this study, the frequency of Lake Albacutya overflowing was approximately 1 in 49 years under 2004 regulation compared with 1 in 4 years under natural conditions. The average duration of overflow events had also been reduced from 19.2 months to 11 months under natural and 2004 conditions respectively. Major floods which caused substantial flow in Outlet Creek downstream from Lake Albacutya were predicted to occur only once in 100 years under 2004 conditions compared with 17 times in 100 years under natural conditions.

This model also examined the likely occurrence of various flood intervals and determined that overflow events of 6 months duration would occur every 6 years under natural conditions and every 60 years with 2004 levels of regulation. Overflow events of 2 years duration would occur less than every 100 years with regulation, compared with every 10 years naturally. The maximum duration of the lake being totally empty would have been 43 months (about 4 years) naturally, compared with up to 368 months (about 30 years) under the regulation conditions of 2004.

Table 4.6 Analysis of modelled durations spent empty, shallow (<1m deep), full and full + 2m (with substantial flow into Outlet Creek) under natural and current (2004) conditions for Lake Albacutya (Ecological Associates, 2004)

Scenario	Threshold	Lake level below threshold			Lake level above threshold		
		No. Events (in 97.5 yrs)	Average Spell Duration (months)	Maximum Spell Duration (months)	No. Events (in 97.5 yrs)	Average Spell Duration (months)	Maximum Spell Duration (months)
Natural	Empty	6	16.2	43	6	178.8	392
	Shallow	7	32.7	55	7	134.4	322
	Full	23	32.5	321	22	19.2	50
	Full + 2m	18	61.3	382	17	3.9	8
Current	Empty	7	122.9	368	6	51.7	112
	Shallow	6	159.7	387	5	42.4	98
	Full	3	382.7	647	2	11	21
	Full + 2m	2	583.5	875	1	3	3

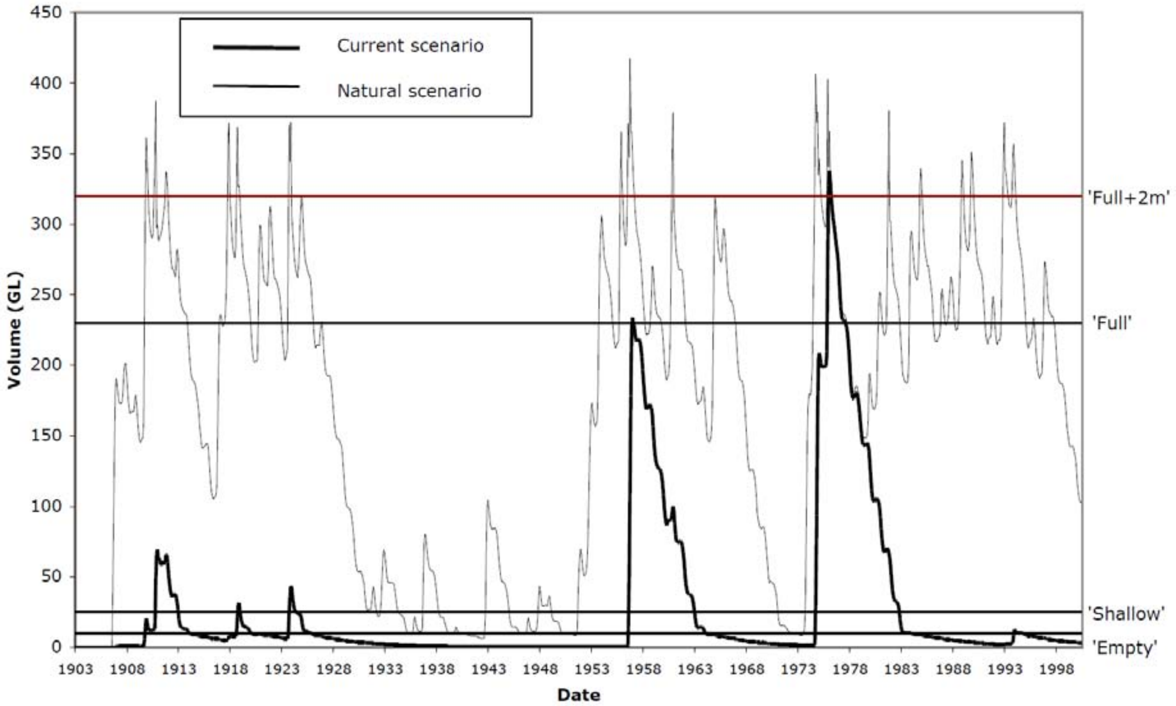


Figure 4.5 Modelled water levels in Lake Albacutya from 1903 to 2000 under natural conditions and current (2004) regulation conditions (Ecological Associates, 2004)

Wet antecedent conditions in the Wimmera River are important to enable sufficient flows to produce flooding in Lake Albacutya. When antecedent conditions are dry (which was often the case with high levels of regulation) significant amounts of water are lost during transmission down the river system and even potentially large flow events do not reach Lake Albacutya. Because of the large amount of water diverted from the system at the time of listing, significantly more rainfall was required for Lake Albacutya to receive water or fill to capacity, making it significantly less likely.

4.1.2.3 The role of hydrology in the ecological character of Lake Albacutya

The hydrological cycle of Lake Albacutya is arguably the most important process defining the ecological character of the site. It is the hydrological cycle which supports the various plant and animal populations and drives most biotic processes. The distinct wet/dry phases of the hydrological cycle determine the unique ecological character of the site. Like the hydrology, much of the ecology of the site operates in phases and therefore can be very different at any given time depending upon the water availability. When dry, the lake assumes many of the characteristics of terrestrial ecosystems supporting grasslands and terrestrial fauna. When flooded, however, the lake becomes a major aquatic ecosystem supporting significant populations of waterbirds and aquatic flora and fauna. Because the lake spends long periods dry, but holds water for several years when flooded, it is capable of supporting well developed and mature communities in both states (Ecological Associates, 2004).

Hydrology plays a crucial role in the following ecological processes:

- Maintaining River Red Gum health
- Stimulating River Red Gum recruitment
- Driving the development of the Albacutya provenance of drought-resistant River Red Gum
- Creating aquatic habitat and supporting development of mature aquatic ecosystems
- Stimulating water-bird arrival and breeding
- Replenishing groundwater and diluting saline groundwater
- Resetting succession of terrestrial lakebed vegetation
- Contributing to nutrient cycling through driving successional phases

4.1.3 Eucalypt woodland

The key component of vegetation at the site is the approximately 1,271 ha Eucalypt woodland that fringes the lake around the high water mark within the Lake Albacutya Ramsar site. This community is comprised primarily of River Red Gum and Black Box. Lignum is an important understorey component in some locations. This community provides important roosting and nesting habitat for waterbirds and the nationally vulnerable Regent Parrot. The population of River Red Gum at Lake Albacutya is genetically unique, showing particularly high levels of drought and salt tolerance (Bren & Acenolaza, 2000).

4.1.3.1 Ecology of Eucalypt woodland at Lake Albacutya

It has been widely documented that River Red Gums require regular flooding for their ongoing survival (Bren & Acenolaza, 2000, Wouters, 1993). Repeated flooding of the root zone increases soil moisture and dilutes salt concentrations (Ecological Associates, 2004). It is thought that flood periods stimulate tree growth and enable the trees to withstand subsequent drought periods. It has been suggested that the health of River Red Gum communities at Lake Albacutya relies heavily on the natural hydrological cycle and that recent disruptions to this cycle are having detrimental effects on the River Red Gum population. Bren & Acenolaza (2000) compared maps of flooding in 1976 with maps of River Red Gum health for the area and found that areas of regrowth and healthy vegetation were generally associated with the area recently inundated. The incidence of slight and moderate dieback increased with distance from the previously flooded area for up to 1 and 2 km respectively from the area inundated. The incidence of severe dieback increased proportionally to the distance from flooding to the limit of the mapped areas. It was concluded that the dieback of River Red Gum reflects the recent absence of flooding.

River Red Gum communities also require flooding for successful recruitment (Bren & Acenolaza, 2000, Wouters, 1993). Flooding at Lake Albacutya leads to mass recruitment along and below the high water mark. Seedlings densely colonise the lake fringes as floodwaters recede (Morton & Heislers, 1978). It has been suggested that these species require considerable moisture or even prolonged submersion for successful germination and establishment (Morton & Heislers, 1978). Regular recruitment is necessary to preserve a viable age structure in this community and to secure the long-term viability of the population (Ecological Associates, 2004). Early seedling survival is dependent on adequate soil moisture reserves until a tap root is formed to reach subsoil moisture, thought to take two years (Jensen, 2008).

Although River Red Gum are reliant on regular surface flooding for persistence and regeneration, they may also source part of their water requirements from the groundwater during droughts. Their large root system allows them to access water from deep in the soil, while shallow lateral roots make use of surface moisture. Therefore the quantity and quality of groundwater may also be important to the health and survival of River Red Gum community (Wouters, 1993). Groundwater at Lake Albacutya is approximately 9 m below the surface and is highly saline, limiting its usage by River Red Gums. During flooding, however, a freshwater lens may form above these saline groundwaters, which may provide a water source for River Red Gum. Reduced flooding at Lake Albacutya may result in increased groundwater salinity, impacting negatively on River Red Gum health.

Black box, although not as widespread at the site, also makes up an important part of the fringing woodlands of Lake Albacutya in some areas. Like River Red Gum, Black Box thrives where there is periodic flooding of its roots in areas which are subject to alternate flooding and drying. They are often found close together and often co-exist, Black Box however tends to dominate on loamy soils in slightly higher topographical situations than River Red Gum (Morton & Heislers, 1978). Black box extends to the upper limit of floodwaters. Lignum is often a component of the understorey of the Eucalypt woodland and like these species it persists during floods and is well adapted to the prevailing hydrological cycle (Ecological Associates, 2004). Flooding is also needed to stimulate regeneration in Black Box and Lignum populations (National Parks Service, 1980).

Inundated Eucalypt woodland at Lake Albacutya (photo M. Krelle)

Eucalypt woodland around Lake Albacutya plays a fundamental role in the ecology of the lake. Unlike ephemeral populations of either strictly aquatic or strictly dryland species which colonise the lake at various times, this community is a constant component of the ecological character of the site. Rather than opportunistically exploiting various phases in the hydrological cycle, this community is adapted to the periodic wetting and drying that is characteristic of this environment. Lake Albacutya provenance River Red Gum has the highest tolerance to salinity and drought conditions of all varieties tested (Bren & Acenolaza, 2000).

The main canopy species (River Red Gum and Black Box) are persistent within the Eucalypt woodland community throughout wet and dry cycles, whereas the understorey changes with the hydrological regime. When dry, the understorey of the community also comprises terrestrial woodland species such as sticky hop-bush, three-nerve wattle, ruby saltbush, berry saltbush, nodding saltbush and short-leaf bluebush, and grasses. When the Eucalypt woodland is flooded these are replaced with water dependent species such as red water-milfoil, southern liquorice, common reed and Australian saltgrass (Ecological Associates, 2004).

The constancy of the main components of this community, the River Red Gum and Black Box, means that they interact with other components from both the wet and dry phases of the lake. In particular they provide important habitat for both terrestrial and aquatic fauna and flora species.

Mature River Red Gums provide an important source of tree hollows which are important for terrestrial species including the nationally vulnerable Regent Parrot, as well as Major Mitchell's Cockatoo and the Sulphur Crested Cockatoo (Ecological Associates, 2004). During dry phases the understorey also accumulates woody debris and leaf litter, which provide habitat for terrestrial invertebrates, which in turn provide food and foraging environment for reptiles and mammals.

During large floods, the River Red Gums closest to the lake become inundated, their trunks becoming crucial substrate for aquatic flora and fauna. The accumulated organic matter also provides habitat and nutrients for aquatic organisms. With prolonged inundation, the understorey terrestrial vegetation together with woodland species that may have colonised the dry lakebed flood and drown, and also contribute structural habitat and nutrients to the lake's aquatic ecosystem. The aquatic plants which then colonise the understorey during flooding also provide habitat and a food source for aquatic fauna and waterbirds. The presence of submerged dead and living vegetation and organic material is crucial to the abundance and diversity of aquatic invertebrates, which in turn provide the trophic building blocks for fish and waterbird communities. During the wet phase River Red Gums and other emergent vegetation become an important breeding and roosting habitat for many waterbirds such as heron, cormorant, darter and numerous species of duck (Ecological Associates, 2004). Regent Parrot is also more likely to breed in trees that are within 16 m of water (DEWHA, 2009).

4.1.3.2 Condition of the Eucalypt woodland at Lake Albacutya.

A study of River Red Gum health at Lake Albacutya in 1993 revealed that the trees at Lake Albacutya were suffering from widespread dieback (Wouters, 1993). As indicated by Figure 4.6, slight to severe dieback was affecting much of the River Red Gum community to the north, east and south of the lake. There were also very few areas of healthy River Red Gum recruitment with the exception of a small patch on the north western edge. There were however significant patches of healthy mature River Red Gum, particularly on the western side of the lake. This trend is constant throughout the River Red Gum communities of the lower Wimmera, with dieback affecting over 80 % of River Red Gums in the area and over 50 % suffering moderate or severe dieback.

Eucalypt dieback refers to a range of diseases or stresses which produce deterioration in crown health and vigour. It is thought that the dieback of River Red Gums in the terminal lakes system is a result of the ongoing trend of reduced flooding over the last century. The lack of regular surface flooding in combination with rising groundwater salinity, has led to a decrease in the availability of usable water (Wouters, 1993). Groundwater levels are closer to the ground surface in the vicinity of Lake Hindmarsh, and surface salinisation and high groundwater salinity has probably contributed to dieback of River Red Gum in that area. Groundwater is much deeper at Lake Albacutya so groundwater salinity is less likely to be a cause of dieback in this area.

There is thought to be a time lag between the factors affecting River Red Gum health and the occurrence of obvious dieback. River red gum are highly drought and salinity tolerant and may withstand adverse conditions for long periods of time, however if poor conditions are prolonged, energy reserves will become depleted and crown deterioration will occur. This is likely to be the situation at the Wimmera terminal lakes system. Tree death may occur if conditions continue. Trees suffering from dieback may recover, however, if conditions improve (Wouters, 1993).

The limited amount of River Red Gum recruitment in the area is attributed to a reduction in flooding of the site, as two years of soil moisture is required for seedling survival (Jensen, 2008). Grazing by rabbits and high numbers of kangaroos are also thought to have impeded River Red Gum recruitment (Wouters, 1993).

Prior to gazettal of the Lake Albacutya Park in 1980, the area was privately owned and sheep grazed most if not all of the site. Sheep grazing is directly linked to low recruitment of River Red Gum (Jensen, 2008), and is likely to be a factor that influenced the observation of Wouters in 1993.

The exact extent of dieback at the time of listing in 1982 is unknown, however it has been reported that dieback of River Red Gums associated with the Outlet Creek system of the Wimmera subterminal lakes had began by at least 1960 and dieback in the area was well-advanced by the mid 1970s (Wouters, 1993). This indicates that River Red Gum dieback at Lake Albacutya was probably already significant at the time of listing, but the extent is unknown.

Examples of River Red Gum dieback at Lake Albacutya (photos A. Cibilic)

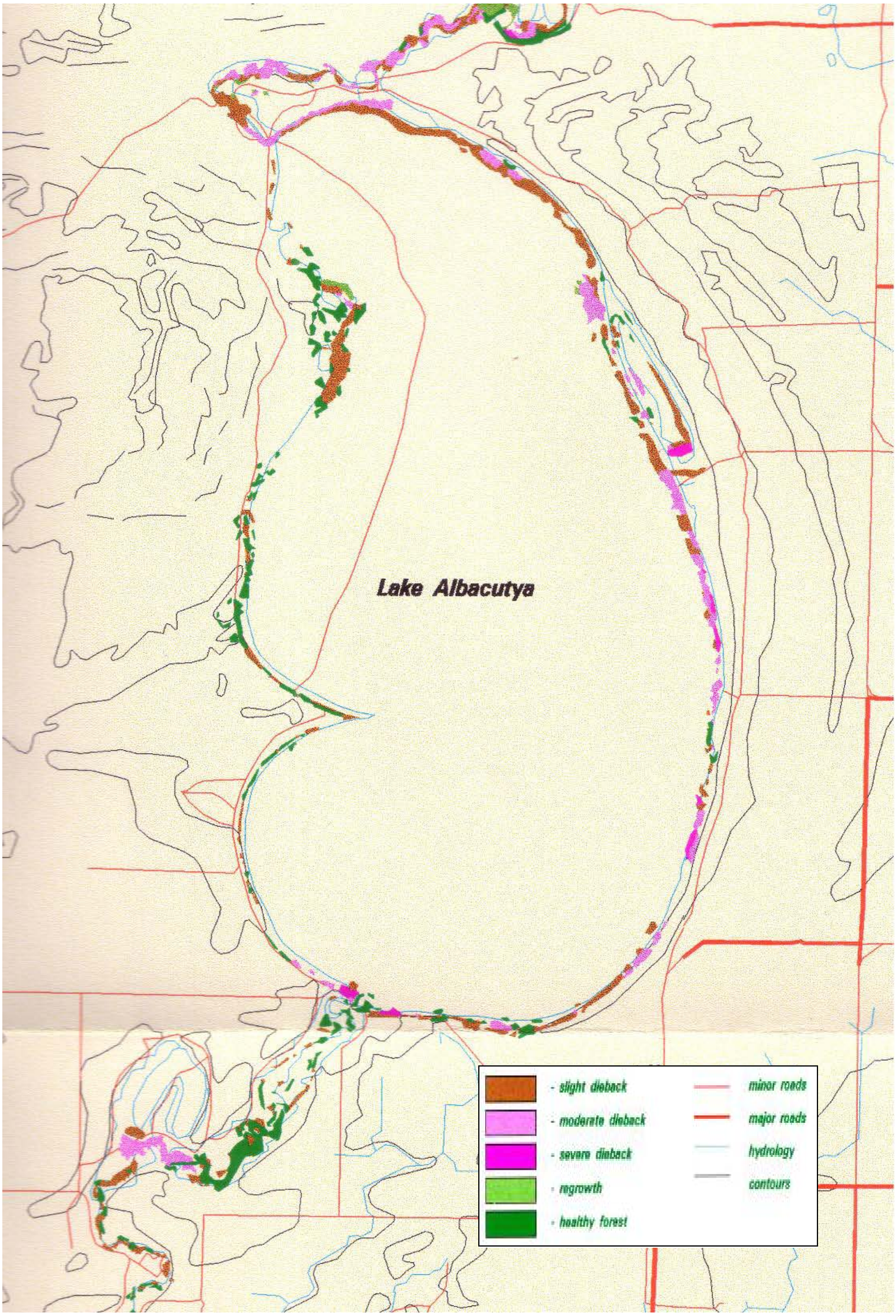


Figure 4.6 River red gum dieback at Lake Albacutya in 1993 – see Appendix 2 for definition of dieback categories (adapted from Wouters, 1993)

4.1.4 Waterbirds

When Lake Albacutya fills a significant waterbird community may form at Lake Albacutya, becoming a highly significant part of the site's ecological character. Large numbers of individuals and many species of waterbird utilise Lake Albacutya as habitat, feeding on the highly productive aquatic community that develops. During flood events waterbird breeding may occur if the event is of sufficient duration and extent, with many species using the fringing macrophytes and Eucalypt woodland as nesting habitat.

Very few waterbird data prior to 1982 exist, with most records commencing in 1981 after the major 1974 to 1977 lake-full event. Prior to this event, Lake Albacutya was known for its duck hunting and large numbers of waterbirds, however records proved difficult to locate. As a result, more recent data have been used to substantiate the significance of waterbirds for Lake Albacutya. As little replication of results has occurred, the confidence level of this data in relation to long-term water bird occurance is relatively low.

4.1.4.1 Waterbirds using Lake Albacutya as habitat

According to the Victorian Fauna Database 60 waterbird species have been recorded at Lake Albacutya and 12 species have been recorded breeding at the site. Of the species recorded 13 are on the CAMBA list,11 of these are also listed on JAMBA, and a further 8 of these are also listed on ROKAMBA. Eighteen of the recorded species are listed on the Advisory List of threatened vertebrate fauna in Victoria (2007) and 8 of these are also listed on the *Flora and Fauna Guarantee Act 1988 (Victoria)* threatened list, 2009 (see Appendix 1).

Several species have been recorded in very high numbers. Up to 20 000 Grey Teal have been recorded at Lake Albacutya, along with 3000 Eurasian Coot, 3000 Australian Shelduck, 3000 Pacific Black Duck and 2000 Australian Wood Duck. More than 10 000 Banded Stilt were recorded in 1983, which represents over 4.5 % of the estimated Australian population (Rose & Scott, 1994, Delany & Scott, 2006).There are also records of up to 1000 nationally endangered Freckled Duck occurring at the lake in 1982 and 1983 which represented more than 5 % of the south east Australian Freckled Duck population, which was estimated at a maximum of 19 000 birds around that time (Martindale, 1984). In 1993 there are records of 1,000 nationally vulnerable Australasian Shoveler, meeting the current 1 % threshold of the south-east Australian population of this species (Delany & Scott, 2006). There are records of 1500 Hardhead which are listed as vulnerable on the Victorian Advisory List. Over 1000 Red-necked Stint have been recorded, along with over 750 Sharp-tailed Sandpiper and 87 Curlew Sandpiper, all of which are listed on JAMBA, CAMBA and ROKAMBA. High numbers of Red-necked Avocet, Red-capped Plover, Black-winged Stilt, Red-kneed Dotterel, and Black-fronted Dotterel have also been recorded.

Common Greenshank – an international treaty species recorded at Lake Albacutya (photo I. Morgan)

These numbers include records up to the present time. Counts of 50 and above for all species in all years are presented in Table 4.6 below. Freckled Duck, Banded Stilt, Black-fronted Dotterel, Black-winged Stilt, Curlew Sandpiper, Red-capped Plover, Red-kneed Dotterel, Red-necked Avocet, Red-necked Stint and Sharp-tailed Sandpiper were recorded in high numbers around the time of listing, when the lake was drying from a lake-full event of several years. High counts of many species were recorded in 1993 when a small flow entered the lake and these have been included. It is interesting to note that abundant waterbird species recorded were completely different between the two events. It is possible that the waterbird data was collected with a different focus, or more thoroughly in recent years than at the time of listing, which could account for the vast difference in high count species between the two time periods. Alternatively, the more recent records from 1993 may represent a baseline for short, low flow events, while the previous records from around the time of listing may be representative of the end phase of a large flood event of longer duration.

It should be noted that the waterbird data available for Lake Albacutya are not comprehensive. The majority of waterbird records available are from the early 1980s onwards and few data are available prior to this time. There are no known data from or before 1982 to support Ramsar criterion 5 (a wetland should be considered internationally important if it regularly supports 20 000 or more waterbirds). The fact that the site was listed as meeting this criterion in 1982 appears to have been determined on the basis of expert opinion at the time. Records since the time of listing have verified that this criterion is met.

Table 4.7 Records of high numbers* of waterbird species occurring at Lake Albacutya (DSE, 2009b, Birds Australia, 2009)

*Only records of 50 or more individuals are listed here.
Highlighted records are those that exceed 1% of the species population.

Common name	Latin name	Count	Year recorded
Counts from around the time of listing			
Banded Stilt	*Cladorhynchus leucocephalus*	>10 000 (up to 100 000)	1983
Black-fronted Dotterel		69	1981
Black-winged Stilt		221	1983
Curlew Sandpiper		87	1983
Freckled Duck	*Stictonetta naevosa*	300	1981
Freckled Duck	*Stictonetta naevosa*	200	1981
Freckled Duck	*Stictonetta naevosa*	133	1981
Freckled Duck	*Stictonetta naevosa*	120	1981
Freckled Duck	*Stictonetta naevosa*	50	1981
Freckled Duck	*Stictonetta naevosa*	1 000	1982
Freckled Duck	*Stictonetta naevosa*	242	1982
Freckled Duck	*Stictonetta naevosa*	1 000	1983
Freckled Duck	*Stictonetta naevosa*	700	1983
Freckled Duck	*Stictonetta naevosa*	700	1983
Red-capped Plover		564	1983
Red-kneed Dotterel		69	1981
Red-kneed Dotterel		52	1983
Red-necked Avocet		384	1982
Red-necked Avocet		53	1982
Red-necked Avocet		116	1982
Red-necked Avocet		684	1983
Red-necked Stint		181	1981
Red-necked Stint		390	1983
Red-necked Stint		1 029	1983
Sharp-tailed Sandpiper		58	1981
Sharp-tailed Sandpiper		87	1982
Sharp-tailed Sandpiper		751	1983

Common name	Latin name	Count	Year recorded
Counts since the time of listing			
Australasian Shoveler	*Anas rhynchotis*	1 000	1993
Australasian Shoveler	*Anas rhynchotis*	1 000	1993
Australian Shelduck	*Tadorna tadornoides*	3 000	1993
Australian Shelduck	*Tadorna tadornoides*	300	1993
Australian Wood Duck	*Chenonetta jubata*	2 000	1993
Australian Wood Duck	*Chenonetta jubata*	500	1993
Banded Stilt	*Cladorhynchus leucocephalus*	100	1993
Black Swan	*Cygnus atratus*	50	1993
Black-winged Stilt	*Himantopus himantopus*	100	1993
Black-winged Stilt	*Himantopus himantopus*	100	1993
Eurasian Coot	*Fulica atra*	3 000	1993
Eurasian Coot	*Fulica atra*	1 000	1993
Grey Teal	*Anas gracilis*	20 000	1993
Grey Teal	*Anas gracilis*	1 200	1993
Grey Teal	*Anas gracilis*	750	1993
Hardhead	*Aythya australis*	1 500	1993
Hardhead	*Aythya australis*	500	1993
Masked Lapwing	*Vanellus miles*	100	1993
Pacific Black Duck	*Anas superciliosa*	3 000	1993
Pacific Black Duck	*Anas superciliosa*	1 000	1993
Red-necked Avocet	*Recurvirostra novaehollandiae*	50	1993
Red-necked Avocet	*Recurvirostra novaehollandiae*	50	1993
Silver Gull	*Chroicocephalus novaehollandiae*	200	1993
White-necked Heron	*Ardea pacifica*	100	1993
Yellow-billed Spoonbill	*Platalea flavipes*	100	1993

Table 4.8 Waterbirds recorded breeding at Lake Albacutya (DSE, 2009b, Birds Australia, 2009)

Common name	Latin name	Years breeding recorded
Australasian Grebe	*Tachybaptus novaehollandiae*	1980
Australian Shelduck	*Tadorna tadornoides*	1979, 80, 81
Black-winged Stilt	*Himantopus himantopus*	1979
Darter	*Anhinga novaehollandiae*	1980
Grey Teal	*Anas gracilis*	1979
Hoary-headed Grebe	*Poliocephalus poliocephalus*	1961
Little Pied Cormorant	*Microcarbo melanoleucos*	1980
Masked Lapwing	*Vanellus miles*	1980, 81
Pacific Black Duck	*Anas superciliosa*	1981
Red-capped Plover	*Charadrius ruficapillus*	1980, 81
Red-kneed Dotterel	*Erythrogonys cinctus*	1980
White-faced Heron	*Egretta novaehollandiae*	2003

Table 4.9 International treaty waterbird species recorded at Lake Albacutya (DSE, 2009b, Birds Australia, 2009)

Common name	Latin name	Treaties	Years recorded
Bar-tailed Godwit	*Limosa lapponica*	CJR	1983
Black-tailed Godwit	*Limosa limosa*	CJR	1980, 81
Caspian Tern	*Hydroprogne caspia*	CJ	1978, 79, 80, 81
Common Greenshank	*Tringa nebularia*	CJR	1977, 80, 81
Common Sandpiper	*Actitis hypoleucos*	CJ	1979
Curlew Sandpiper	*Calidris ferruginea*	CJR	1979, 80, 81, 83
Eastern Great Egret	*Ardea modesta*	CJ	1961, 76, 77, 78, 79, 80, 81
Glossy Ibis	*Plegadis falcinellus*	C	1961, 78, 80, 81, 93
Marsh Sandpiper	*Tringa stagnatilis*	CJR	1980, 82, 83
Red-necked Stint	*Calidris ruficollis*	CJR	1964, 77, 79, 80, 81, 82
Ruddy Turnstone	*Arenaria interpres*	CJR	1980, 82, 83
Sharp-tailed Sandpiper	*Calidris acuminata*	CJR	1961, 80, 81, 82, 83
White-bellied Sea-eagle	*Haliaeetus leucogaster*	C	1978, 80, 81

Legend: C = CAMBA, J = JAMBA, R = ROKAMBA

4.1.4.2 Waterbird ecology at Lake Albacutya

Waterbird ecology interacts strongly with the wetting and drying regime of Lake Albacutya. The timing and characteristic of this regime determines the species present, species numbers and breeding behaviour of the waterbird species at the lake. Flooding provides the trigger for the arrival of waterbirds, supplies habitat and food and stimulates breeding. Waterbirds may arrive from Lake Hindmarsh which always fills before Lake Albacutya and is less than 20 km away.

Waterbirds occupy the open water, the lake edge and Eucalypt woodland as habitat, and feed on the aquatic fauna and vegetation communities that develop. For many species of waterbird the flooded lake provides conditions necessary to enable breeding.

Research shows that the movements of waterbirds are controlled primarily by food supply which is driven by flooding. Filling of lakes leads to the appearance of aquatic plants, macro-invertebrates and fish which draw waterbirds to the resulting plentiful food supply (Scott, 1997). Different species tends to specialise in collecting different food items or the same foods from different parts of the wetland, thus minimizing competition and allowing huge numbers of waterbirds to thrive (Scott, 1997).

Feeding preferences determine which area of the habitat is used by certain species. Fish eating species tend to utilize deep open water at the centre of the lake, while the shallow muddy environment on the lake edge created by rising and receding lake levels provides important habitat for wading birds (Ecological Associates, 2004).

There are three main types of food for waterbirds although many will eat a range of food items and many are omnivorous. Primarily fish eating birds include cormorants and terns. Some ducks, swans and coots are primarily herbaceous, feeding on aquatic and dryland plants. Most other species feed on invertebrates and other small aquatic fauna such as frogs, which they obtain in a variety of ways.

Pacific Black Duck, Grey Teal, Chestnut Teal, Pink-eared Duck and Australian Shoveler usually dabble in shallow water and mud for invertebrates and vegetation. Egrets and herons use their sharp bills to hunt in shallow water for invertebrates, frogs, tadpoles and small fish. Ibis use their long, curved beaks to capture beetles, grubs, and insects, by probing along the water’s edge or in damp ground. Spoonbills capture aquatic invertebrates by walking through shallow water and using their flat bill to sieve the water and wet mud. Blue-billed Duck and Musk Duck feed mainly on benthic invertebrates by diving underwater (Scott, 1997).

Table 4.10 Feeding ecology of waterbirds with high counts (≥50) recorded at Lake Albacutya (Antos & Weston, 2004)

Species	Feeding ecology
Australasian Shoveler	Filter feeds aquatic insects and vegetation from the surface of the water
Australian Shelduck	Feeds on a wide range of wetland and terrestrial plants
Australian Wood Duck	Grazes on terrestrial plants
Banded Stilt	Forages in shallow water for a range of invertebrates
Black Swan	Feed on emergent and underwater aquatic vegetation
Black-fronted Dotterel	Catches small invertebrates from the ground at wetland margins
Black-winged Stilt	Feed on crustaceans and other invertebrates from the margins of shallow wetlands
Curlew Sandpiper	Forages in mud for small invertebrates
Eurasian Coot	Feeds on aquatic plants and invertebrates from the water surface or by diving
Freckled Duck	Filters through shallow water for small insects, fish, aquatic plants and algae
Grey Teal	Dabbles on the water surface for aquatic plants, insects and crustaceans
Hardhead	Feeds on aquatic plants obtained by diving or from the water surface
Masked Lapwing	Seeks out invertebrates and plant material in short grass or bare ground
Pacific Black Duck	Dabbles the surface of the water filtering small aquatic invertebrates and algae, occasionally graze on terrestrial vegetation
Red-capped Plover	Captures small invertebrates from the ground at bare lake edges
Red-kneed Dotterel	Probes in mud or water for small invertebrates
Red-necked Avocet	Wades or swims in shallow water using sweeps of its bill to sieve small invertebrates and plant material.
Red-necked Stint	Pecks small aquatic invertebrates from the soft mud
Sharp-tailed Sandpiper	Probes in shallow water or mud for aquatic invertebrates
Silver Gull	Feeds on worms, fish, insects and crustaceans
White-necked Heron	Captures fish, frogs, small reptiles, crustaceans and invertebrates by stealthily stalking through the shallows
Yellow-billed Spoonbill	Catches fish, insects and snails by sifting through mud and shallow water with its specialised bill

Feeding preferences determine waterbird distribution not only on a spatial scale, but also on a temporal scale. Successional changes that occur with the filling and drying of wetlands influence which species will be abundant at any given time. Species that feed on invertebrates are likely to colonise the site early in the flooding when these become abundant (Scott, 1997). Those, including cormorants, which feed on secondary aquatic fauna such as fish arrive later as populations of these animals may take longer to increase (Scott, 1997). As the wetland begins to dry and becomes shallower, refugia for fish are lost and piscivorous waterbirds dominate (Scholz et al, 2002). As the lake dries further, fish numbers diminish and macrophytes grow in the shallow water, attracting herbivorous species, then when the wetland is in the last stages of drying, wading species feed in the resultant mud flats (Scott, 1997). Waterbirds will generally leave the system when it has fully dried out and aquatic fauna and flora have died or significantly diminished (Ecological Associates, 2004).

The abundant food provided when previously dry wetlands are flooded induces breeding in waterbirds. Many also require flooding to provide nesting sites. There is often a lag time of 2-6 months between initial flooding and breeding, allowing the food supply to build up and allowing waterbirds to increase their fat reserves prior to egg-laying. This time lag varies between species due to feeding preferences and the season of flooding and breeding. Waterbirds which eat invertebrates will have a shorter lag time than fish eaters as their food resources establish more quickly. A few species such as the Musk Duck and Blue-billed Duck breed seasonally and won't breed until a certain time of year even after inundation, so their lag time will depend on the seasonality of flooding (Scott, 1997).

The lake may not need to reach full capacity to enable waterbird breeding as water depth is not directly important, however depth is an indication of flooding duration and extent, which may both be important (Scott, 1997). Flooding duration is important to allow breeding cycles to be completed, while flood extent may be important to provide suitable nesting sites such as submerged or overhanging vegetation. Studies from other wetlands in the Murray-Darling Basin indicate that there may be a threshold in volume and duration for a particular wetland after which breeding can take place (Scott, 1997). In 1993, when Lake Albacutya received small inflows, waterbird breeding was not recorded even though large numbers of several waterbird species were present, indicating that this small event was insufficient to stimulate breeding. Breeding of numerous waterbirds was recorded at Lake Albacutya between 1979 and 1981, however, when it still held water from a lake-full event of several years duration. This suggests a volume/duration threshold somewhere between these two events.

Duration of flooding is important for the success of waterbird breeding. Waterbirds may take several months to build their nests, lay and hatch their eggs and fledge their young. A minimum flooding duration of 4-10 months is necessary for the successful breeding of most waterbird species including lag-time, and active breeding (Scott, 1997). Ducks are generally the quickest to commence breeding and may require as little as 4 months flooding to successfully complete breeding whereas other species may require flooding of up to 10 months duration for successful breeding (Scott, 1997). Minimum duration for each species is the time theoretically needed to allow breeding to be completed, however longer than minimum flooding durations are desirable to allow peak breeding success within the population. If water levels drop before the young fledge, the adults may abandon the nest and breeding will be unsuccessful (Scott, 1997). Lake-full periods of several years duration allow major breeding events which may make significant contributions to sustaining regional populations (Ecological Associates, 2004).

As well as an abundant food source, waterbirds require suitable places in which to build their nest to stimulate and enable successful breeding. Nesting sites vary from species to species, and usually include fringing trees (both on branches and in hollows), shrubs and aquatic vegetation at the lake margin (Scott, 1997).

In almost all cases, waterbirds require healthy fringing terrestrial vegetation or emergent aquatic vegetation to provide suitable places to build nests (Ecological Associates, 2004). Cormorants, herons and darters build stick nests in trees fringing the lake. The tree species most often used is River Red Gum. Some avian species will only nest in live trees, while others such as darter, will nest in live or dead trees. Many ducks including Grey Teal, Australian Shelduck and Pacific Black Duck nest in tree hollows of Eucalypt woodland. River red gum are thought to provide the most hollows but Black Box may also be used. Other species, such as grebes will form a nest at water level in dense stands of reeds and rushes and may collect and use submerged and floating water plants (Scott, 1997).

Table 4.11 Breeding habitat of waterbirds recorded as breeding at Lake Albacutya (Antos & Weston, 2004)

Species	**Breeding habitat**
Australasian Grebe	Builds a floating nest of aquatic plants
Australian Shelduck	Nests in large tree hollows
Black-winged Stilt	Constructs a nest from aquatic plants, on the ground or in shallow water
Darter	Builds a stick nest in trees usually over water
Grey Teal	Nests in tree hollows or occasionally on the ground.
Hoary-headed Grebe	Constructs a floating nest of aquatic plants which is usually attached to emergent vegetation.
Little Pied Cormorant	Builds a small nest of sticks and Eucalypt leaves in a tree or on the ground
Masked Lapwing	Nests in a scrape or a shallow cup of grasses on the ground
Pacific Black Duck	Nests in tree hollows or among dense wetland vegetation
Red-capped Plover	Nests in a scrape or depression in bare ground
Red-kneed Dotterel	Nests in a shallow scrape in the ground
White-faced Heron	Constructs a stick nest in a tree

Waterbirds are an ephemeral component of the biota at Lake Albacutya, yet the site provides an important habitat resource for this important group. Waterbirds opportunistically colonise areas of suitable habitat, moving between wetlands as they dry and fill. They rely on the availability of at least some suitable wetland within their range at any given time. They require adequate food and nesting resources in the form of healthy, well-established aquatic and Eucalypt woodland communities. When full for significant periods, Lake Albacutya represents a valuable habitat resource for waterbirds in the region, nationally, and internationally.

4.1.5 Threatened fauna

Four species of fauna listed as threatened under the EPBC Act have been recorded within or around the Lake Albacutya Ramsar site, specifically Black-eared Miner, Mallee Emu-wren, Malleefowl and Regent Parrot. Most notable of these is the Regent Parrot which is nationally vulnerable and has been recorded in relatively large numbers and breeding at the lake. Black-eared Miner, Mallee Emu-wren and Malleefowl are more likely to inhabit Mallee habitat, 399 ha of which occurs within the Ramsar site with much larger areas adjoining the Ramsar site.

4.1.5.1 Regent Parrot at Lake Albacutya

The total national population size is below 2500 individuals and a maximum count of 50 individuals has been recorded at Lake Albacutya, representing at least 2 % of the national population. This species is also known to breed at the site, with breeding records from at least 3 occasions in 1929, 1992, and 1993. This species requires tree hollows for nesting sites, especially those in large live or dead trees, greater than 150 cm in diameter and 30 m tall (DEWHA, 2009). Favoured nesting tree species are River Red Gum and Black Box, especially in close proximity to permanent water. Successful nesting also depends on close proximity of large tracts of Mallee vegetation, within 20 km of the nesting site, which the birds require for feeding habitat. When breeding, the birds may make three trips from nesting to foraging sites in a day (DEWHA, 2009). These habitat requirements are well provided for at Lake Albacutya with an extensive Eucalypt woodland community, containing large, mature River Red Gum, in close proximity to large tracts of Mallee vegetation and a source of permanent water when the lake is full.

Male Regent Parrot (photo I. Morgan)

4.2 Essential elements

4.2.1 Climate

Lake Albacutya lies within the semi-arid region of Victoria. Annual rainfall is low and quite variable and unreliable. Average annual rainfall is about 350 mm at Lake Albacutya but may vary from around 200 mm to 700 mm. The winter months from May to October are generally the wettest months, receiving 60 % of the yearly total, though some rain can occur in any month of the year and occasionally some significant falls of summer rain occur. The heaviest rains usually occur in February, but these are infrequent. Recurrent droughts of longer than 12 months are a normal feature of the environment. Plant growth during these periods is poor and wind erosion causes widespread deterioration of the soil.

Evapotranspiration is generally very high at Lake Albacutya, approximately 1300 mm annually. It ranges from 40-50 mm per month in winter to around 230 mm in January. Annual evaporation from Lake Albacutya is estimated to be as much as 60 000 ML when the lake is full (State Rivers and Water Supply Commission, 1980).

Clearly, annual evaporation at Lake Albacutya well exceeds the annual local rainfall. For this reason, in order to fill, Lake Albacutya relies on flows from the Wimmera River which carries runoff from much higher up in the catchment where rainfall is far greater, up to about 1,000 mm per year. It has been found that filling of Lake Albacutya is correlated with high two-yearly rainfall totals, indicating that filling of Lake Albacutya depends on two consecutive years of above average stream flows in the Wimmera River (Bren & Acenolaza, 2000). It has been determined that stream flows of over 620 000 ML at Horsham over a two year period are necessary to fill Lake Albacutya (Bren & Acenolaza, 2000).

Under the high regulation regime of recent decades 1317 mm of rainfall within the catchment over a 2-year period is required to cause high enough stream flows to enable Lake Albacutya to fill (Bren & Acenolaza, 2000). It should be noted that modelling showed that under natural or low regulation conditions only 1174 mm of rainfall over two years was required to have the same effect.

The regional climate has a crucial role in defining the ecological character of Lake Albacutya, by controlling the hydrology of the lake, primarily the frequency and duration of lake filling and emptying.

4.2.2 Landforms

The land surrounding Lake Albacutya is mostly gently undulating to flat. Lunettes, crescent shaped deposits of wind blown sediment, have accumulated on the eastern shoreline of the lake (Environment Australia, 2001). Wind usually blows from the northern, western or southern quarter, and the lunette formation on the eastern margin indicates that the prevailing winds have a westerly component. Lunettes are formed when sandy beach sediments on the lake's foreshore (during wet phases) or dry lakebed clay sediments (during dry phases) are blown by prevailing winds and accumulate in a large dune on the downwind side of the lake (Wimmera CMA, 2004).

Steep sided banks down to the high water level occur around the south, south-east and south-west edges of the lake (National Parks Service, 1980). Extensive wind erosion occurs at the site (National Parks Service, 1980). Wind blown sediments form sand dunes, especially in the north west and north eastern sections of the lake. The soils on the ridge to the east of the lake (a lunette) are mainly sandy loams, loamy sands and sandy clay loams and are generally protected by the native vegetation but where timber has been removed drift is severe (National Parks Service, 1980).

These processes are important as they contribute to the evolving geomorphology of the site.

Figure 4.7 Lunette at Lake Albacutya (Robinson et al, 2005). This image is © State of Victoria, Department of Primary Industries 2005. Reproduced with permission.

4.2.3 Water quality

Surface water quality at Lake Albacutya has not been comprehensively studied. Some water quality parameters were measured and documented as part of an aquatic invertebrate study in April and September of 1977 when the lake had been flooded for about 3 years (Morton & Heislers, 1978).

All measured parameters were satisfactory for freshwater ecosystems. pH ranged from 8.7 to 8.4. Turbidity was 2.5 NTU. Electrical conductivity (salinity) ranged from 1568 to 1580 µS/cm, and total dissolved solids ranged from 940 to 948 PPM. Dissolved oxygen remained near maximum levels possibly due to wind action or algal photosynthetic activity. Levels of organic detritus ranged from low to high depending on the location of the lake. The incidence of bare sand on the substrate was high to very high, but this may reflect the depth of water.

Water quality data collected by Waterwatch at Outlet Creek just south of Lake Albacutya during the last flow period in 1996 is presented in the table below. As could be expected, salinity and turbidity were much higher during this low flow event than in 1977 when the lake had been full for some years.

Table 4.12 Water quality at Outlet Creek south of Lake Albacutya during 1996 (data provided by Waterwatch, Victoria)

Date:	**23/10/1996**	**7/11/1996**	**14/11/1996**	**21/11/1996**
Electrical Conductivity (µS/cm)	6200	6100	5900	5600
pH (pH Units)	8.5	8.5	8.5	8.5
Turbidity (NTU)	300	95	70	55

One of the key differences between subterminal and terminal lakes is that because subterminal lakes overflow salts are occasionally flushed out (Timms, 2001). True terminal lakes are generally saline as outflow is solely through evaporation and seepage, allowing salts to accumulate (Timms, 2001). Lake Albacutya is a subterminal freshwater lake as it overflows after filling. In low flow events, however when the lake only partially fills, it does not overflow and then acts as a terminal lake, with the potential for salt build-up.

4.2.4 Groundwater

4.2.4.1 Groundwater hydrology

The underlying geology of Lake Albacutya interacts with the hydrology of the area to determine groundwater characteristics of the site. A groundwater model of the Lower Wimmera River has been developed which examines these interactions (Hocking, 2005).

The underlying geology of the lower Wimmera area is primarily composed of 5 layers or aquifers, which are also shown in Figure 4.7:

Layer 1 – Quaternary alluvium
This surface layer consists of a thin sequence of fluvial and lacustrine sediments including clay, silt and thin beds of fluvial sand. It is recharged directly from above by rainfall or flood waters and locally recharged by upward seepage from underlying aquifers such as the Palaeozoic bedrock and the Parilla sand aquifers in some areas. In other areas it is quite hydraulically disconnected from underlying aquifers and vertical leakage into underlying Parilla Sands can be minimal.

Layer 2 - Pliocene Parilla Sands
This layer forms a broad shallow aquifer across the Wimmera region and is the most significant contributor to salinisation in the region. It is of marine origin of Pliocene age. The Parilla Sand may be up to 50 m thick, and is separated from the underlying Murray Group Limestone by a clay layer.

Layer 3 – Murray Group Limestone
This layer consists predominantly of grey to white calcarenite, marl, calcareous silt and clay. Another layer of clay separates the Murray Group Limestone from the confined Renmark Group aquifer.

Layer 4 – Renmark Group
This layer is comprised of course sand and clay from a sequence of depositional phases, the first fluvial followed by two marine sequences. It is split into two main units – the Warina Sand and the Olney formation. Warina sand is relatively homogenous, comprising a thick sequence of medium to coarse quartz sand up to 225 m but averaging 60 m thick. The Warina sand is hydrogeologically confined by the upper Olney unit, and is comprised of a mixture of sand, silt, clay and carbonaceous material.

Layer 5 – Palaeozoic Bedrock
This layer consists of siltstone and shale of Cambrian-Ordovician age.

The Parilla Sands Aquifer is found at or near the land surface throughout most of the lower Wimmera (Dyson & Hocking, 2006). This regional aquifer is highly permeable, allowing groundwater to move through it quite freely. As a result the watertable in this aquifer is relatively flat, regardless of local topography, and flows north toward the Murray River (Wimmera CMA, 2005).

The stratigraphy of sediments underlying Lake Albacutya has not yet been fully investigated but it is thought that there is the potential for a perched aquifer to form in the lakebed sediments during flood events, as is known to occur at Lake Hindmarsh (Ecological Associates, 2004). This occurs when a relatively impermeable layer (such as clay) occurs beneath surface sediments in a localized area, allowing the overlying sediments to hold water above the underlying groundwater aquifer. When Lake Albacutya is full, there is a reported rise in groundwater wells to the west of lake, suggesting the formation of a perched aquifer (Ecological Associates, 2004). Groundwater data available is insufficient to accurately determine the interaction between surface water and groundwater at Lake Albacutya (Ecological Associates, 2004).

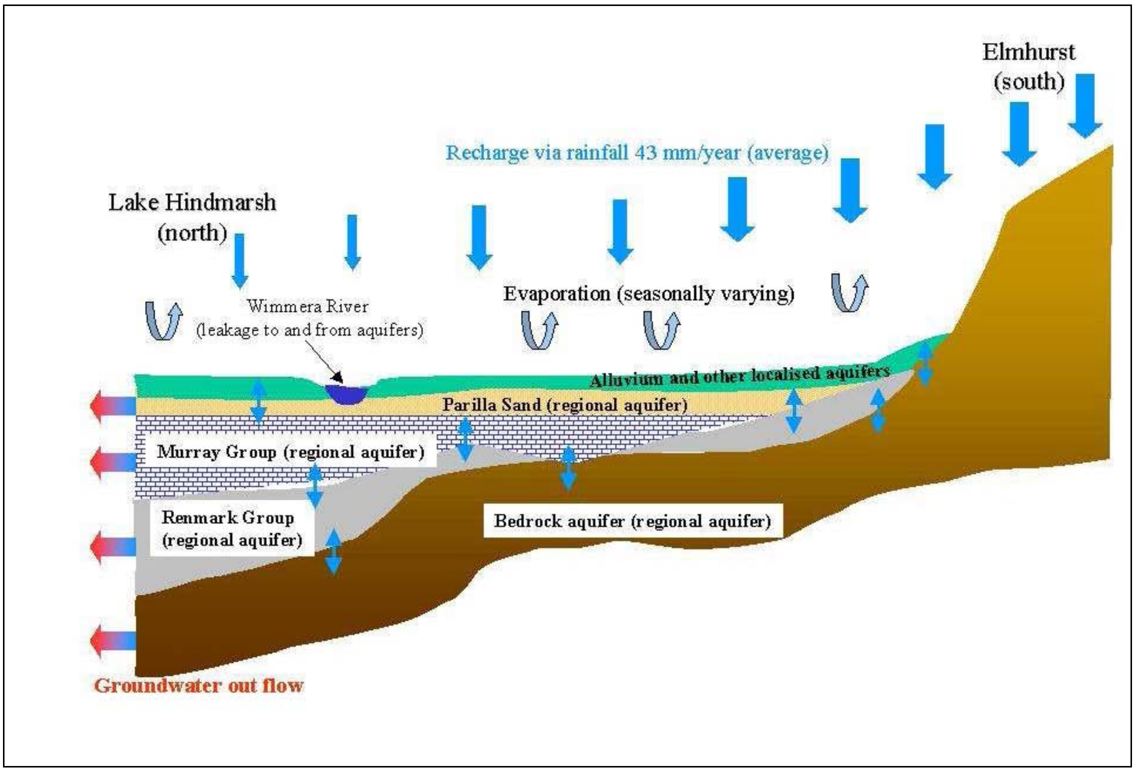


Figure 4.8 Model of groundwater in the Wimmera (Hocking, 2005)

Lake Albacutya is potentially a groundwater recharge zone as the potentiometric surface of the water table in the aquifer beneath it is well below the surface of the lakebed. In 2000 it was reported that the average depth to groundwater between 1993 and 2001 was 9.05 m (Bren & Acenolaza, 2000).

There is a lack of comprehensive long term groundwater data, however the level appears to be relatively stable. Large-scale clearing of the Wimmera Catchment for agricultural purposes is likely to result in rising regional groundwater levels due to reduced water uptake by native vegetation, and subsequent greater infiltration of surface water into the underlying aquifer. This has occurred in other regions of Australia, and appears to have occurred at Lake Hindmarsh and the lower Wimmera River area near Jeparit.

A rising groundwater trend ranging from 0.01 to 0.03 metres per year in the lower Wimmera catchment has been reported (Sandell, 1996). Support for such an increase is also found in Hocking (1998) which reported that the groundwater level in the regional Parilla Sands aquifer had been increasing at 0.04 m per year for 15 years and that general data from the Millicent Basin also suggested a slight increase in groundwater level.

However since then the watertable in the shallow aquifer around Lake Albacutya showed a downward trend between 1996 and 2004 due to low rainfall recharge in the region (Ecological Associates, 2004). Bren & Acenolaza (2000) reported little change in shallow aquifer groundwater depth at Lake Albacutya between 1993 and 2000.

Figure 4.8 depicts trends in depth to groundwater at the bores with long-term data nearest to Lake Albacutya. Trends indicate rising groundwater prior to about 1996, followed by a fall in groundwater after this time. This supports other reported trends, although two of the bores exhibit a greater fall in groundwater since 2006.

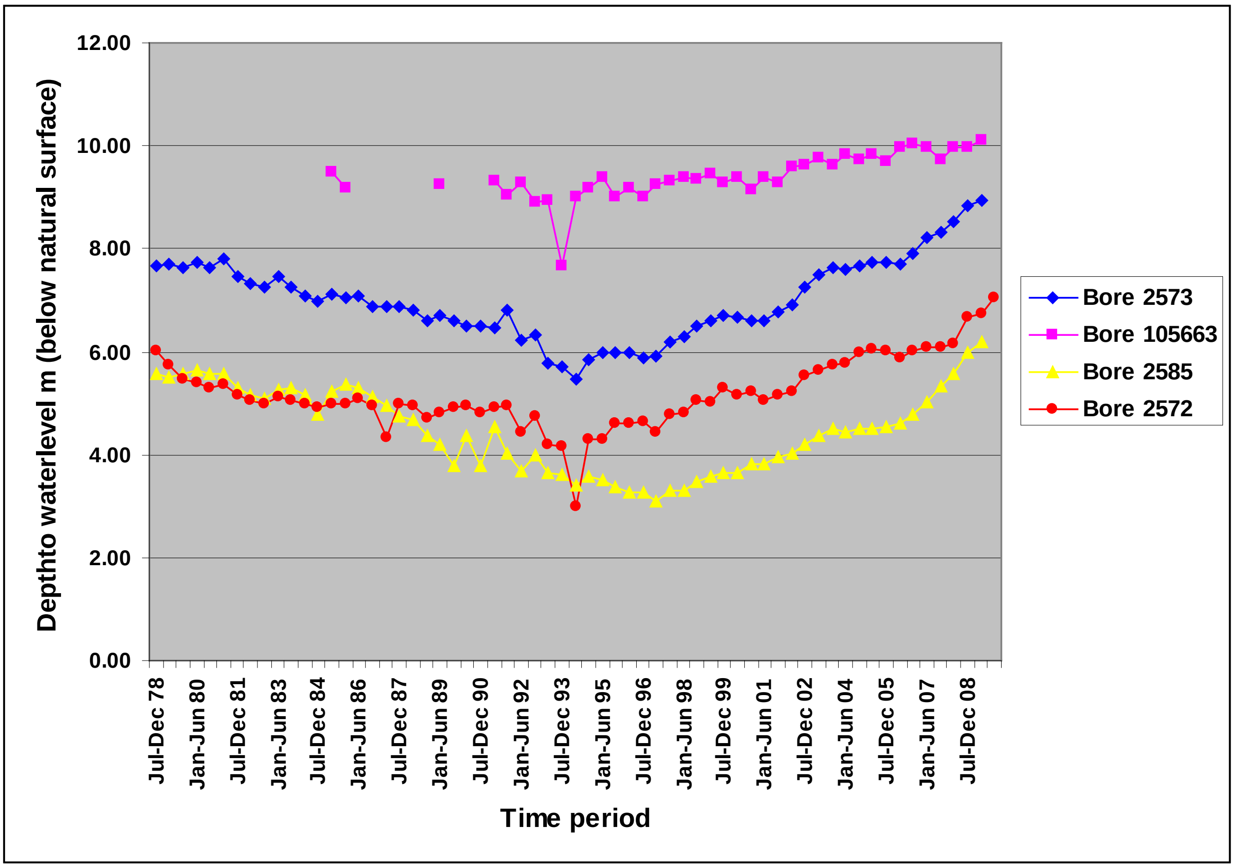


Figure 4.9 Depth to waterlevel - trends at bores near Lake Albacutya (Bore 2573 – 10 km south of Lake Albacutya, Bore 105633 – 18 km north-east of Lake Albacutya, Bore 2585 – 7 km south of Lake Albacutya, Bore 2572 – 10 km south-east of Lake Albacutya)

From the available data it is reasonable to conclude that at the time of listing in 1982 groundwater levels at Lake Albacutya were rising slowly and that they have been slowly falling since then, however neither trend is significant to the present time.

4.2.4.2 Salinity

The salt concentration of the groundwater in the Parilla Sand aquifer (the regional aquifer closest to the surface) ranges from about 10 000 µS/cm in the south of the Wimmera catchment to more than 60 000 µS/cm in the north (Wimmera CMA, 2005).

Wouters (1993) measured the salinity of groundwater at Lake Albacutya between June and December 1993 and reported values between 15 000 and 22 000 µS/cm. The mean salinity of groundwater at Lake Albacutya between 1993 and 2000 was 21 310 µS/cm (Bren & Acenolaza, 2000). This level of salinity is above the toxicity limit of salinity tolerance of River Red Gums (Bren & Acenolaza, 2000) and most agricultural livestock (DPI, 2005).

Data confirms that the salinity levels in the groundwater of the region are rising. Parks Victoria measured groundwater salinity at Lake Albacutya for 5 years prior to 2000 and found a marked increase in salinity in the last 1-2 years of the study (Bren & Acenolaza, 2000). Flooding of the terminal lakes is thought to dilute groundwater and also flush salts down the soil profile, and it is predicted that the lack of flooding of the lakes is leading to increased groundwater salinity (Bren & Acenolaza, 2000).

Deep plant roots extract water from moist soil above the saturated aquifer as few plants are adapted to extract water from saturated anaerobic environments. Capillary action which transports water also carries salts upwards in the soil profile, and this is reversed through leaching after rainfall and flooding. Vegetation dieback occurs when this dynamic equilibrium is disturbed by changes in the groundwater and/or surface hydrology, such that the soil profiles accumulate salt in the dry times at rates exceeding that which can be leached down again during the infrequent wet periods (CSIRO, 2002).

Groundwater discharge and salinisation of surface soils occurs when levels of saline groundwater rise to within 2 metres of the land surface bringing with it dissolved salts (Wimmera CMA, 2005). This critical water table depth may be more variable than 2 m, as many areas that are underlain by relatively shallow and saline groundwater actually experience alternating cycles of salt accumulation during dry periods and salt leaching during periods of rainfall or flooding (CSIRO, 2002).

The effects of elevated groundwater salinity can be mitigated somewhat by rainfall and floods, through the percolation of freshwater down the soil profile where it may remain on top of the more dense saline water as a freshwater lens. Reduced flood frequency has reduced the frequency of expansion of freshwater lenses overlying more saline water in the groundwater sequence (Jensen, 2008).

Groundwater at Lake Albacutya is currently well below the surface (at around 9m depth), and unless groundwater levels rise substantially to around 2m depth, there is no potential for salinisation to occur.

4.2.5 Flora

According to the DSE flora database there is a total of 63 species of plants from over 20 families occurring within the Ramsar site. 132 plant species are recorded within the Lake Albacutya Park Boundary (see Appendix 1 for full list). Most of these records are of terrestrial species, as few flora assessments have been conducted during the wet phase of the lake.

4.2.5.1 Aquatic vegetation

An aquatic vegetation community develops in the available aquatic habitat when Lake Albacutya fills. Propagules and organisms are carried in by inflows. The stored lakebed seed bank of aquatic and water-dependent species responds quickly to flooding, while the terrestrial vegetation dies with prolonged submersion, and is eventually replaced by submerged and emergent aquatic vegetation such as water-milfoils. Algae and phytoplankton also establish.

There is no comprehensive data on the aquatic vegetation community at Lake Albacutya, however the following aquatic species have been recorded (Morton & Heislers, 1978):

- *Myriophyllum porcatum*, Ridged Water-milfoil - an EPBC listed vulnerable aquatic herb
- *Myriophyllum verrucosum,* Red Water-milfoil - a widespread aquatic herb
- *Lepilaena sp*.,Watermat - a salt tolerant aquatic herb
- *Chara sp*. - submerged green algae.

There is only one record from 1887 of Ridged Water-milfoil at the site, and this single record may be an anomaly. However the species is rare with only around 4400 individuals known from 15 sites, all shallow ephemeral wetlands in Victoria. Most plants occur at just two sites, and unconfirmed anecdotal information suggests that the species may be present in the seed bank of Lake Albacutya (Murphy, 2006).

The aquatic vegetation provides habitat for small fish such as Gudgeon and Smelt, and provides a foraging environment for waterbirds. Live and dead aquatic vegetation, including phytoplankton, provide the basis of the food web in aquatic fauna communities. The presence of aquatic vegetation has been found to be especially crucial for the diversity and abundance of aquatic macroinvertebrates (Morton & Heislers, 1978) which in turn represent a vital food resource for fish and waterbirds.

The abundance and diversity of aquatic plants in Lake Albacutya appears to be limited by relatively high turbidity and wave action, and possibly soil type (Morton & Heislers, 1978), however this may be more relevant as the lake water recedes or during periods of high wind speed, as low turbidity is also reported (Ecological Associates, 2004). The aquatic vegetation community establishes gradually and it has been suggested that long flood durations of at least two years may be necessary to allow the development of a substantial aquatic vegetation community (Morton & Heislers, 1978).

When the lake dries, aquatic vegetation dies and becomes part of the nutrient rich substrate of the lakebed, which subsequently supports terrestrial lakebed plant communities.

4.2.5.2 Lakebed vegetation

During the dry phase, the bed and banks of Lake Albacutya support a community of terrestrial vegetation. The clay soils of the inner lakebed are colonised by native grasses and herbs such as Wallaby Grasses, Spear Grasses and Bluebushes (*Maireana spp*) while some of these dry phase colonizers are exotic species such as Patersons Curse, Horehound and False Sow-thistle (Ecological Associates, 2004). The shallower sandier soils of the outer lakebed tend to be colonized by shrubs as well as grasses, including three-nerve wattle (*Acacia trineura*), chenopods (e.g. *Atriplex spp*) Lignum (e.g. *Muehlenbeckia florulenta*) and sedges (e.g. *Ficinia nodosa*) (Ecological Associates, 2004).

This terrestrial vegetation (except Lignum) dies after it is submerged for extended periods but provides important nutrients that support primary productivity in the aquatic ecosystem that forms, while also providing structural habitat and food for aquatic fauna. This abundance of structural habitat and nutrients contributes to the abundance and diversity of aquatic invertebrates which are a vital food source for fish and birds during flooded stages.

The flooding cycle has an important role in the ecology of the dry phase terrestrial vegetation of the lake. Because all terrestrial lakebed species die with prolonged flooding, the ecological succession of the community is re-set. This provides habitat for early colonizers of the drying lakebed such as Native Orache (*Atriplex australasica)*, Australian Hollyhock (*Malva preissiana)* and Three-nerve Wattle (*Acacia trineura),* which may eventually be superseded by climax species (Ecological Associates, 2004). After flooding, new species which were not present immediately prior to flooding occur on the lakebed while those that were present reappear in different densities (Morton & Heislers, 1978). This lakebed community is characterized by episodic recruitment after flooding, and the desirable disturbance period is reported to be ten years (Department of Sustainability and Environment, 2004).

The hydrological regime and climate interact with soil type to promote biodiversity of the lakebed on a spatial and temporal cycle. Nutrients in the lakebed soil increase with increasing clay content so immediately after flooding or during periods of high rainfall when soil moisture is not limiting, the clay soils of the inner lakebed are colonised by vigorously growing species which are not common during dry periods. During dry conditions however when moisture is limiting, the coarser sandier soils of the outer lakebed have more favourable moisture characteristics as the coarser soils are more permeable and hold water at lower tensions than clay. Long after flooding and during dry periods, semi-drought tolerant species can persist in these areas in the prevailing arid climate better than on clays (National Parks Service, 1980).

4.2.6 Aquatic fauna

Many species of native aquatic and water-dependent fauna have been recorded within and around the Lake Albacutya Ramsar site (See Appendix 1 for species lists). The most significant components of aquatic fauna at Lake Albacutya are invertebrates and fish which provide food for waterbirds during lake-full periods.

4.2.6.1 Invertebrates

During a study of the Wimmera terminal lakes system during the last major flood period in 1977 (Morton & Heislers, 1978), 19 aquatic macro-invertebrate species were recorded in Lake Albacutya and described as sparsely to moderately abundant. Lake Albacutya contained less species and a lower abundance of organisms than any of the other subterminal lakes, both upstream and downstream, and this was thought to have resulted from an absence of rich aquatic plant communities and solid detritus. Within the lake, sites with flooded trees and bushes providing solid substrate showed richer and more diverse aquatic fauna. Much of the inner lakebed of Lake Albacutya, however, has no terrestrial trees or shrubs and floods to a depth of around 6 m, providing large areas of pelagic open water with no complex substrate.

Macro-invertebrates tended to be patchily distributed, with some restricted to solid objects, particularly well-weathered sticks and logs. Density of submerged vegetation and the amount and character of organic sludge influenced whether species were present in parts of the lake that were sampled. Shallow water less than 30 cm overlying deep sludge had more variable temperature and dissolved oxygen levels and consequently had reduced fauna, even when vegetation was present. Characteristics such as structural diversity, leaf litter, algal levels, organic detritus and substrate type were thought to determine macro-invertebrate faunal assemblages, with availability of suitable habitat thought to a greater limiting factor than water quality.

Morton & Heislers found that many of the species present in Lake Albacutya were common and widespread within the subterminal lakes, such as crustacean *Austrochiltonia sp*., water boatmen *Micronecta robusta,* a caddisfly *Oecetis sp*., and a snail of the genus *Bulinus.* These are also common and widespread throughout Victoria and are tolerant to a wide range of conditions. These common species are opportunistic colonizers, establishing where conditions are favourable. Other species present were less widespread, or were found only in Lake Albacutya during sampling, such as an unidentified Hydrophilidae beetle.

Table 4.13 Aquatic macro-invertebrates recorded in Lake Albacutya (adapted from: Morton & Heislers, 1978)

Phylum	Order	Family	Species	Abundance
Arthropoda	Amphipoda – shrimp-like crustaceans	Chiltoniidae	*Austrochiltonia sp.*	Abundant
Arthropoda	Ephemeroptera – mayflies	Caenidae	*Tasmanocoenis sp.*	Sparse
Arthropoda	Coleoptera – beetles	Dytiscidae	*Bedessus sp.*	Sparse
		Hydrophilidae	Unspecified	Sparse
Arthropoda	Diptera – flies and mosquitoes	Chironomidae	*Ablabesmyia sp*	Sparse
		Chironomidae	*Cryptochironomus sp.*	Abundant
		Chironomidae	*Rheotanytarsus sp.*	Sparse
		Chironomidae	*Cladotanytarsus sp.*	Sparse
		Ceratopogonidae	Unspecified	Sparse
Arthropoda	Trichoptera - caddisflies	Ecnomidae	*Ecnomus continentalis*	Sparse
		Leptoceridae	Unspecified	Moderate
		Hydroptilidae	Unspecified	Sparse
Arthropoda	Hemiptera - bugs	Corixidae	*Micronecta robusta*	Moderate
Mollusca – snails, slugs etc.	Unspecified	Unspecified	Unspecified	Sparse

The lake is renowned for a high population density of Yabbies (*Cherax destructor*), however this is generally known through recreational catches rather than scientific surveys.

Aquatic invertebrate communities develop from organisms and propagules washed in with upstream floodwaters, as well as some that emerge from resting stages within the dry lakebed (Ecological Associates, 2004). Some of the macroinvertebrate species found in Lake Albacutya are known to have quiescent stages which are capable of withstanding long dry periods and may lay dormant in the dry lake bottom and establish quickly when the lake floods (Ecological Associates, 2004). Even though flooding occurs infrequently in Lake Albacutya the invertebrates that persist in the lakebed can significantly influence the structure and diversity of the invertebrate community that forms during flooding (Ecological Associates, 2004).

The lakebed also contains a number of dams which provide water for livestock, and may also serve as dry-phase refugia for micro- and macro-invertebrates. Some invertebrates may also emerge seasonally from egg banks after rainfall events, if sufficient water collects in the clay depressions of the inner lakebed, and return to quiescent stages as the seasonal water pools dry.

The aquatic invertebrate community at Lake Albacutya fulfils a crucial role in the food web by providing a food source for fish and waterbirds. These animals also have an important role in the breakdown of organic matter and nutrient cycling.

4.2.6.2 Fish

When Lake Albacutya receives flows from Lake Hindmarsh, fish communities develop from dispersal of species from upstream, however it may take several years of flooding to allow significant fish populations to develop in the lake.

There is a paucity of data on the composition and abundance of fish communities within the lake itself, however species of native fish in the lower Wimmera River provide an indication of species likely to inhabit Lake Albacutya during flooding. Only two species of indigenous native fish have been found in the lower Wimmera River upstream from the terminal lakes system, the Australian Smelt (*Retropinna semoni)* and Flat-headed Gudgeon (*Philypnodon grandiceps)* (Davies et al, 2008). These species have also been recorded downstream from Lake Albacutya during times of flooding (Morton & Heislers, 1978), and must have travelled through Lake Albacutya to reach this downstream section, and could be assumed to occupy Lake Albacutya when full.

The Wimmera River has been stocked with several species of threatened native fish which are not indigenous to the system, including Murray Cod (nationally vulnerable), Silver Perch, Golden Perch, and Freshwater Catfish, as part of the Department of Primary Industries' fish stocking program. These species could move into Lake Albacutya during floods but have not been recorded to date with the exception of the Freshwater Catfish (DSE, 2003).

The Freshwater Catfish (*Tandanus tandanus)* is known to have occurred in Lake Albacutya. Although not native to the system, the Wimmera River population of catfish has been regarded as a very important stronghold of this species which is in decline in its natural range (Clunie & Koehn, 2001)

Exotic fish species are discussed in Chapter 8, and include Redfin (also known as English Perch) and European Carp. Anecdotal and photographic records show that Redfin have been caught in large numbers by recreational and commercial fishers. Redfin feed on invertebrates and fish and are effective predators.

Most of the fish species listed above could be assumed to inhabit Lake Albacutya in 1982, at the time of listing.

These species indicate the potential for the lake to develop a fish community with a variety of species including large high-order predators. In addition, records identifying the presence of a variety of piscivorous birds such as cormorants, darters, terns and the White-bellied Sea-eagle, some of which are known to breed at the site, provide indirect evidence for the presence of rich fish populations. Despite the relatively low documented species richness of the native fish community in the lake, this group of fauna has a vital role in the aquatic food web, in nutrient cycling and as a food source for waterbirds.

4.2.6.3 Ecology of aquatic fauna

During flooding the lake provides habitat for aquatic fauna including invertebrates and fish, which in turn attracts a variety of waterbirds. Prolonged flooding (2 years) may be necessary for ensuring diverse and abundant aquatic fauna communities are able to develop, including predatory guilds (Ecological Associates, 2004). When the lake dries, the majority of aquatic fauna become stranded and die and waterbirds leave the system. Dead organisms and accumulated organic material decompose in the lakebed to form a nutrient rich substrate for colonisation by plants and animals of the dry phase of the lakebed.

It has been suggested that ephemeral lakes pass through various stages after flooding (see Figure 7.3) - the first is characterized by high habitat diversity and complexity, high productivity and relatively few aquatic predators; in the second phase fish abundance increases while habitat complexity decreases; as a lake contracts further, organisms become concentrated and the numbers of predators increase, exerting a significant top-down pressure on the invertebrate community; as a lake becomes too shallow to serve as a refuge for fish, avian predation becomes an important structuring force, producing a trophic cascade that causes invertebrate numbers to increase and this continues until the physical conditions become too harsh and the lake dries (Gawne & Scholz, 2006).

4.2.7 Terrestrial fauna

Many species of terrestrial fauna are known to utilise the Lake Albacutya Ramsar site (see Appendix 1 for full species lists). Waterbirds and the Regent Parrot are discussed in Chapters 4.1.4 and 4.1.5 respectively. Most recorded species are birds with significantly fewer records of mammals, reptiles and invertebrates. It is likely that this represents an observation and recording bias toward birds and that there are far more species of mammals, reptiles and (especially) invertebrates which inhabit the area than those recorded.

Lake Albacutya and its biotic components have an intimate connection with the fauna of the terrestrial Mallee and woodland communities surrounding it and in the adjacent Wyperfeld National Park (Ecological Associates, 2004). The Lake Albacutya Ramsar site also includes approximately 399 ha of Mallee habitat.

The Lake Albacutya Eucalypt woodland, especially River Red Gum, provides important habitat for terrestrial fauna that depend on tree hollows for breeding. These include the Regent Parrot, Mallee Ringneck, Major Mitchells Cockatoo and Barking Owl. These birds feed primarily within the surrounding dryland Mallee habitat but utilise tree hollows around Lake Albacutya for breeding (Ecological Associates, 2004). Mammals such as possums and bats may also benefit from River Red Gum tree hollows. Mallee reptiles such as Marbled Gecko and Skinks also utilise River Red Gum trunks. Dead River Red Gum also provide perching and nesting sites for raptors (Ecological Associates, 2004). Other terrestrial birds such as Magpie-lark and White-winged Chough, Bustard, Gilbert's Whistler and Bush Stone-curlew may also nest in or among vegetation fringing the lake (Ecological Associates, 2004).

The dry lakebed vegetation is grazed opportunistically by Western Grey Kangaroo. When flooded the lake provides a source of drinking water for terrestrial fauna and a food source for insectivorous species such as Rainbow Bee-eater, Welcome Swallow, Australian Tree-martin and Willie Wagtail. The relative abundance of fauna such as insects and frogs when the lake is full may provide a local abundance of food to birds, mammals and reptiles from the Mallee landscape, and this may then represent an increase of food for predators of the Mallee ecosystem.

Due to the long duration of the dry phase (up to and possibly exceeding 30 years), it is likely that the full complement of common terrestrial taxa colonise the site

Known exotic fauna include wild dog, rabbit, fox, and sheep which graze approximately 2,000 ha of the lakebed herbland under grazing licences, and these are discussed at Chapter 8.

4.2.8 Food web and nutrient cycling at Lake Albacutya

The wet/dry cycle of Lake Albacutya drives the nutrient cycling and trophic pathways of the system. Ephemeral wetlands always recede and dry, and the dead aquatic vegetation and fauna and their by-products form a rich organic substrate. In the dry period terrestrial vegetation and animals establish and utilise some of this organic matter and simultaneously produce more organic material. When the lake re-floods and the terrestrial flora and fauna die, the organic substrate along with the decomposing flooded vegetation provides a rich nutrient source on the lakebed. A pulse of nutrients and organic matter are also washed in with the initial floodwaters. These basal resources promote the rapid development of detritivorous invertebrates such as chironomids and colonising wetland flora. Along with high productivity, there is an also an initial scarcity of predators immediately after flooding, allowing the macroinvertebrate community to rapidly expand (Gawne & Scholz, 2006).

In time a more complex invertebrate community forms to include predatory guilds, along with the development of a more complex community of aquatic flora. These communities in turn provide resources for vertebrate aquatic and water-dependent fauna such as fish and frogs allowing the development of a complex aquatic ecosystem with several trophic levels including detritivores, herbivores, and predators. This aquatic community supplies an abundance of food for waterbirds, at times providing suitable breeding conditions for many species. As the lake begins to dry and becomes too shallow to serve as a refuge for fish, piscivorous waterbirds dominate, creating a trophic cascade which again allows invertebrate numbers to build up (Gawne & Scholz, 2006). When the lake dries completely the cycle begins again. Terrestrial fauna which opportunistically utilise resources from wet and dry phases of the lake ecosystem also play a role in nutrient cycling.

The unique hydrological regime of Lake Albacutya is crucial for maintaining the health of persistent ecosystem biota (River Red Gum and other Eucalypt woodland species) and for driving fluctuations in populations of the cyclical ephemeral biota (lakebed flora and fauna when dry, aquatic flora and fauna when wet) which together make up the biotic system. These biotic components interact with each other within the context of the successional sequences determined by the hydrological regime (for example terrestrial lakebed vegetation and leaf litter provide nutrients for aquatic communities at the onset of flooding, which in turn provide nutrients for terrestrial communities when the lake dries). Additionally there are important secondary components which opportunistically interact with the system at specific times. These include waterbirds colonising and utilising the lake when it contains water and terrestrial fauna grazing on the lakebed vegetation when dry and utilising Eucalypt woodland for breeding habitat.

5. CHANGES IN THE CRITICAL COMPONENTS AND PROCESSES SINCE THE TIME OF LISTING

Lake Albacutya was first listed under the Ramsar convention as a wetland of international importance in December 1982. Unfortunately there is limited data available on the ecological condition of the site in 1982 or at the time of writing, with much of the available data falling somewhere in the intervening period. Since the time of listing however there have been some changes in critical elements of the wetland that have the potential to impact on the ecological character in the future. Conversely, where important factors have remained essentially the same, it can be assumed that the ecological character is unlikely to have changed.

This section summarises the changes in the ecological character of Lake Albacutya since the time of listing and discusses their significance.

5.1 Hydrology - surface water

Reduced rainfall, which has ocurred in the Wimmera River catchment from 1995 to the time of writing, may be partly due to anthropogenic climate change and if this is the case then the surface water hydrology may be also undergoing change. However there is no evidence to indicate that the hydrology of Lake Albacutya has changed significantly since the time of listing in 1982.

In 1982 the hydrological regime of the lake had been significantly altered from its natural condition due to long term regulation of the Wimmera River for water supply since the 1850s, and this increased significantly from the 1950s to the 1970s (Moore, 1988). Specifically, the frequency, extent and duration of flooding in Lake Albacutya were reduced.

Lake Albacutya held water at the time of listing due to a period of exceptionally wet years which flooded the lake from 1974. It has not filled since that event which essentially continued through to 1983 as a result of additional river flows, however small flows also entered the lake in 1993 and 1996. The lake may have dried substantially in 1980 or 1981 (Krelle, M., 2009, pers. comm.).

Regulation of the Wimmera River, particularly since the 1950s, had reduced the frequency, duration and magnitude of flow events reaching the terminal lakes at the time of listing (Ecological Associates, 2004). In 1989 the Land Conservation Council made recommendations that the flows of the lower Wimmera River be urgently investigated and reported on.

The volume of water captured in storage reservoirs by GWMWater averaged 189 000 ML per year from 1983 to 1996 however declined to an average of 38 000 ML from 1997 to 2008. The quantity of water annualy diverted from storages to the supply system peaked in 1982 at 226 000 ML.

This recent reduced capture of catchment flows has been primarily a result of the drought and subsequent reduced streamflows experienced in the catchment from 1995 (National Water Commission, 2005), and this has recently been attributed at least in part to climate change (Steffen, 2009) and if this is correct then this trend is likely to continue.

The hydrological outlook for Lake Albacutya also shows the potential for some improvement as a result of recent programs to replace the approximately 18 000 km open channel rural supply system with a series of pipelines. The Northern Mallee Pipeline was completed in 2002, and was expected to produce water savings that would result in an environmental entitlement of approximately 32 400 ML to be shared between the Wimmera and Glenelg basins (Victorian Government, 2003). The reliability of these annual returns was estimated at 72 % based on historical inflows (Victorian Government, 2003), however due to ongoing drought conditions, actual returns to 2009 have been minimal and have been targeted at slowing the decline of high value waterways including the lower Wimmera River, but have had no impact on the hydrology of Lake Albacutya.

Construction of the Wimmera Mallee Pipeline due to be completed in 2010 will generate further water savings with an average of 83 000 ML annually expected to be allocated to environmental flows in the various waterways from which water was harvested. A proportion of this entitlement (approximately 38 500 ML) is to be allocated to the Wimmera and Glenelg Rivers (Victorian Government, 2003). Exact entitlements for the Wimmera River have not yet been finalised, however modelling in the Wimmera Mallee Pipeline business case (Victorian Government, 2003) suggests significant benefits to the terminal lakes including Lake Albacutya. This is highly dependent on climatic conditions, resulting water availability, infrastructure constraints, and actual volumes and flow regimes released into the Wimmera River.

Planning for the Wimmera Mallee Pipeline suggested that future water releases could increase channel wetness and winter flood volumes of the Wimmera River and enable flows to reach Lake Albacutya by enhancing natural flood events (McMahon et al., 2003). However it now appears that the drought affecting southern Australia from 1995 is at least partly a result of anthropogenic climate change and that reduced rainfall and catchment runoff are likely to continue. As a result, management of the environmental water reserve faces many challenges, and the most likely result in the near future is for some improvement to the hydrology of the Lower Wimmera River but little chance of any significant benefit to Lake Albacutya under low catchment rainfall conditions.

In summary then, it is concluded that the surface water hydrology has not changed significantly since the time of listing, however it does appear to be undergoing change as a result of anthropogenic climate change and this trend should be monitored.

5.2 Eucalypt woodland

The River Red Gum health at Lake Albacutya has been surveyed once in 1993, 11 years after listing, when significant dieback was recorded. Wouters (1993) reported that River Red Gum dieback at the site was widespread in 1960. It is not known whether the area of this community has contracted or if dieback has become more advanced in recent times. It is therefore impossible to determine any trend in the condition of River Red Gum at Lake Albacutya since the time of listing.

It is likely that, at the time of listing, River Red Gums at Lake Albacutya were benefiting from the previous flooding in 1974 and the continued water availability into the early 1980s. The River Red Gum community at the lake has not had the benefit of major flooding since that time. It is possible that impacts from the altered hydrology have intensified since the time of listing as it is known that a significant time lag often occurs between a change in flow regime and the detection of environmental impacts and the point where these impacts stabilise (Whittington, et al, 2000). The impacts of reduced flooding on populations of long-lived species such as Eucalypts may not be apparent for tens or even hundreds of years. Due to the progressive nature of the dieback process there may have been a continuation of, and potentially an increase in, dieback symptoms.

A field visit by one of the authors in August 2009 confirmed that the Eucalypt woodland persists, and that River Red Gum recruitment has occurred, probably in the past 20 to 40 years, as many trunks at breast height were less than 150 mm in diameter. Many of these recruits were on the lakeside of mature trees and may die in a major lake-full event. Some areas of River Red Gum showed signs of decline, however other areas appeared healthy. Black box generally appeared healthy, but little recruitment was evident.

At the time of writing there is no evidence of trends in the condition or extent of Eucalypt woodland. Without further field assessment of the River Red Gum it is not possible to establish if this species, and the Eucalypt woodland community as a whole, is changing or has changed.

5.3 Waterbirds

Lake Albacutya held water at the time of listing, due to higher than average catchment rainfall in the mid to late 1970s, and the lake is known to have supported significant waterbird populations between 1981 and 1983. The lake again held water in 1993 when small flows entered the lake, and again, the lake supported large numbers of waterbirds. In fact, the highest recorded numbers of Grey Teal, Eurasian Coot, Pacific Black Duck, Australian Shelduck, Australian Wood Duck, Hardhead and Australian shoveler were all recorded in 1993. Large numbers of Freckled Duck, however, have not been recorded since 1983. No waterbirds were recorded during the period of the small 1996 inflow event, and the lake has not held water since then.

Waterbird data earlier than 1983 appears to be unreliable as common species may not have been recorded. There are very few records prior to 1979, however it appears that when the site holds water, Lake Albacutya frequently supports high numbers of waterbirds - one of the criteria for its Ramsar listing.

The appearance of waterbirds at Lake Albacutya may be linked to the different flooding regimes of the various inland wetlands that provide alternative habitat throughout their range. Unlike most of the Murray-Darling River wetlands which are most likely to fill from rainfall events originating over eastern or tropical northern Australia, Lake Albacutya fills from the Wimmera River whose headwaters originate in the Pyrenees to the south.

There is no evidence that national populations of Banded Stilt, Freckled Duck, and Australian Shoveler have changed significantly since the time of listing (Rose & Scott, 1994, Delany & Scott, 2006), and therefore this factor is not likely to affect their occurrence at Lake Albacutya.

The majority of records of waterbirds breeding at the site occurred between 1979 and 1981, just prior to listing and during the time of extensive and ongoing flooding of the late 1970s. It is likely that if extensive flooding again occurs at the site significant breeding will again occur.

Little information is available on the extent and condition of Eucalypt woodland and especially River Red Gum, however it is likely that sufficient woodland is maintained at the site to provide nesting hollows and roosting habitat. In the short to medium term dieback, which is affecting the River Red Gum at the site, will possibly result in an increase in the number of tree hollows.

Filling events at Lake Albacutya are so episodic that no long term data exists. However on balance, there is no evidence to indicate any change in waterbird number or variety during flood events since the time of listing.

5.4 Threatened species

The Australian population size of the Regent Parrot (eastern) in 1982 is not known, however was possibly declining at that time as this would have contributed to its listing as a nationally threatened species on 16 July 2000.

The total population size has been estimated twice since that time, at around 1500 breeding birds in 2000 and over 2240 breeding birds in 2002-2004 (DEWHA, 2009), indicating increasing numbers.

Regent Parrot is recorded as breeding at Lake Albacutya in 1929, 1992 and 1993.

The nationally vulnerable Regent Parrot (eastern) uses Eucalypts adjoining a foraging Mallee landscape as preferred habitat and hollows in River Red Gums and other Eucalypts near the lake for breeding. Changes in the condition of the hydrological cycle and Eucalypt woodland therefore impact upon the condition of the lake as a resource for this species. There had been some deterioration in both of these elements at the time of listing, but there is no evidence that this has progressed substantially since that time. In addition, Regent Parrots can also utilise hollows in dieback affected trees for nesting and any increase in dieback could actually increase the number of tree hollows in the short term.

There is no evidence of any negative change in the occurrence of Regent Parrot since 1982, and numbers in the eastern population as a whole have increased.

5.5 Summary of the ecological condition of Lake Albacutya past to present

There is no evidence that the ecological character of the site has changed since 1982. The ecology of Lake Albacutya is threatened primarily by changes to the hydrological regime, and the subsequent deterioration of many of the wet phase and water dependent ecological components and processes which are adapted to the lake's natural wet-dry cycle. The impacts of this human-induced change have been apparent at the site for some time, for example the long-standing dieback of fringing River Red Gums which was well advanced at least 10 years prior to listing.

There is no evidence that the hydrological regime has changed since the time of listing. However, as the hydrological regime was already somewhat degraded in 1982, it is possible that deterioration has occurred since then in some elements of the lake ecology that depend on the hydrology as a result of progressive deterioration that commenced before 1982.

However, the extremely high rainfall in the late 1970s, which flooded the lake and caused it to hold water at the time of listing, may have provided a respite within a period in which flooding of the lake was reduced due to the high levels of flow regulation. It is likely that the 1974 to 1983 flood event has sustained the ecological character of the lake to the present time.

6. BENEFITS AND SERVICES

Benefits and services are defined as the benefits that people receive from ecosystems, including items such as food, water, hazard regulation, recreation opportunities, economic resources and cultural values (DEWHA, 2008a). It is important to note, however, that the underlying components and processes within the system are crucial for ecological functioning and for the production of all other services. These ecological services, such as supporting biodiversity, have important indirect benefits for humans.

This section outlines the benefits and services provided by the Lake Albacutya ecosystem. Where benefits and services have come to light since the time of listing, these have been included.

Australian Wood Duck, one of several waterbird species for which Lake Albacutya provides important habitat (photo I. Morgan)

6.1 Critical benefits and services of Lake Albacutya

As with the multitude of components and processes that comprise a wetland, only some benefits and services relate directly to the ecological character of the site and its ability to meet the nominated Ramsar criteria. This section details the critical benefits and services of the Lake Albacutya Ramsar site. Supplementary benefits and services are considered in a later section.

Table 6.1 Critical benefits/services, components and processes that contribute directly to the Ramsar values of Lake Albacutya and potential threats

Benefit/service	Description	Ramsar criteria	Critical components/ processes	Potential threats
Near-natural wetland - representativeness	Lake Albacutya is a representative example of a near-natural intermittent subterminal lake within the Murray Darling Drainage Division. As a gazetted Park under the *Victorian National Parks Act 1975*, its key land-based values are protected.	1	Morphology Hydrology	– River regulation – Climate change
Waterbird habitat	Supports more than 20,000 waterbirds particularly ducks, Banded Stilt and Eurasian Coot when full.	3, 5	Waterbirds Hydrology Eucalypt woodland	– River regulation – Climate change – Decline in Eucalypt woodland health – Recreation – Invasive species – Declining surface water quality
Waterbird habitat	Supports more than 5 % of the south-eastern Australian population of Freckled Duck, more than 4.5 % of the Banded Stilt population and 1 % of the Australasian shoveler population.	3, 6	Waterbirds (Freckled Duck, Banded Stilt and Australasian Shoveler) Hydrology Eucalypt woodland	– River regulation – Climate change – Decline in Eucalypt woodland health – Recreation – Invasive species – Declining surface water quality
Supports threatened species	Supports breeding populations of nationally vulnerable Regent Parrot. 2 % of the national population recorded at site.	3, 2	Threatened species (Regent Parrot) Hydrology Eucalypt woodland	– Reduced flooding. – Decline in Mallee condition

6.1.1 Wetland representativeness

Lake Albacutya represents a near-natural example of its Ramsar wetland category ‘seasonal intermittent freshwater lakes over 8 ha including floodplain lakes’ in the bioregion Murray-Darling Drainage Division.

It is one of 10 Ramsar sites of this wetland type within the Murray-Darling Drainage Division, which contains over 30 000 wetlands in total. The Directory of Important Wetlands in Australia lists 71 wetlands of equivalent type (B6 - Seasonal/intermittent freshwater lakes > 8 ha, floodplain lakes) in the Murray-Darling Basin, however most of these are wetland complexes with more than one wetland type. Approximately 43 are relatively simple intermittent lake systems with less than 4 wetland types, and of these only 6 are greater than 5000 ha in area.

Lake Albacutya also provides a relatively intact representative example of an intermittent subterminal lake. It is one of only two large subterminal lakes over 5000 ha in the north flowing Avon-Wimmera Drainage Basin, and the only one which is relatively intact, in the largest internal drainage system in Victoria. The other, Lake Hindmarsh, is impacted by rising water tables and salinisation.

Due to increasing pressures on all wetlands in the Murray Darling Basin and southern Australia and arguably all inland Australian wetlands, this service is even more significant than in 1982. There is no evidence that it has diminished.

6.1.2 Waterbird habitat

Waterbird habitat is one of the key services provided by the site and is a significant contributor to its Ramsar status. Lake Albacutya provides habitat for at least 60 waterbird species and breeding habitat for at least 12 waterbird species. The site provides habitat for 13 important migratory species listed on international agreements. Of the 18 500 wetlands in the Murray-Darling Basin only 98 or 0.53 % were found to support more than 10 000 waterbirds (Scott, 1997). It is clear that Lake Albacutya provides a highly valuable resource as waterbird habitat on a regional, national and global scale.

This service is supported by several key components and processes interacting at the site. Waterbird habitat is provided by filling of the lakebed during the wet phase of the wet-dry hydrological cycle but relies on the cycle in its entirety for the quality of the habitat. The hydrological cycle maintains healthy permanent vegetation in the form of Eucalypt woodland which many waterbirds require for nesting. The food to support high numbers of waterbirds feeding and breeding is a result of aquatic fauna and flora communities which develop during adequate flooding and are a result of nutrient cycling within and between phases.

6.1.3 Supporting threatened species

Lake Albacutya and the surrounding area provide important habitat for the nationally vulnerable Regent Parrot (eastern) with at least 50 individuals (of a maximum population of 2500) historically known to occupy the site and the species has been recorded breeding at the site three times. The Eucalypt woodland surrounding the lake provides suitable breeding habitat for the species which nest in tree hollows in large Eucalypts, particularly River Red Gum. The close proximity of the Eucalypt woodland at Lake Albacutya to the surrounding Mallee landscape which is important foraging habitat for the species adds to the value of the Regent Parrot habitat at Lake Albacutya.

Approximately 399 ha of Mallee occurs within the Ramsar site, however this comprises only a small fraction of that which occurs in the adjoining 361 000 ha Wyperfeld National Park. The support that the Lake Albacutya Mallee habitat provides for other threatened birds (Black-eared Miner, Mallee Emu-wren, and Malleefowl) is important but not significant.

Ridged Water-milfoil was recorded at the site in 1887, and should its occurrence be confirmed in the future, then the support provided by the habitat of Lake Albacutya will be very significant for this rare and nationally vulnerable species.

6.2 Supplementary benefits and services

There are numerous other benefits and services provided to people by the Lake Albacutya ecosystem. Although these are not critical to the ecological character of the site, they are benefits and services of significant value.

6.2.1 Food

Fish, crustacea and waterbird populations at Lake Albacutya provide an important regional food resource. At the time of listing Lake Albacutya was licensed for commercial fishing (Wimmera Catchment Co-ordinating Group, 1992), providing a source of income to the operators and a source of food for the end consumer. Finfish harvested from Lake Albacutya for commercial purposes included Redfin and European Carp (both exotic species) and Golden Perch, while Yabbies have also been caught commercially (Wimmera Catchment Co-ordinating Group, 1992, DSE, 2003).

When full, Lake Albacutya is a popular location for recreational fishing and duck hunting, providing a source of food to recreational users. Indigenous people of the area have a long-standing relationship with the Wimmera River, including Lake Albacutya, as a food source. They occupied the area seasonally, making use of abundant food provided by plant and animal communities at various times of the seasonal and hydrological cycles. This connection was formalised in 2005 by a native title determination which allows traditional owners access for non-commercial hunting and gathering purposes.

6.2.2 Agricultural grazing & cropping

Grazing of sheep has occurred for over a century at Lake Albacutya within most areas of the lakebed and Eucalypt margins. In 1983, shortly after the time of listing, grazing of part of the lakebed was formalised through a licensing system, currently managed by the Department of Sustainability and Environment. Four lakebed grazing licences were granted, totalling an area of about 2000 ha. Cropping of the lakebed has also occurred intermittently, but ceased around 1983.

6.2.3 Genetic material

The River Red Gum population at Lake Albacutya represents an important and unique genetic resource, which is acknowledged as the best performing genotype of the species, now used for forestry purposes worldwide. Seed of the Lake Albacutya provenance has been exported to the Middle East and Africa where it is used as a fast-growing, salt tolerant plantation timber species (Sandell, P., 2009, pers. comm.). It has rapid growth rates, straightness, and excellent drought and salinity tolerance compared to genotypes from other locations (Bren & Acenolaza, 2000). River red gums sourced from Lake Albacutya are also used as drought tolerant ornamentals and for lowering water tables in saline areas (DSE, 2003). Commercially available seed is now sourced primarily from plantations, however the original population remains important for maintaining genetic vigour (DSE, 2003).

6.2.4 Flood mitigation

As the second largest subterminal lake of the land-locked Wimmera River system, Lake Albacutya plays some role in flood mitigation. In times of high flow, Lake Albacutya receives excess flows from Lake Hindmarsh via Outlet Creek, storing this excess run-off and mitigating local flooding. Given the lack of infrastructure in the immediate area, this is probably a minor benefit. Lake Albacutya also acts as a reservoir for its small local catchment. The water is lost slowly over time through percolation and evaporation (60 000 ML per year) (Binnie & Partners, 1991).

6.2.5 Tourism/recreation

Lake Albacutya has a very high value for tourism and recreation, and when the lake is full it is one of the most popular areas in the region. Lake Albacutya Park provides a destination for tourists and locals and supports many recreational activities. The park provides picnic and camping facilities in several locations around the lake. There is a concrete boat launching ramp at Western Beach and boats may be launched from the shore at Yaapeet Beach when the lake is full. The park is popular for swimming, water skiing, fishing, yabbying and boating when water levels are high enough. When the lake is full, recreational activities are often focused on the south western and eastern shore of the lake (Sandell, 1996). Recreational duck hunting is permitted in areas of the park in accordance with the regulations. There are numerous walking tracks and 4WD tracks throughout the park. There are opportunities for bushwalking, bicycle riding, bird watching and nature appreciation, even during the dry phases of the lake. Lake Albacutya contributes to social wellbeing by providing opportunities for relaxation, enjoyment and appreciation of the environment which adds to people's quality of life.

Visitation rates to Lake Albacutya vary significantly depending on whether the lake is empty or full. When it contains water the lake is often surrounded by recreational campers. There are no records for when the lake last filled in the 1970s but in the year 1982-83 when the lake held water it was recorded that there were a total of 1142 camper nights. This compares with records as low as 140 camper nights when the lake is empty. Even in 1992-93 when a small amount of water entered the lake, numbers of recreational campers increased dramatically (Sandell, 1996). The majority of visitors are from the local area but visitors are also attracted from the national and international tourism markets.

Table 6.2 Visitation at Lake Albacutya 1989-1995 (Sandell, 1996)

year	Visits western beach	camper nights
89-90	26,900	140
90-91	23,300	200
91-92	23,500	350
92-93	38,000	600
93-94	38,700	400
94-95	22,800	100+

Recreational users of the site benefit from healthy terrestrial and aquatic communities which provide resources for fishing, bird watching, duck hunting and nature appreciation. The filling of Lake Albacutya with fresh, clean water as part of the hydrological cycle provides opportunities for a wide variety of aquatic activities.

Tourists attracted to Lake Albacutya contribute to the economy of the region (Sandell, 1996). When people visit an area they spend money on items such as fuel, food, camping and fishing supplies, accommodation and tours. Together these purchases contribute directly to the viability of local businesses as well as indirectly through a multiplier effect as the money is subsequently spent throughout the region helping to support the local and regional economy. A survey of residents in nearby towns of Jeparit, Rainbow and Dimboola revealed that the subterminal lakes are seen as being linked to the social and economic wellbeing of the towns. Especially when full, the subterminal lakes including Lake Albacutya, are an important factor in income generation within the region and there is community concern that the lack of flooding and deterioration in the health of the subterminal lakes compromises this capability (DSE, 2003).

Recreational visitors at Lake Albacutya during a lake-full period (photo M. Krelle)

6.2.6 Indigenous values

Aboriginal people from the Wimmera River area including Lake Albacutya refer to themselves as the Wotjobaluk people (Brown, 2001). They have long had and continue to have a physical and spiritual link with the land that is essential to their existence and wellbeing. The Wotjobaluk were hunters and gatherers and lived by a detailed knowledge of where and when plant and animal resources would be available, with the Wimmera River system including Lake Albacutya serving as a major focus (Brown, 2001).

Since the time of listing this profound relationship of Wimmera traditional owners to their land was formally recognized and a native title determination was gazetted in 2005 for areas of the Wimmera River including Lake Albacutya. Traditional owners now have non-exclusive rights to hunt, gather, fish and camp for personal, domestic and non-commercial needs. The Barengi Gadjin Land Council Aboriginal Corporation administers the determination on behalf of the Wotjobaluk people.

There are 17 registered heritage sites within the Lake Albacutya Ramsar site, including artefact scatters, burial sites, and scarred trees for making canoes, shelters, containers and shields (Heritage Council of Victoria, 2009). There are likely to be more culturally significant sites that have not yet been registered (DSE, 2003). Additional registered Aboriginal Cultural Heritage Places also occur in the area surrounding Lake Albacutya. These sites demonstrate the long-standing connection of Indigenous people with the area.

Lake Albacutya features within local indigenous creation stories. A dreaming track follows the Wimmera River from Stawell to Wirrengren plain (DSE, 2003). It is said that Doan the gliding possum set out to hunt Purra the kangaroo, whose tracks made the bed of the Wimmera River. During the chase Doan was eaten by Wembulin the spider. Realising he was no longer being chased, Purra stopped at a place where there was a lot of sweet grass and ate the ground bare. This bare patch became Guru (Lake Hindmarsh). Purra then continued slowly north forming Outlet Creek. He then came to a place where sour quandongs grew and stopped to feed again, this place becoming Lake Albacutya (Brown, 2001). Albacutya is derived from the aboriginal word 'nalbagadja' and means 'place of bitter quandongs'.

6.2.7 Scientific/educational

As it is relatively undisturbed, intact and in public ownership, Lake Albacutya provides an opportunity for scientific research, particularly into the ecology and hydrology of terminal lake systems. The site also provides an opportunity for visitor information and education, helping to raise knowledge about the values and significance of wetlands within the local, national and international community. Educational activities at the site include interpretive signage, nature trails and school education programs. The Wimmera River terminal lakes system also has geomorphological significance. The sediments and dunes surrounding the lake provide a record of past water levels and reflect climatic changes in the region over the last 10 000 000 years (Environment Australia, 2001).

6.2.8 Biodiversity

In total, over 500 species of plants and animals have been recorded at the site. In reality the number of species occupying the site is significantly more than this as invertebrates (which are often the most speciose groups in any given area) are very poorly documented.

Lake Albacutya and its surrounding area provide important habitat for numerous threatened species at a state and national level. A total of 46 species of fauna listed on the Victorian Advisory List have been recorded in the area and four of these are considered threatened nationally. Six species of flora found in and around the Ramsar site are listed as threatened in Victoria, one of which is nationally threatened. The site contains over 20 % of all records of *Acacia trineura* which is vulnerable in Victoria (DSE, 2003).

Lake Albacutya provides habitat not only for aquatic species but also for species from the surrounding Mallee landscape, which utilise components of the lake ecosystem. This value relates to its presence as a mesic floodplain within the surrounding arid landscape (Sandell, 1996). This juxtaposition of riverine and Mallee landscapes provides a valuable opportunity for species to utilise elements of both, enabling a greater diversity of species than would otherwise exist in the region (Sandell, 1996). For example the flood dependent River Red Gum community surrounding the lake provides nesting habitat for the nationally vulnerable Regent Parrot. These birds require hollows in large trees for nesting in close proximity to the surrounding Mallee landscape in which it feeds (DEWHA, 2009). Large trees also provide breeding sites for raptors. Other endangered species which may benefit from this situation include the Bush Stone-curlew, Barking Owl, Major Mitchell Cockatoo and Bustard (Sandell, 1996). Terrestrial fauna drink from the lake and insectivorous species also benefit from increased insect activity during flooding (Morton & Heislers, 1978).

The lake provides important breeding habitat for aquatic and non-aquatic species, particularly birds, contributing to the recruitment and persistence of regional populations. A total of 48 bird species have been recorded as breeding at Lake Albacutya. Five of these are threatened in Victoria, and two (the Malleefowl and Regent Parrot) are nationally vulnerable.

The near-natural state of the system also makes it an important refuge for biodiversity, particularly within a catchment in which much of the natural environment has been heavily disturbed or replaced by agriculture.

It is clear that the hydrological cycle and physical characteristics of Lake Albacutya support numerous flora and fauna species and combine to drive a complex ecology. Links occur within and between all of the communities found at and around the site such as Eucalypt woodland adjoining Mallee landscape, terrestrial dry-phase lakebed, aquatic flora and fauna, and visiting waterbirds and terrestrial fauna. Due to the cyclical hydrology of the lake, successional processes are repeatedly being reset so that more than one climax community may occur at any given place on the site in different phases of the cycle (i.e. lakebed vegetation giving way to an aquatic community when the lake fills), or indeed in different episodes of the same phase (i.e. the community composition of lakebed vegetation may be significantly different between subsequent dry phases). Due to the physical structure of the lake there are a variety of spatial habitats that allow various communities to form (i.e. deep water, shallow water, moist flats, littoral zone, and higher dry areas). The diversity of communities at the site both spatially and temporally enables a great complexity of food web and nutrient cycling processes which reinforce the species richness of the area. These factors enable the site to provide suitable habitat for significantly more species than may be possible for a spatially and temporally homogenous area of similar size.

Major Mitchell Cockatoo (photo I. Morgan)

6.3 Lake Albacutya significance listings

The ecological and social significance of Lake Albacutya is well recognised. The site is a listed Ramsar wetland primarily because it is representative and for its importance as waterbird habitat. It is also listed on the Directory of Important Wetlands in Australia. The area is a designated Park under Section 3 of the *Victorian National Parks Act 1975*. It forms part of the listed heritage river section of the Wimmera River. The site is also listed on the Australian Heritage Places Inventory and on the Register of the National Estate.

7. A CONCEPTUAL MODEL FOR LAKE ALBACUTYA

7.1 Introduction

Conceptual models use diagrams combining symbols, pictures and colours to explain complex scientific knowledge in a form that is immediately informative and accessible. Models can highlight knowledge gaps, establish priorities, clarify and synthesise thinking, and inform monitoring programs. (Department of Environment and Resource Management QLD, 2009).

There are benefits in reducing the vast array of Australian wetlands to a smaller number of wetland classes that are likely to have similar characteristics and processes in order to capture the current scientific understanding of their key processes and components. An adaptive management framework can use conceptual models to assist understanding of the wetland for planning, monitoring and management purposes (Heydon et al., 2007). This is represented in Figure 7.1.

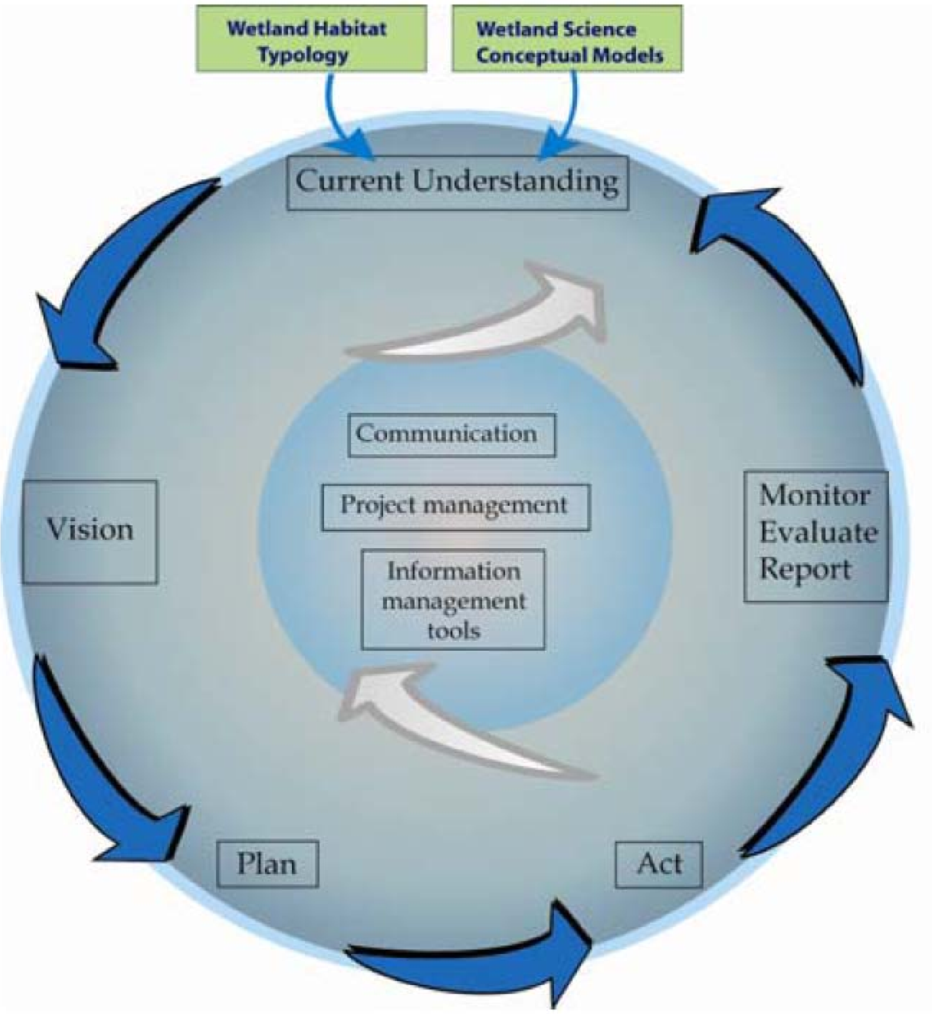


Figure 7.1 Adaptive management framework incorporating conceptual models (Heydon et al, 2007)

Conceptual models can be used to show the linkages between the chemical, physical and biological components, of a wetland ecosystem, as well as the ecological processes, benefits and services. For many situations, one all-encompassing model may be too difficult to understand, and in these cases it may be useful to have a number of conceptual models which focus on different temporal phases, components or processes (DEWHA, 2008a).

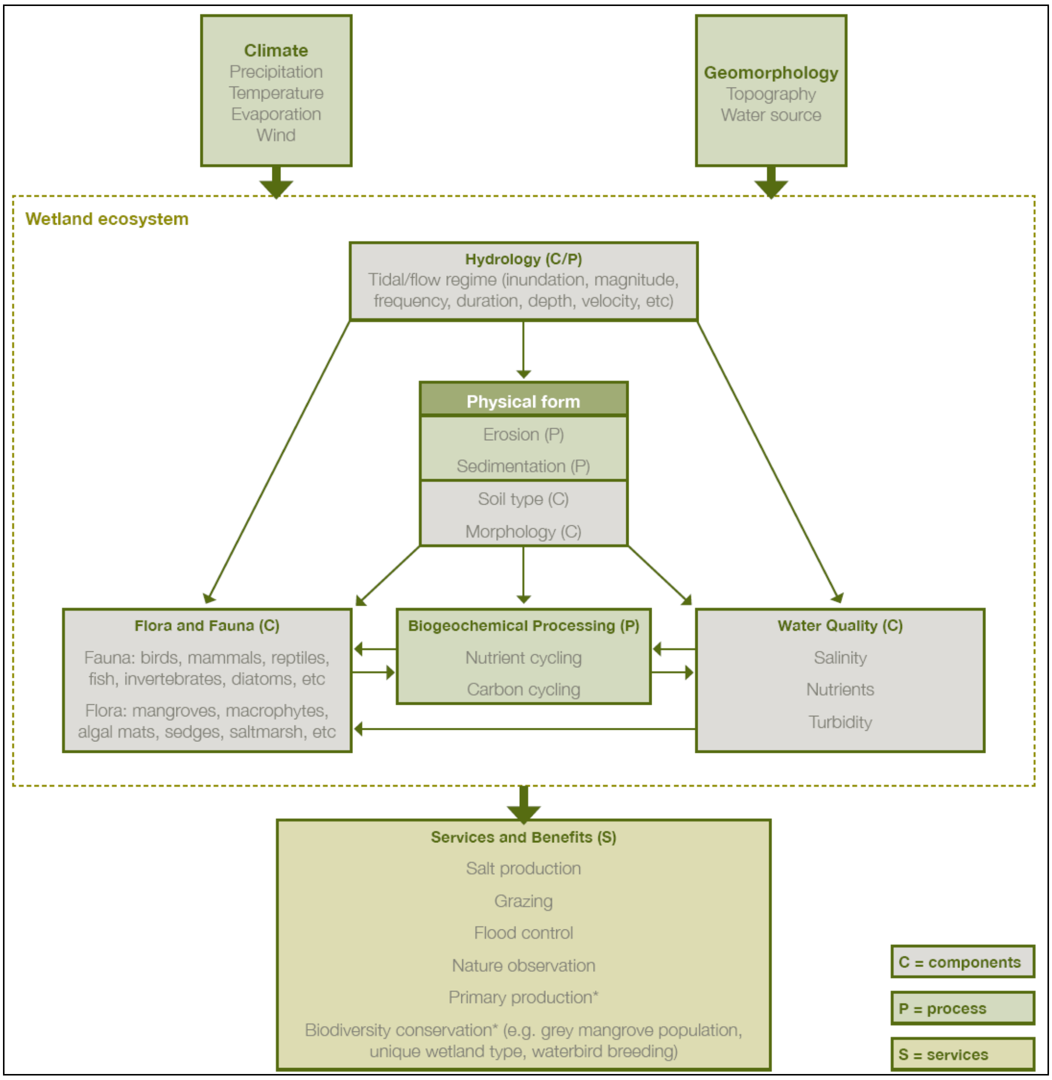
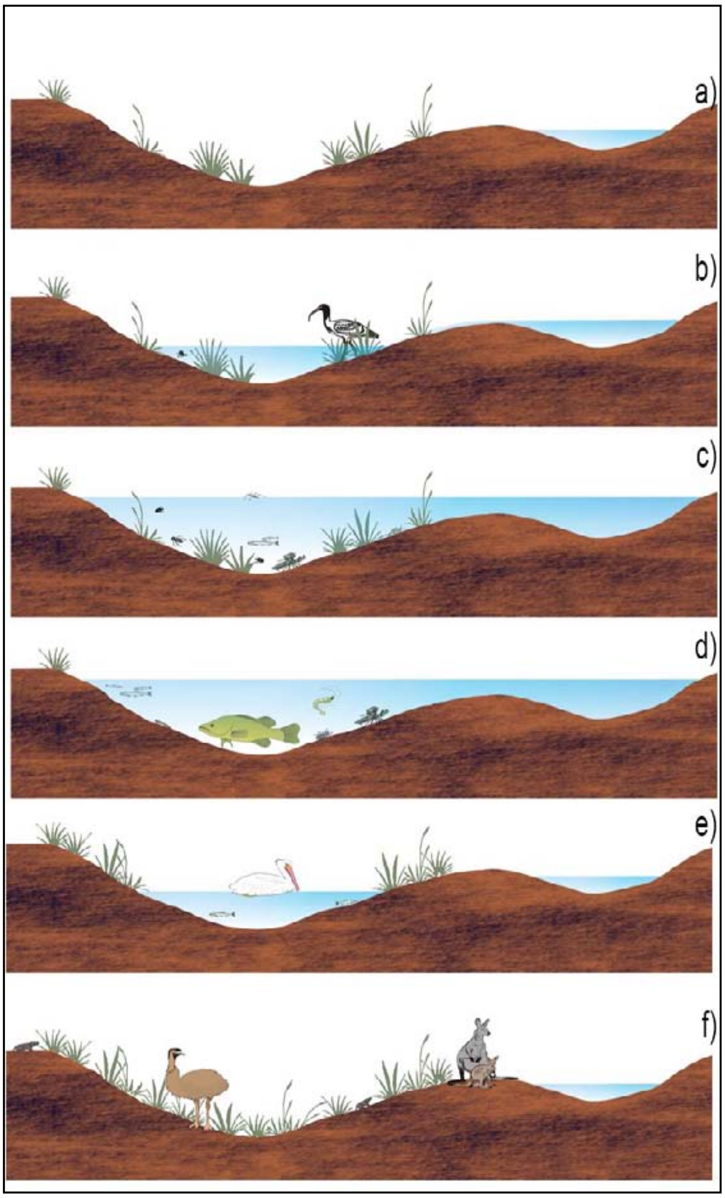


Figure 7.2 Simple conceptual model of a wetland ecosystem (DEWHA, 2008a)

Those marked with an * may be considered as components or processes as well as ecosystem services or benefits.

Until recently, relevant conceptual models concerning Australian lake ecology were derived from lakes or tropical rivers in the Northern Hemisphere and had variable application in an Australian context. Gawne & Scholz (2006) identified key advantages and limitations of major categories of existing conceptual models which they classified as: Alternate Stable States, Trophic Cascade, Flood Pulse, and Geomorphic-Trophic, models. They then developed a five stage model to represent the key transition processes associated with Ephemeral Deflation Basin Lakes (EDBL), applicable to the Murray Darling Drainage Basin, and of which Lake Albacutya is an example.

The five stages of EDBL filling and drying are represented in Figure 7.3 below which begins and starts with a dry lake.



a. Dry lakebed with forbs and grasses
b. shallow flooding creates a heterogeneous, nutrient-rich aquatic habitat with few aquatic predators
c. established lake with established invertebrate and fish communities
d. late-flooding cycle with low habitat heterogeneity, and well established predatory fish community
e. drying lake in which avian predation dominates
f. dry lake, providing productive habitat for terrestrial plants and animals

Figure 7.3 Five stage conceptual model for ephemeral semi-arid zone lakes (Gawne & Scholz, 2006)

7.2 Conceptual models - recent Australian developments

In recent years in Australia, a great deal of effort has focused on developing practical and useful wetland models. The National Land and Water Resources Audit (NLWRA), in conjunction with state agencies, developed a framework for monitoring wetland extent, distribution and condition, and this framework is supported by conceptual models that synthesise our understanding of the ecological functioning of wetlands. This approach is also supported by other key national, state, interstate and regional bodies (Price and Gawne, 2009).

Price and Gawne (2009) report that conceptual modelling is being undertaken collaboratively for seven major arid-zone wetland types, and other wetland classes, by New South Wales, Queensland, South Australia, and the Murray Darling Basin Authority, and these models will be used for:

- synthesis of knowledge and to identify knowledge gaps
- identifying key links between drivers, stressors, and system responses
- understanding how the processes, threats and system dynamics differ between wetland types
- facilitating the selection and justification of indicators
- interpreting monitoring data (specific to different wetland types) and identifying acceptable levels of change
- education and communications tools.

Shared responsibility between national and state jurisdictions for developing wetland conceptual diagrams has resulted in Queensland leading development of conceptual models for tropical and sub-tropical wetland types, NSW developing conceptual models for temperate areas, South Australia developing conceptual models for the arid zones, and the Murray Darling Freshwater Research Centre (on behalf of the Murray Darling Basin Authority) developing models for wetland types in the semi-arid zone.

Price and Gawne (2009) worked with the jurisdictions identified above to develop a nested suite of models comprising four types of conceptual model to best represent the complexity of semi-arid wetlands in a way that clearly depicts key components, drivers and processes. Models for seven major semi-arid wetland types were developed:

- commonly wet freshwater lakes
- periodically-inundated floodplain freshwater lakes
- periodically-inundated non-floodplain (depressional) freshwater lakes
- floodplain freshwater swamps
- non-floodplain (depressional) freshwater swamps
- saline lakes
- saline swamps (developed by the Qld DENR and available from the website: http://www.epa.qld.gov.au/wetlandinfo/site/ScienceAndResearch/ConceptualModels.html)

7.3 Conceptual model - semi-arid wetlands

The nested suite of conceptual models produced for semi-arid wetlands has four main types of models (Price and Gawne, 2009) as outlined below.

1. Overarching Component Models for:
    - wetland geomorphology
    - wetland hydrology
    - water Quality: pH, turbidity, dissolved oxygen, temperature and salinity
    - dissolved nutrient loads
    - dominant vegetation
    - dominant form of primary production
    - microbial production
    - invertebrates
    - fish
    - waterbirds
    - frogs

2. A single generic key driver model

3. Type specific Character Description Models for:
    - commonly wet freshwater lakes
    - periodically-inundated freshwater floodplain lakes
    - shrub/Lignum swamps
    - eucalypt swamps
    - sedgeland/Grassland swamps
    - periodically-inundated freshwater non-floodplain (depressional) lakes
    - saline lakes

4. Wetland-type specific Inundation Models for all wetland types that are temporary:
    - commonly wet freshwater lakes
    - periodically-inundated freshwater floodplain lakes
    - periodically-inundated freshwater non-floodplain (depressional) lakes
    - freshwater floodplain swamps
    - freshwater non-floodplain (depressional) swamps
    - saline lakes

7.4 Significant conceptual model elements

The significant elements identified as drivers of the ecological character of Lake Albacutya, and those required to properly represent the ecological character in one or more concept model diagrams, are specified below.

1. Components & Processes
    - geomorphology
    - climate
    - hydrology - surface and groundwater
    - flora - aquatic and terrestrial
    - fauna - waterbirds, aquatic, terrestrial (e.g. threatened species)

2. Benefits & services
   - provisioning Services - food, grazing, genetic material
   - cultural Services – tourism/recreation, indigenous values, scientific & educational, wetland representativeness
   - supporting Ecosystem Services – waterbird habitat, biodiversity

3. Threats
   - hydrological change through water regulation and diversion
   - climate change
   - decline in Eucalypt woodland health
   - recreation
   - terrestrial and aquatic invasive species
   - declining surface water quality

Many of these ecological character elements for Lake Albacutya are the subject of, or are included in, individual models developed by Price and Gawne (2009). Many of the ecological processes and components have been represented, for semi-arid wetlands, in simple box and arrow charts that display key interactions.

Figure 7.4, Wetland Hydrology, is a typical example, and others are shown below for: Dominant aquatic primary production, Waterbird community composition and abundance, Invertebrate community composition and abundance, and Microbial production.

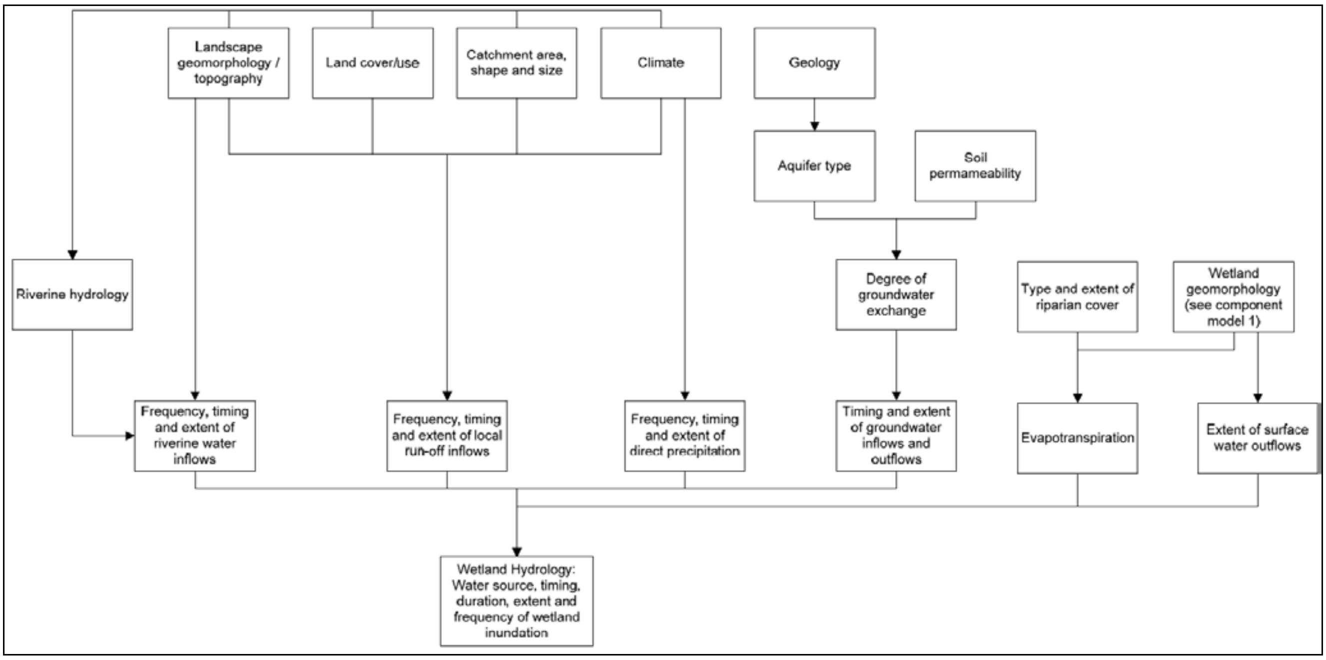


Figure 7.4 Wetland hydrology (Price and Gawne, 2009)

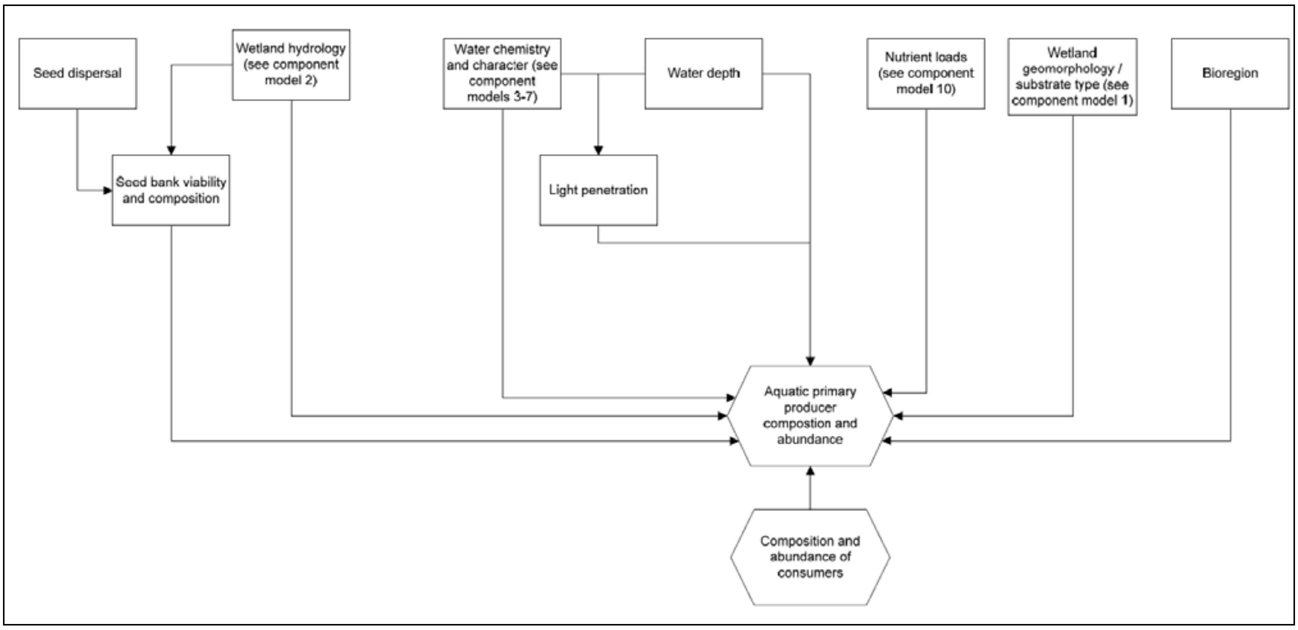


Figure 7.5 Dominant aquatic primary production (Price and Gawne, 2009)

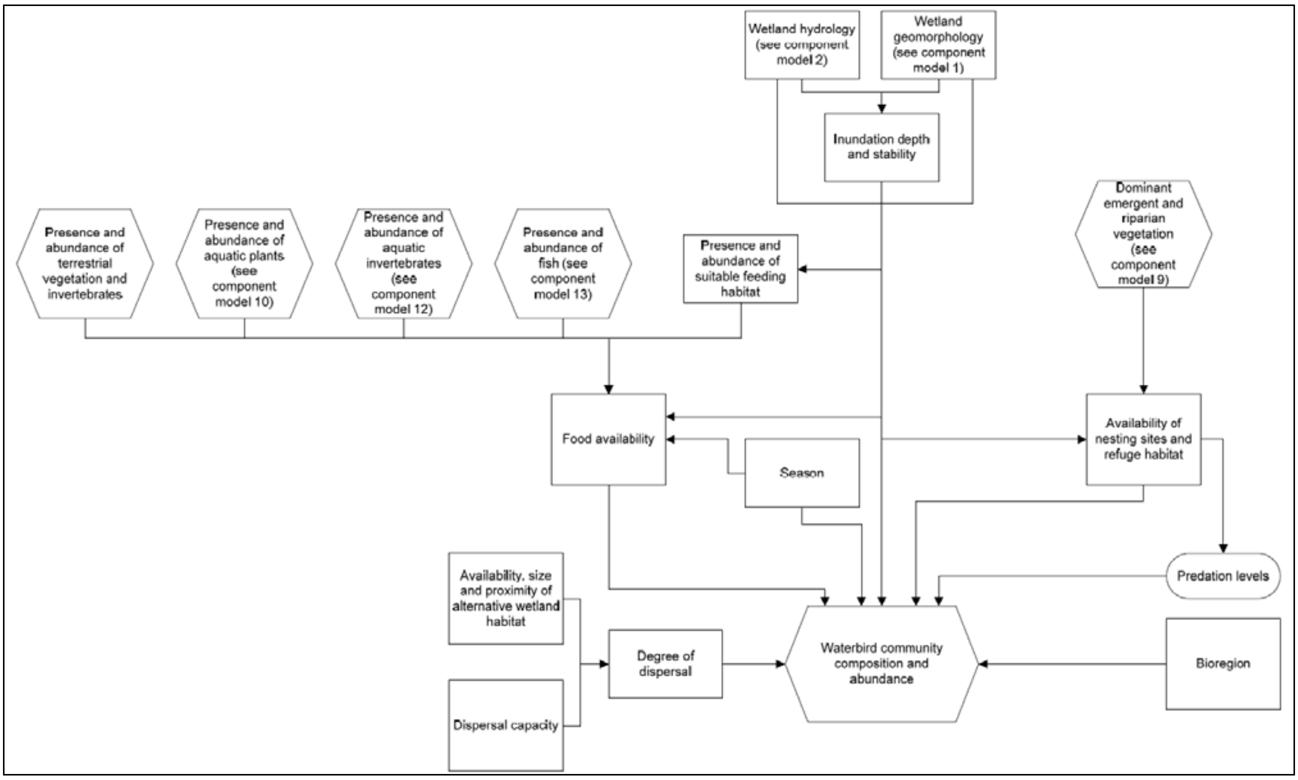


Figure 7.6 Waterbird community composition and abundance (Price and Gawne, 2009)

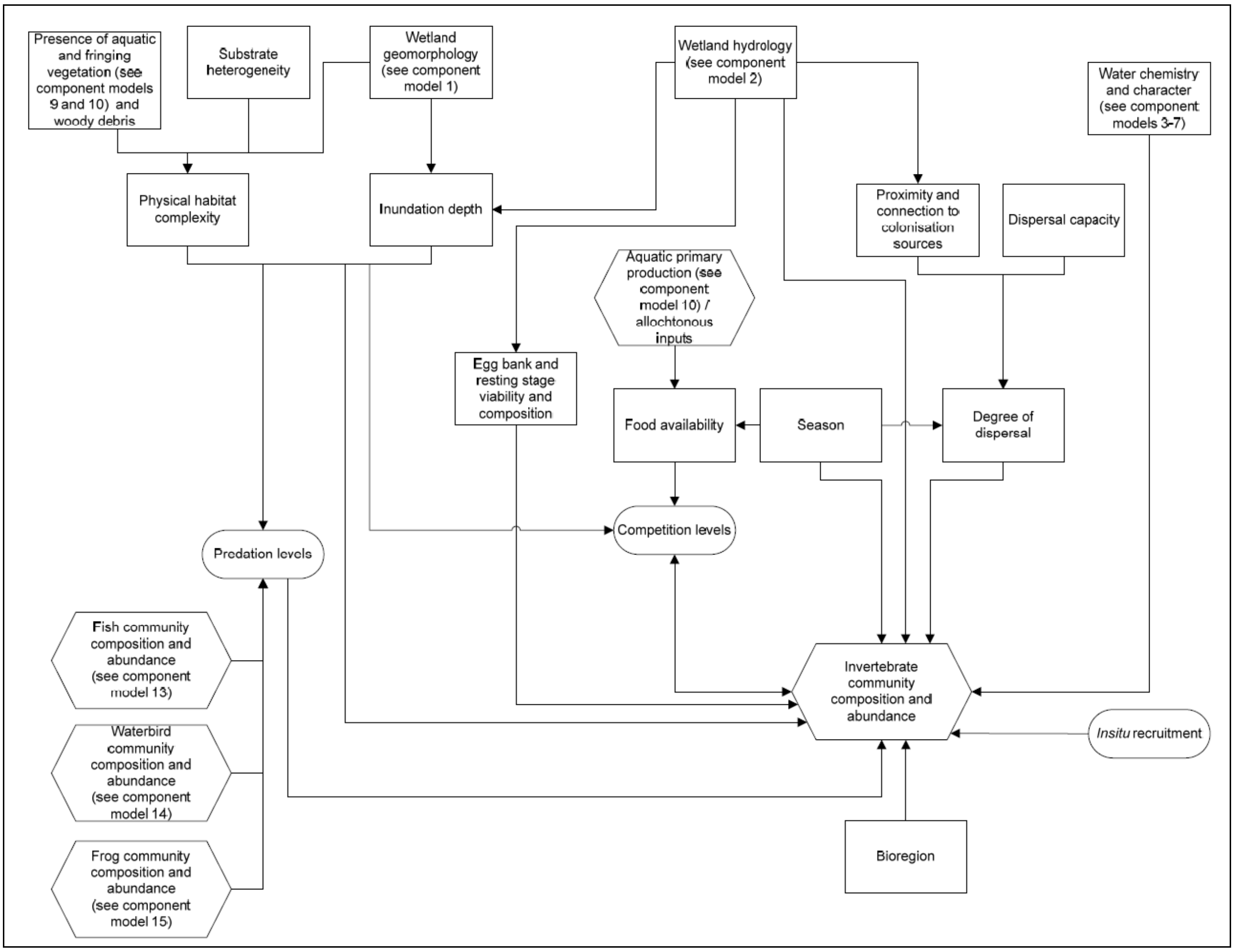


Figure 7.7 Invertebrate community composition and abundance (Price and Gawne, 2009)

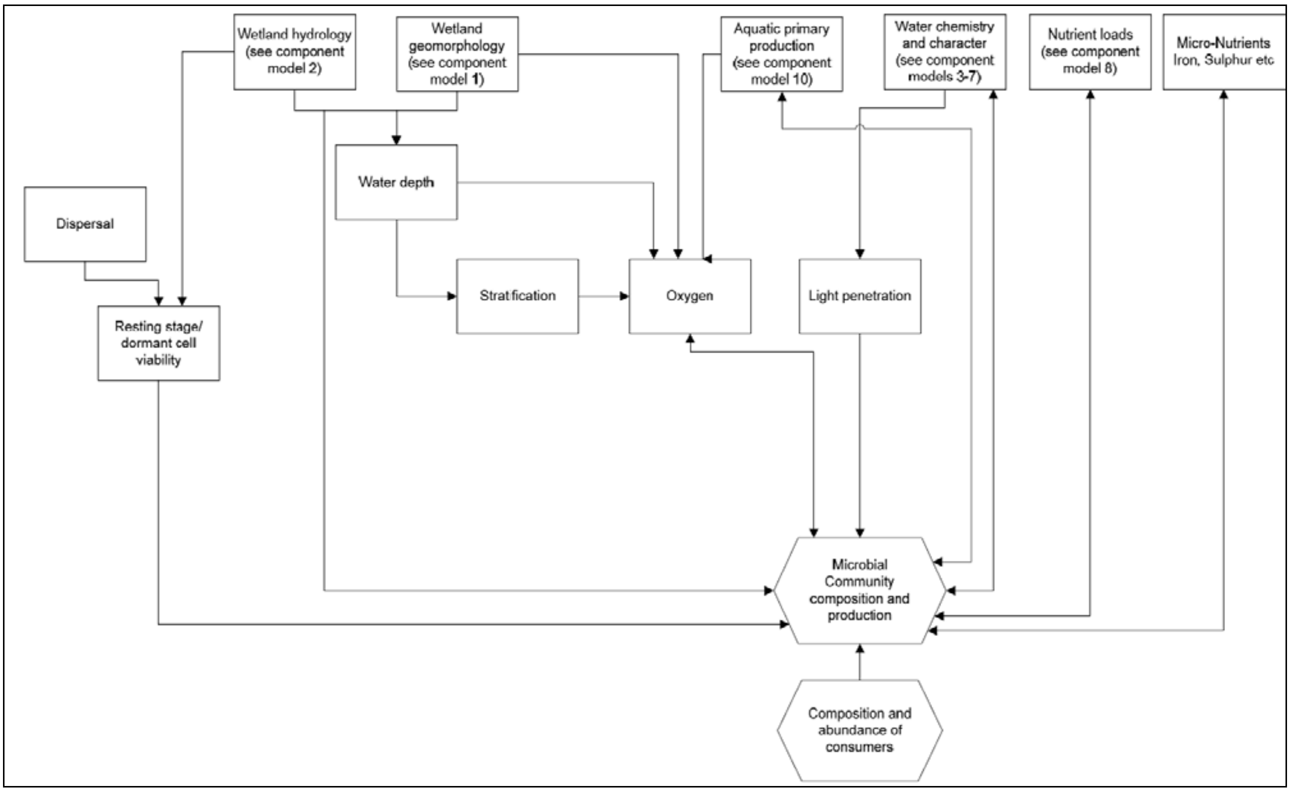


Figure 7.8 Microbial production (Price and Gawne, 2009)

In addition to representing components and processes as displayed in the figures above, key drivers of ecological character have also been represented in their own model, shown at Figure 7.9, below.

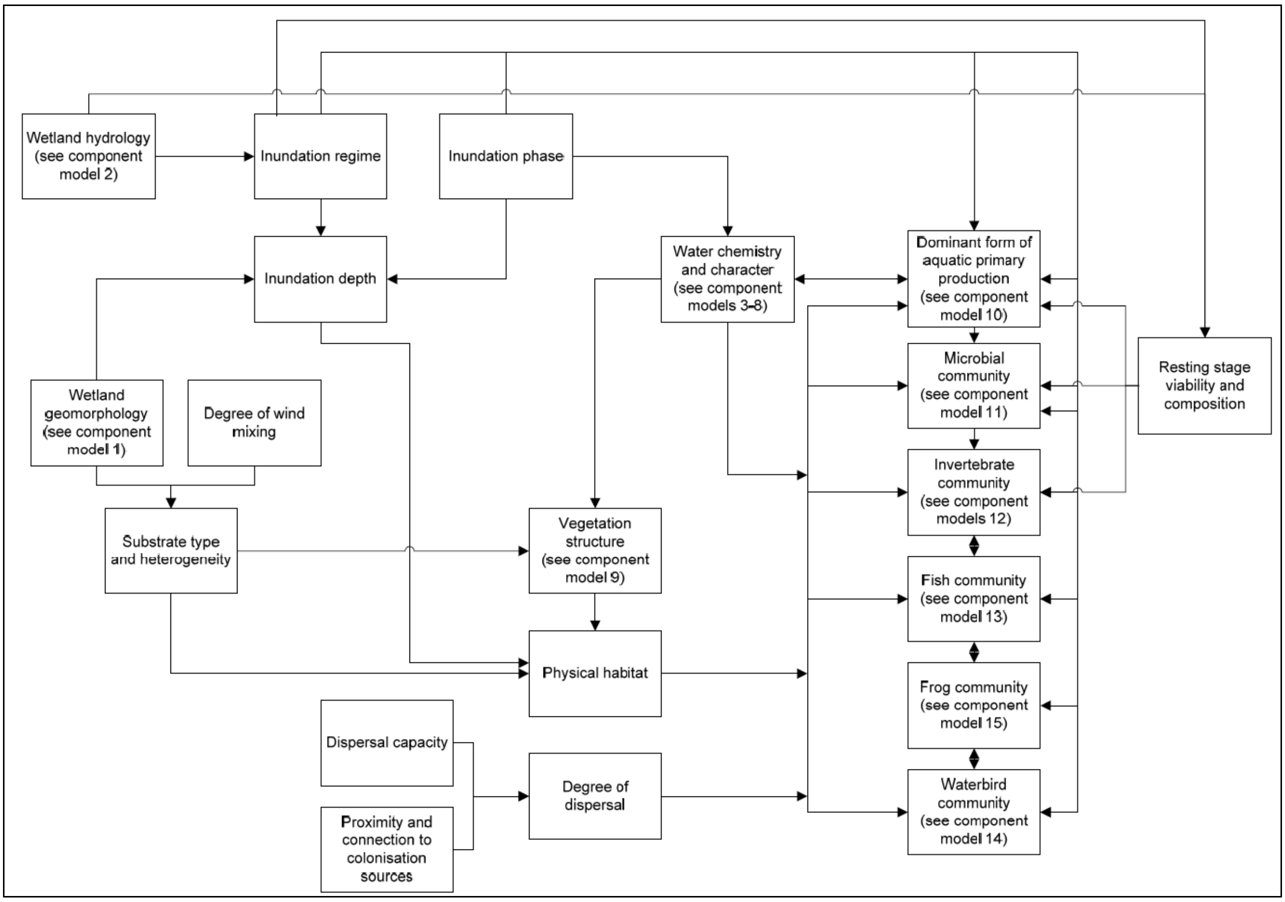


Figure 7.9 Generic wetland key driver model (Price and Gawne, 2009)

These box and arrow models focus on representative ecosystems but do not include some elements which are considered critical components of a conceptual model as described in the National Framework, such as benefits and services, and threats to ecological character (DEWHA, 2008a).

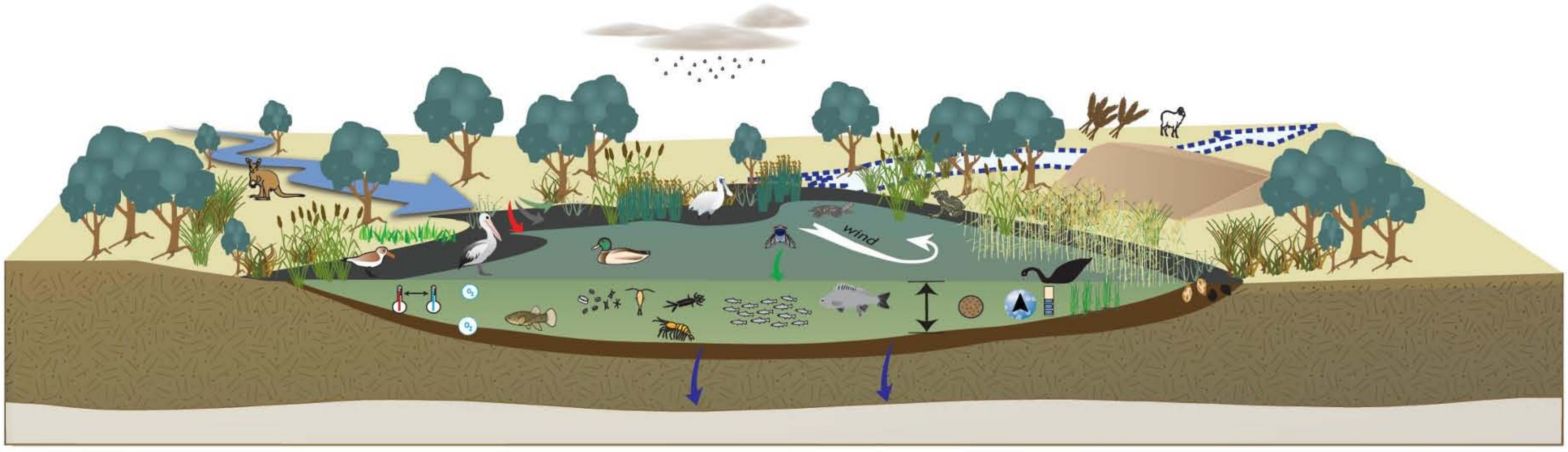
7.5 Conceptual models for Lake Albacutya

A pictorial Ecological Character Description model is designed to portray key elements of the ecology of a site in a visual format that is easy to follow and understand. The following Ecological Character Description model for Lake Albacutya, Figure 7.10, is based on models developed by the Murray Darling Basin Authority and the Queensland Wetland Program. A full suite of their models can be viewed at the Queensland government Wetland Info website - http://www.epa.qld.gov.au/wetlandinfo/site/ScienceAndResearch/ConceptualModels.html (If this is not available, see www.derm.qld.gov.au). Due to space limitations, some threats, and benefits and services, have not been included in this model.

In addition to Figure 7.10, an inundation model has also been developed for Lake Albacutya to represent those important aspects of the ecology that are linked to the inundation phases of the wetland. The Lake Albacutya inundation model, Figure 7.11 has been adapted from Price and Gawne, 2009.

A Stressor-driver model for Lake Albacutya, designed to show the impacts of the most significant threats to the wetland, is shown in Chapter 9.

Lake Albacutya



Components/Features

Soil mainly made up of aeloian and fluvial sands and clays to considerable depth.

Substrates: inner lakebed is usually clay wih sandier substrate at outer lakebed.

At least two lunette dunes present mainly at east and north east as a result of deflational processes.

Water depth may be shallow to deep (up to 8 m) depending on the flood characteristics of the inundation phase.

Water Quality

Water temperature is temporally and spatially variable, and more responsive to air temperature in shallow areas.

Dissolved oxygen concentrations are temporally and spatially variable. Decomposition of organic matter during flooding may lead to low dissolved oxygen.

pH is generally alkaline but may vary depending on inundation phase and production.

Water is fresh but may become partly saline when drying. Small inflows may also be saline.

Turbidity levels generally low, depending on depth, wave action and wind mixing. European Carp may contribute to future turbidity.

Fauna

Aquatic invertebrates: A diverse and abundant invertebrate community comprised of micro and macroinvertebrates occurs. Early invertebrate colonisers are dessication-resistant species that emerge from egg banks and resting stages. Other freshwater invertebrates colonise via aerial (wind and bird) and aquatic dispersal. Community composition and abundance varies depending on factors including inundation phase, water quality and food and habitat availability. Invertebrates represent an important link in the food chain as they convert primary production into animal biomass that represents a food resource for fish and birds with different species of life stages providing food for different predator species.

Fish colonise the lake from upstream and their abundance depends on factors including inundation phase, water quality and food and habitat availability. Few endemic species occur and introduced native and pest species are common.

Frogs and turtles are likely to disperse from local farm dams and also from upstream. As the lake dries, the development of lake bed vegetation provides an important habitat and food resource for terrestrial animals such as kangaroos, emus and lizards. Sheep graze about 54% of the dry lake bed.

Waterbirds

A variety of waterbirds including herbivores, piscivores, waders, shorebirds, ducks and grebes, may be absent or present in low to high abundances depending on food and habitat availability. The major determinants of habitat are depth and vegetation. In general feeding habitat is shallow while deep water is required for successful breeding. Eucalypt woodland including River Red Gum, and other fringing vegetation provide important breeding sites.

Herbivores — Large wading birds — Shorebirds — Piscivores — Ducks and grebes

Processes

Inputs from the single inflowing creek (Outlet Creek) and minor local runoff are the most important inputs of water, sediments, nutrients, and allochthonous (externally sourced) material. Lakebed dry-phase community adds nutrients and organic matter.

Biota disperse into Lake Albacutya mainly via Outlet Creek and aerial dispersal.

Seed and egg banks within the lake sustain communities through internal regeneration and recruitment.

Groundwater recharge.

Rare and episodic overflow discharge via Outlet Creek.

Episodic lakes undergo major changes with inundation phase that lead to changes in the major source of primary production with macrophytes, attached algae and phytoplankton making significant contributions at different times. Lake Albacutya fills infrequently and the dry phase may last for periods of up to 30 years. The flood-mediated wet phase may last from months to many years. Winter rainfall, while low, can still benefit some water-dependent species.

Flora

Fringing vegetation: Lake margin is fringed by Eucalypt woodland (River Red Gum, Blackbox, Lignum) which persists through the wet-dry cycle. Understory varies with inundation phase, and is made up of shrubs, herbs, and grasses. River Red Gum is affected by dieback, but recruitment is evident.

Emergent macrophytes: Little information is available. Presence , density and composition of emergent macrophytes varies spatially and temporally and is dependent on factors such as frequency of inundation and phase.

Lakebed herbland: As the lake dries a diverse plant community develops comprised of shrubs, grasses and herbs. The community composition is influenced by sediment type and soil moisture. This vegetation represents an important food resource for terrestrial animals and also influences productivity, habitat and water quality when the lake is inundated.

Submerged and floating macrophytes: Little information is available. Submerged macrophytes may be present depending on a variety of factors including presence and composition of viable seed banks, water quality, water depth, and light penetration.

Algae: Algae production is likely to include a diverse range of macro- and microscopic species that occupy all habitats. Macroscopic algae include filamentous algae and species which are attached to the sediments. Microscopic algae includes phytoplankton which predominates in open water and periphyton that grow attached to sediment, plants and other surfaces. Algal production may be the dominant form of primary production depending on variables such as water depth, nutrient loads and the degree of light penetration.

Cereal and other crops in local catchment

Key Threats

River regulation, climate change (reduced rainfall), decline in Eucalypt woodland condition, introduced species and, potentially, recreational activities.

Aquatic Ecology

Lake Albacutya fills episodically to an average depth of around 6m before it overflows, and it can retain water for several years or more, with annual evaporative losses of up to 1.3m. The lake's aquatic ecology is driven by the temporal phase and physical variables such as nutrient load, turbidity, and depth. The first floodwaters carry high organic loads and trigger biochemical interactions in the wet substrate, causing a nutrient pulse which boosts microbial activity after flooding and provides the basis for the lake's food web. On first flooding, inundated terrestrial plants of the inner lakebed also start decomposing and add to the nutrient levels.

Primary production and lake ecology are driven largely by water depth. The shallow littoral zone around the lake edge is characterised by warmer water and coarser sediments. Shrubs and eucalypt woodland plants which colonise the outer lakebed in the dry phase, die after inundation and provide substrate for algae and shelter for early macroinvertebrate colonisers. Species diversity in this zone may be high as emergent and submerged macrophytes also increase habitat complexity for invertebrates and juvenile and small-bodied species of fish which find cover from larger predators. Due to its shallow depth, the littoral zone is also part of the photic zone, the area of light penetration. Photic zone photosynthesis provides most of the organic matter for the lake's aquatic fauna. In the interior of the lake away from the littoral zone, the photic zone is called the limnetic zone. Here where the water is too deep for rooted macrophytes, primary production is dominated by phytoplankton, and larger fish find protection from waterbird predation. With a maximum depth of around 8m and generally low turbidity, Lake Albacutya has no real profundal or aphotic zone (the zone of little or no light penetration).

Water clarity and nutrient loads are also major determinants of the dominant form of primary production - high levels of turbidity and dissolved nutrients favour phytoplankton dominance. There are reports of high water clarity when Lake Albacutya is full, however when shallow, wind may disturb sediment and increase turbidity. During the last drying stage the lake may become brackish, and eutrophy is also likely.

Figure 7.10 Ecological character model for Lake Albacutya

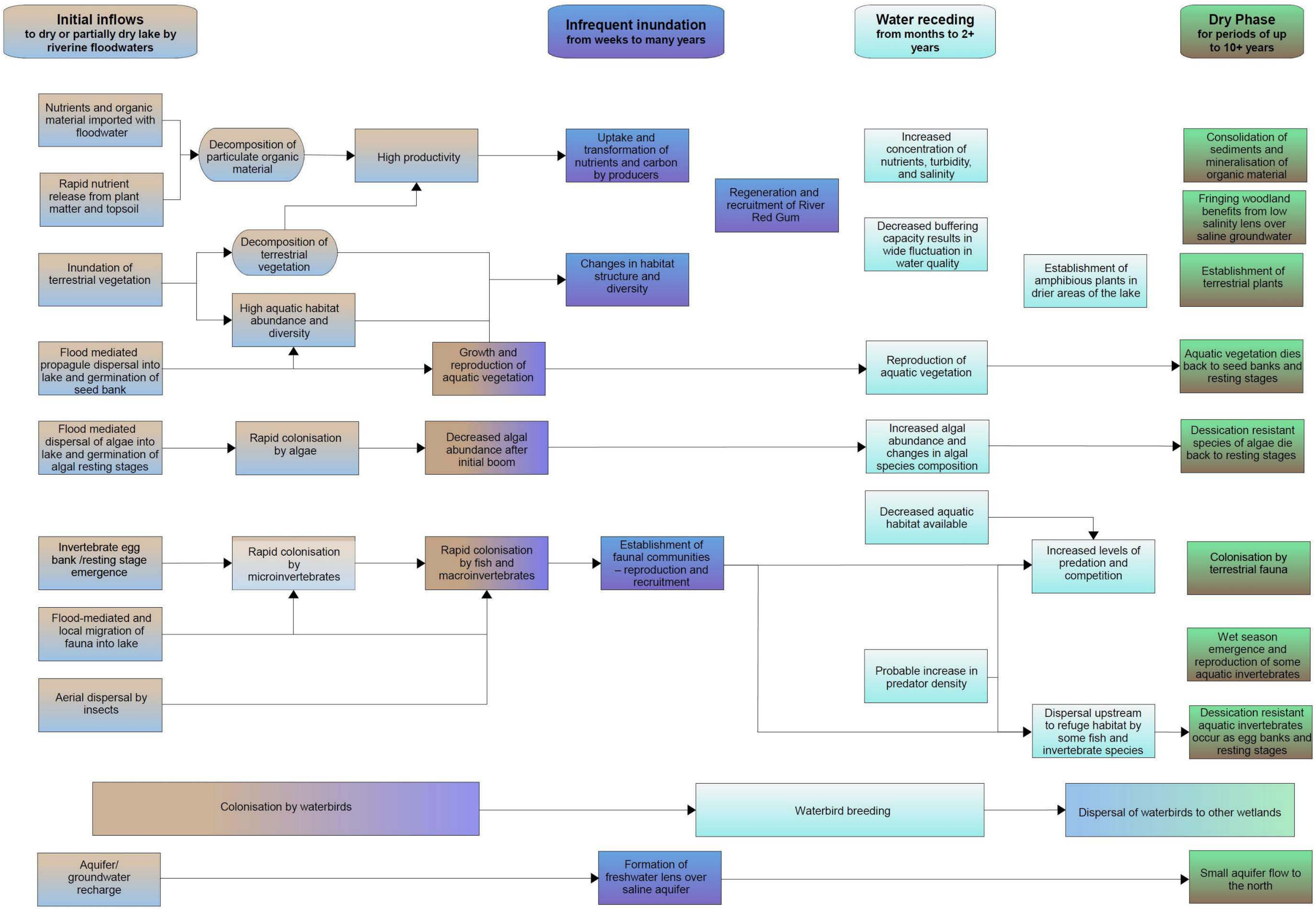


Figure 7.11 Inundation model for Lake Albacutya (adapted from Price and Gawne, 2009)

8. LIMITS OF ACCEPTABLE CHANGE

The limits of acceptable change make it easier to determine if the ecological character is likely to change or has changed since listing and the reasons for this change or likely change. Change in ecological character occurs when the critical parameters of the wetland ecosystem fall outside their normal range (Ramsar Convention, 1996).

Phillips 2006 has defined limits of acceptable change as the variation that is considered acceptable in a particular measure or feature of the ecological character of the wetland, as represented in Figure 8.1.

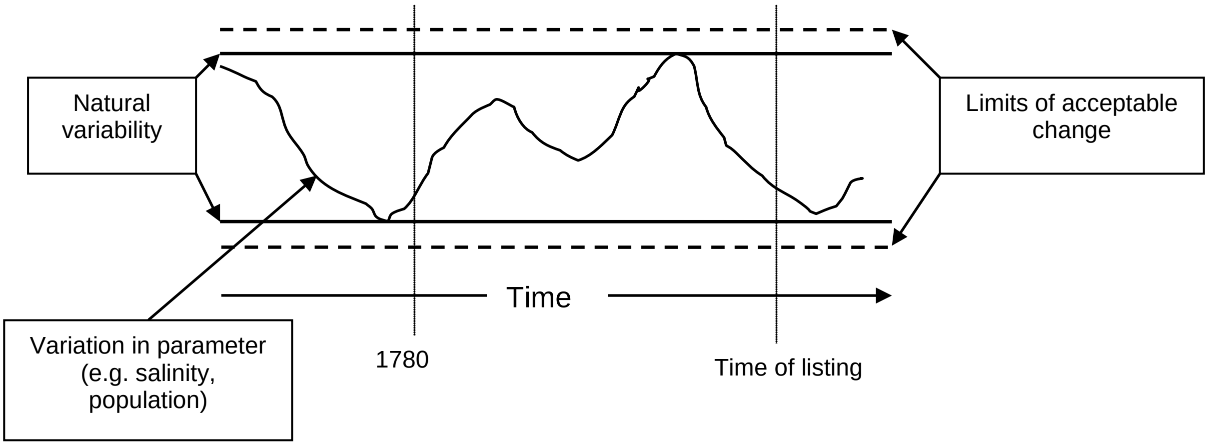


Figure 8.1 Relationship between natural variability and limits of acceptable change (Phillips 2006).

Australian semi-arid environments generally experience a high degree of natural variability, and Lake Albacutya is extremely variable largely due to an episodic hydrological regime which is totally dependent on infrequent flood events originating in the upper catchment.

Therefore, understanding the range of natural variation in the critical components, processes benefits and services of the wetland is the first step to set limits of acceptable change for the wetland.

The datasets to describe the natural variation in the attributes of Lake Albacutya are very limited. The use of natural variation as the basis for determining the limits of acceptable change is made more complex by the cascading series of anthropogenic changes over the past 150 years. It may be that limits of acceptable change for a specific attribute under historical conditions do not apply under the changed conditions resulting from multiple anthropogenic pressures, due to the reduced resilience of the ecosystem as a whole.

Resilience has been described as the capacity of a system to absorb disturbance, established by the amount of change a system can undergo while essentially retaining the same function, structure and feedbacks (Walker and Salt, 2006).

In the absence of the necessary research it has not been possible to incorporate resilience analysis into this document. However in the event that new information on ecosystem resilience for Lake Albacutya should become available, then the limits of acceptable change should be reviewed.

For the purpose of this chapter, only those components and processes, and benefits and services, identified as critical in maintaining the ecological character relevant to the Ramsar listing, are considered.

Exceeding or not meeting a Limit of Acceptable Change does not necessarily indicate that there has been a change in ecological character. While the best available information has been used to prepare this Ecological Character Description and define Limits of Acceptable Change for the site, in many cases only limited information and data is available for these purposes. The Limits of Acceptable Change in Table 8.1 may not accurately represent the variability of the critical components, processes services and benefits under the management regime and conditions that prevailed in 1982 when site was listed as a Ramsar wetland.

8.1 Limits of acceptable change for critical components and processes

8.1.1 Morphology

Morphological attributes rarely change significantly as a result of natural processes in the short to medium term, and such changes are generally discernible only over very large timeframes. There is no evidence to suggest that the morphology of Lake Albacutya has changed appreciably over the past 150 years, and it is unlikely that it has changed much over several millennia. Human intervention, however, can result in significant change within years or decades.

Lake Albacutya, about 10 km long and 5 km wide, is comprised of an inner flat lakebed, rising by 1-2 meters within about 1 km of the perimeter of the lake, forming a shallow outer lakebed around the perimeter. At the outer edge of the lake, the bank rises more steeply, usually in a series of rises within 250 m of the lake margin.

The inner lakebed is comprised of clay substrate enabling it to hold water for extended periods to depths of up to 8 m when overflowing, while allowing some seepage which helps recharge the groundwater aquifer. The inner lakebed soils are generally cracking clays such as Vertisols (Robinson et al, 2005) while the outer lakebed usually has sandier soils which allow greater rates of infiltration and, potentially, groundwater recharge.

The lake margins rise to an elevation of around 20 m or more, through a series of rises in many locations rather than in a single rise. This feature allows much of the fringing woodland to become flooded in lake-full events that result in significant discharge.

The single upstream inlet at Outlet Creek allows sufficient flows to travel from an overflowing Lake Hindmarsh to fill Lake Albacutya to capacity over a period of up to about 6 months, while a single downstream discharge point at Outlet Creek prevents discharge until the average depth of water reaches about 6 m. This depth assists Lake Albacutya to retain water for long periods despite high levels of evaporation. The ability of Lake Albacutya to overflow ensures that salts are flushed downstream and do not accumulate and also creates a definite shoreline, both characteristics of subterminal lakes.

These natural morphological attributes are critical in that they underpin the hydrology of the lake. The morphological attributes are not presently threatened in any way, however potential activities such as filling, excavating, channel construction, bed lining, human-induced erosion, and bank works, could in future impact on the morphology to such an extent that the ecological functioning of the lake is impaired. There is an unconfirmed report, for example, that the elevation of the discharge sill at Lake Hindmarsh has been lowered in the past, probably to increase flows to Lake Albacutya.

In order to preserve the ecological character, the following limit of acceptable change in relation to morphology is established:

- the significant morphological features of Lake Albacutya (lake banks, lakebed, single natural inlet creek, single natural discharge creek, depth from outlet sill to lakebed) must be retained without significant change as a result of human interference.

Note that this does not necessarily prevent future, temporary, management changes within the context of a considered strategic plan, based on sound science, designed to maintain the ecological character of various reaches of the lower Wimmera River and Outlet Creek, including Lake Albacutya and lakes further downstream.

8.1.2 Hydrology

Lake Albacutya's unique hydrology relies on upper catchment rainfall which causes periodic flooding, and local rainfall and evapotranspiration representative of the semi-arid zone which results in drying of the water-filled lake over several years and dry periods without significant annual lakebed ponding. Groundwater at around 9 m below the ground surface is also significant for the health of the Eucalypt woodland at the lake margins.

The Wimmera River catchment experiences great variation in annual rainfall and as a result Lake Albacutya receives water from the upper catchment only episodically and usually only after two successive wet years. Lake Hindmarsh, the largest freshwater lake in Victoria, is located immediately upstream of Lake Albacutya, and must first overflow before Lake Albacutya begins to receive water from Outlet Creek. Extensive water diversions mainly for agriculture and domestic use have reduced flows in the Wimmera River and this regulation, which commenced in the late 1800s and was already quite developed in the 1920s, expanded after the 1950s and peaked about the time of Ramsar listing.

Due to the characteristics of Wimmera River flows, the hydrology of Lake Albacutya is best described over large temporal scales, in the order of centuries rather than years or decades. Fortunately, lake-filling events are economically and socially highly significant human milestones, and records since the time of European settlement provide us with a useful, but still incomplete, dataset covering the past 179 years. Records of smaller inflow events may not be as accurate, especially if they occurred soon before or after a major lake-full event.

Hydrology underpins the following critical elements of the ecology of Lake Albacutya:

- eucalypt woodland recruitment
- eucalypt woodland condition
- waterbird occurrence and diversity
- regent parrot breeding.

Only a lake-full overflow event can flood the Eucalypt woodland fringing the lake and significantly recharge the groundwater through the sandy outer lakebed, and so periodic overflow events are required to revitalise the constituent species, aid recruitment, and sustain trees between floods by replenishing groundwater reserves.

However, relatively short duration, shallow, floods can be sufficient to support large numbers and variety of waterbirds and trigger Regent parrot breeding, as evidenced by the 1993 flood event of perhaps 9 months duration in total. Such shallow floods may also replenish lakebed reserves of viable propagules and organic matter, and assist to recharge the groundwater aquifer to provide some stress relief for Eucalypt woodland species although this is less certain based on the available evidence.

A number of reports and studies have investigated ecological flow regimes and objectives for Lake Albacutya and at the time of writing the 2004 Ecological Associates report is based on the most recent data and analytical methods using the Realm Model for the Wimmera River developed by the Victorian Department of Sustainability and Environment. This modelling, which provides a close fit to the historical record, shows that for Lake Albacutya under natural (pre river regulation) conditions, lake-full overflow events of 6 months duration occurred approximately every 6 years while lake-full overflow events of 24 months duration occurred approximately every 10 years (Ecological Associates, 2004).

Ecological Associates 2004 proposed the following ecological objectives in regard to river flows:

- fringing Red Gum populations will have a diverse age structure
- fringing Red Gum populations will persist at the perimeter of the lake
- the aquatic phase of the lake will contribute significantly to the viability of visiting fauna populations
- a mature and diverse aquatic ecosystem will develop during "full" lake events.

To achieve these ecological objectives Ecological Associates recommended:

- a 6 months duration lake-full overflow event should occur every 8 years on average to provide opportunity for the recruitment and relief from salinity and drought stress for River Red Gum
- a 24 months duration lake-full overflow event should occur every 20 years on average to allow development of a mature aquatic ecosystem and provide opportunity for major breeding events for waterbirds as well as the growth and recruitment of the fringing River Red Gum woodland community.

It is important to note that Lake Albacutya may take around 6 months or more to fill, and once full is likely to dry over a period of two or more years, so a lake-full overflow event of 6 months duration is likely to result in the lake containing at least some water for a minimum period of around three, and possibly up to five, years.

Ecological associates 2004 recommendation that a 24 months duration lake-full overflow event should occur every 20 years on average is consistent with the maintenance of the ecological character of the Ramsar site, and therefore this flow regime is adopted as one of the hydrological limits of acceptable change for surface water hydrology. It is expected that such an overflow event will replenish the shallow groundwater underlying the Eucalypt woodland and rejuvenate the trees (including the most recent recruits) sufficiently to survive the subsequent dry period, even if the lake does not achieve the capacity of full + 2m which would flood the ground surface of significant area of woodland. This, however, should be monitored.

It is accepted that an additional, more frequent, shorter duration, flood event is also required in order to maintain the ecological character, however a lack of knowledge constrains its confidence limit. The limit of acceptable change for a short duration flood is described as a shallow flood of at least 9 months duration which should occur every 8 years on average. It is expected that this will be sufficient to attract a diversity of waterbirds, replenish reserves of lakebed propagules and organic matter, and assist to recharge the groundwater aquifer to provide some stress relief for Eucalypt woodland species.

The capacity for shallow floods to recharge the aquifer sufficiently to benefit woodland trees is unknown, and for this reason the limit of acceptable change has a low degree of confidence. This should be monitored and the limit of acceptable change reviewed if the Eucalypt woodland continues to decline or if recruitment fails, and in this event and in the absence of additional relevant information, the shorter duration LAC should be changed to the Ecological Associates recommendation of a 6 months duration lake-full overflow event to occur every 8 years on average.

In summary, then, the limits of acceptable change for hydrology are:

- a shallow flood of at least 9 months duration should occur every 8 years on average (low confidence level)
- a 24 months duration lake-full overflow event should occur every 20 years on average (medium confidence level as the actual period of overflow has a degree of uncertainty).

The most significant knowledge gaps associated with hydrology include:

- establishing an accurate historical flood record including review of community and newspaper records to ensure a complete record is available, including for short duration floods. This should also include investigation and use of a method to identify long term flood history predating European settlement which may be based on tree growth ring analysis, the sediment record, or other method
- maintaining accurate records into the future, preferably in a central dataset, of lake flood events including flow commencement, depth, extent (area), overflows, date, duration
- determining the relative contribution of identified threats (anthropogenic climate change, river regulation) and environmental flow releases, to the flooding regime of Lake Albacutya
- completing, during the next flood events, an analysis of groundwater recharge as a result of both shallow and lake-full flood events, and the formation of a freshwater lens overlying the more saline Parilla Sands aquifer.

The extent and significance of seasonal wetting of, and ponding in, parts of the lakebed as a result of local rainfall is not known, however this information may also prove to be significant in determining the long term viability of seed and egg banks for some species.

8.1.3 Waterbirds

Waterbirds can appear in large numbers when the lake holds water, however this is likely to depend in part on watering events in alternative inland habitat areas. Wimmera River floods originate in southern Victoria, quite different to Murray Darling floods which provide alternative waterbird habitat and originate in eastern Victoria and New South Wales or more frequently, in sub-tropical and tropical Queensland. As a result, Lake Albacutya floods may occur at times when many other more northern inland wetlands are dry.

Little long term waterbird data exists, however records from recent inflow events in 1993 and around 1974 to 1983 indicate that waterbirds including predatory guilds have arrived in large numbers.

Based on data from just two or three inflow events, up to 60 species of waterbird are known to use the lake when it holds water, and up to 12 species breed at the site; however these species may not occur for each lake flow event. Three species have met the 1 % population level relevant to the Ramsar criterion 6 - Freckled Duck, Banded Stilt, and Australasian Shoveler. However, due to a lack of long-term data it is not known how regularly each species occurs at greater than 1 % levels. Over 40 000 waterbirds in total were recorded at the lake on one occasion in 1993 and the number of Banded Stilt alone in 1983 was classed at between 10 000 and 100 000, suggesting that over 20 000 waterbirds may also have occurred at that time.

Common species of waterbird such as those hunted recreationally appear to have been rarely recorded prior to 1993, so the earlier records of total waterbird counts are probably gross under-estimates of the actual numbers.

Lake Albacutya is renowned for its recreational duck hunting with stories relayed from the 1920s to the present time regarding the value of this resource, and this supports the argument that large numbers of waterbirds generally frequent the lake when it holds water. However, due to the lack of long term data, it is impossible to know specific details in terms of species and numbers, and how frequently, for example, over 20 000 waterbirds have appeared.

It is reasonable to conclude that future flood events will attract a similar variety and number of waterbirds if Lake Albacutya periodically continues to develop a healthy and mature aquatic ecosystem capable of supporting predatory guilds, and if sufficient alternate habitat areas occur to support waterbird populations nationally and internationally.

Waterbird records therefore provide a valuable benchmark against which to assess the overall ecology of the Ramsar site.

Based on the few existing records, the limits of acceptable change in relation to waterbirds, are:

- supports 20 000 or more waterbirds on one in three occasions when the lake holds water for a period of at least 9 months
- supports 1 % of the individuals in a population of at least one species or subspecies of waterbird on one in three occasions when the lake holds water for a period of at least nine months.

Due to the lack of long term data, the level of confidence in these limits of acceptable change is necessarily low. They should be reviewed as more data becomes available.

A significant knowledge gap exists in relation to the seasonal and annual movement of waterbirds between habitat areas, and the relative significance of Lake Albacutya in providing alternative waterbird habitat when many other northern wetlands are dry. Maintenance and analysis of waterbird numbers throughout the population range for significant species, linked to wetland fill events, is required.

8.1.4 Eucalypt woodland

An extensive Eucalypt woodland community occurs as a fringe around the edge of the lakebed, occupying 1271 ha of the Ramsar site. This area beyond the lakebed itself becomes inundated during major flooding and is dominated by flood dependent or flood tolerant species such as River Red Gum and some Black Box which persist throughout the wet and dry cycles. The understorey changes seasonally and with the hydrological regime, and is mainly comprised of grasses, herbs, and shrubs, including Lignum and Three-nerve Wattle.

This Eucalypt woodland community provides important roosting and nesting habitat for waterbirds, and terrestrial species such as the nationally threatened Regent Parrot and Major Mitchell's Cockatoo (nationally near-threatened). Tree hollows of various sizes are required to meet the nesting requirements of individual bird species.

The Lake Albacutya River Red Gum population is genetically unique, showing particularly high levels of drought and salt tolerance. Early seedling survival is dependent on around two years of adequate soil moisture reserves. The trees are reliant on regular surface flooding for persistence and regeneration but also access groundwater reserves during droughts.

Reduced flooding over the last century and rising groundwater salinity has led to a decrease in the availability of usable water and has probably contributed to the increase in dieback which was already well-advanced by the mid 1970s and continues to the present time. Regular recruitment of River Red Gum is required to replace dead and dying trees, and to maintain an adequate reserve of hollows which only start to form after around 75 years.

River red gum area and condition at the lake margins was assessed in 1993 (Wouters, 1993), however area by condition category has not been undertaken. This 1993 data should be used as the benchmark for River Red Gum in the absence of relevant data from 1982. Black box and other woodland species have not been assessed but appear to be healthy. The extent and condition of Eucalypt woodland should be targeted for monitoring.

Ecological Associates (2004) established ecological objectives for the terminal lakes which were used to develop environmental flow objectives, and those that refer to Eucalypt woodland are:

- fringing River Red Gum populations have a diverse age structure (indicator – at least one successful recruitment event every 10 years)
- fringing River Red Gum populations persist at the perimeter of the lake (indicator – salinity and drought stress in fringing red gum is completely relieved in 50 % of occasions when lake is “full”).

These ecological objectives are sound, however are based on specific environmental flow objectives which differ from the limit of acceptable change for hydrology. Based on the best information available, and considering the practical limitations of monitoring and analysis, the limits of acceptable change are identified as outlined below.

- At least one successful River Red Gum recruitment event occurs every 20 years on average. This matches the hydrology LAC for a major lake-full overflow event (low confidence level as this requires successful recruitment at every major flood event).
- At least 75 % of the 1993 extent of River Red Gum is maintained (low confidence level as recent trends are unknown).
- At least 75 % of the extent of the Eucalypt woodland community is maintained, based on a benchmark established as soon as possible after 1982 (low confidence level as recent trends are unknown). This LAC requires the extent to be determined at or as soon as possible after 1982.

Significant knowledge gaps include:

- the extent of Eucalypt woodland at or around 1982 (or as soon as possible thereafter), based on aerial photographic interpretation, or other method which should become the benchmark for determining changes in the extent of Eucalypt woodland
- detailed assessment of condition of the Eucalypt woodland in relation to dominant woodland species, age structure, and area.

8.1.5 Threatened fauna

Four species of fauna listed on the EPBC Act have been recorded within or around the Lake Albacutya Ramsar site, specifically Black-eared Miner, Mallee Emu-wren, and Malleefowl which mainly use and inhabit the adjoining Mallee landscape, and Regent Parrot.

Regent Parrot is nationally vulnerable and has been recorded in relatively large numbers and breeding at the lake. A maximum count of 50 individuals has been recorded at Lake Albacutya or at least 2 % of the total national population size of up to 2500 individuals. This species is also known to breed at the site, with breeding records from 1929, 1992, and 1993.

Regent Parrot requires tree hollows for breeding habitat especially those in large live or dead trees greater than 150 cm in diameter and 30 m tall (DEWHA, 2009). Favoured nesting tree species are River Red Gum and Black Box, especially if close to permanent water. Successful nesting also depends on close proximity of large tracts of Mallee vegetation, within 2 km of the nesting site, which the birds require for feeding habitat. When breeding, the birds may make three trips from nesting to foraging sites in a day.

These habitat requirements are well provided for at Lake Albacutya with an extensive Eucalypt woodland community, containing large, mature River Red Gum, in close proximity to large tracts of Mallee vegetation and a persistent source of water when the lake is full.

Accurate annual records for Regent Parrot are not available, however based on the available information the following LAC is established:

- a local Regent Parrot population is maintained at Lake Albacutya
- at least 2 % of the national Regent Parrot population is recorded at Lake Albacutya in one year in ten, at a minimum.

The key knowledge gap associated with Regent Parrot relates to accurate seasonal and annual population records, and variations in the population over time. As a result, the second LAC above has a low level of confidence.

8.2 Limits of acceptable change for critical benefits and services

8.2.1 Wetland representativeness

Lake Albacutya represents a near-natural example of the Ramsar wetland category ‘seasonal intermittent freshwater lakes over 8 ha including floodplain lakes’, and provides the basis of one of the five criteria that underpins its Ramsar status. It is one of 71 examples of this wetland type within the Murray-Darling Drainage Division that are also listed on the Directory of Important Wetlands in Australia.

It has been suggested that terminal lakes are under-represented in Victorian protected areas (Environment Australia, 2001). Lake Albacutya is also a relatively intact representative example of an intermittent subterminal lake of which there are only two greater than 5000 ha within the north-flowing endorheic Wimmera-Avon sub basin, the largest internal drainage system in Victoria. This is particularly important, as these southern terminal lakes are likely to flood out of phase with other inland lakes that receive south-flowing flood waters from northern Australia.

Lake Albacutya Ramsar site makes up the major portion of the Lake Albacutya Park, which helps to conserve the natural values of the site. The level of protection afforded the natural values of the site by the Victorian *National Parks Act 1975*, is highly significant. The natural habitat of the adjoining Wyperfeld National Park also provides significant benefit to the Ramsar site, in terms of Mallee foraging habitat for Regent Parrot, and as a habitat corridor and buffer from land clearing and land use activity.

Prior to the gazettal of Lake Albacutya Park in 1980, the site was privately owned and it is likely that sheep grazing on the lake margins limited the recruitment of River Red Gum and probably other woodland species, and that cropping of the lakebed reduced the terrestrial and aquatic habitat values. These pressures have since been removed from the site as a result of protection and management under the *National Parks Act 1975*.

Based on the available information the following limit of acceptable change is established:

- Lake Albacutya and the surrounding environment are maintained in a near-natural state.

8.2.2 Waterbird habitat

Of the 18 500 wetlands in the Murray-Darling Basin only 98 or 0.53 % were found to support more than 10 000 waterbirds (Scott, 1997). Lake Albacutya also provides habitat for at least 13 migratory species listed on the CAMBA, JAMBA, or ROKAMBA lists. It is apparent that Lake Albacutya provides a highly valuable resource as waterbird habitat on a regional and national scale when water is present.

This service is supported by several key components and processes interacting at the site. Waterbird habitat is provided during the flooded phase of the wet-dry hydrological cycle but relies on the cycle in its entirety for the quality of the habitat. The hydrological cycle supports healthy permanent vegetation in the form of the Eucalypt woodland which some waterbirds require for roosting and nesting. The food to support high numbers of waterbirds feeding and breeding is a result of aquatic fauna and flora communities which develop during flooding and depend on nutrient cycling within and between inundation phases.

Data that describes and quantifies waterbird habitat is extremely limited. Information on the extent of River Red Gum in 1993, significant for roosting and nesting waterbirds, is available. An aerial photographic interpretation may provide additional information on the extent of Eucalypt woodland over time. However no information exists on the components of aquatic waterbird habitat such as mudflats, emergent vegetation, and submerged macrophytes, the specific nesting materials used at Lake Albacutya, and the specific local foods of waders, paddlers and non-piscivorous divers.

Based on the available information the following limits of acceptable change are established:

– Lake Albacutya terrestrial waterbird habitat LAC is as for Eucalypt woodland above.
– Lake Albacutya aquatic waterbird habitat is maintained in a near-natural state.

These limits of acceptable change have a high level of confidence, however the LAC for aquatic waterbird habitat should be reviewed and preferably quantified, as additional data becomes available on specific components of waterbird habitat.

8.2.3 Supporting threatened species

Lake Albacutya and its surrounding area provide important habitat for the nationally vulnerable Regent Parrot. At least 50 individuals (at least 2 % of a maximum national population of 2500) have been known to occupy the site and the species has been recorded breeding at the site three times. The Eucalypt woodland surrounding the lake provides suitable breeding sites in tree hollows in large Eucalypts, particularly River Red Gum. The close proximity of the Eucalypt woodland at Lake Albacutya to the surrounding Mallee landscape which is important foraging habitat for the species, and to water which is important in the selection of breeding sites, adds to the value of the Regent Parrot habitat at Lake Albacutya

Based on the available information, the limit of acceptable change for Eucalypt woodland above will also ensure the continuation of an acceptable level of support for threatened species. This LAC has a high level of confidence.

Female Regent Parrot at nest hollow (photo I. Morgan)

Table 8.1 Limits of acceptable change in the ecological character of Lake Albacutya (see Explanatory Notes below #)

Critical parameter	Baseline condition and range of natural variation	Limits of acceptable change		Basis for determination	Confidence level
		Short term (0 – 10 years)	Medium term (25 to 50 years)		
Critical components and processes					
Morphology - lakebed	The lakebed is comprised of a suitable substrate enabling it to hold water for extended periods to depths of over 6 m when full, while allowing some seepage to recharge the groundwater aquifer.	Attribute retained without significant change as a result of human interference.	As for short term.	Expert opinion.	High
	The single natural inlet creek allows unimpeded flows from Lake Hindmarsh.	Attribute retained without significant change as a result of human interference.	As for short term.		High
	The sill of the single natural discharge creek allows water to accumulate in the lake to a depth of over 6 m.	Attribute retained without significant change as a result of human interference.	As for short term.		High
	The lake margins have an elevation significantly higher than the discharge creek bed	Attribute retained without significant change as a result of human interference.	As for short term.		High
Hydrology	Lake Albacutya fills intermittently from river flows from the upper catchment, and once full, holds water for several years. Modelling of natural conditions indicates that the recurrence interval for 6 months duration overflow events is 6 years, and for 24 months duration overflow events is 10 years.	Not applicable	The average return period for shallow floods of at least nine months duration will be no more than eight years. The average return period for lake-full overflow events of 24 months duration will be no more than 20 years.	Expert opinion and documented literature - Ecological Associates, 2004.	Low Medium

Critical parameter	Baseline condition and range of natural variation	Limits of acceptable change		Basis for determination	Confidence level
		Short term (0 – 10 years)	Medium term (25 to 50 years)		
Fauna - waterbirds	60 waterbird species occur at the lake, with 12 species breeding (common species were probably not recorded prior to 1993). More than 1 % of relevant Australian waterbird population occurred in 1983 (Freckled Duck and Banded Stilt) and 1993 (Australasian Shoveler). More than 20 000 waterbirds occurred in 1993 and probably in 1983.	Short term goals not applicable, as waterbirds are present only when the lake holds water.	Supports 20 000 or more waterbirds on one in three occasions when the lake holds water for a period of at least nine months. Supports 1 % of the individuals in a population of one species or subspecies of waterbird on one in three occasions when the lake holds water for a period of at least nine months.	Existing records and expert opinion.	Low Low
Eucalypt woodland	Eucalypt woodland provides significant habitat and nesting sites, including in tree hollows, for waterbirds and threatened species. River red gum are suffering dieback, and tree hollows only form after about 75 years. Sheep grazing the Eucalypt woodland may have limited recruitment prior to 1983.	Not applicable River red gum may respond slowly to changes in hydrology therefore changes in condition are difficult to assess in the short term.	At least one successful River Red Gum recruitment event occurs every 20 years on average. At least 75 % of the 1993 extent of River Red Gum is maintained. At least 75 % of the extent of the Eucalypt woodland community is maintained, based on a benchmark established as soon as possible after 1982	Expert opinion and documented literature - Ecological Associates, 2004.	Low Low Low
Threatened fauna	Nationally vulnerable Regent Parrot occurs at the site and breeds in River Red Gum. Up to 50 individuals have been recorded at Lake Albacutya (around 2 % of the national population). Regent Parrot depend on the close proximity of the Lake Albacutya Eucalypt woodland to the important foraging habitat of the adjoining Mallee landscape.	A local Regent Parrot population is maintained at Lake Albacutya. At least 2 % of the national Regent Parrot population is recorded at Lake Albacutya in one year in ten, at a minimum	As for short term. As for short term	Existing records and expert opinion.	High Low

Critical parameter	Baseline condition and range of natural variation	Limits of acceptable change		Basis for determination	Confidence level
		Short term (0 – 10 years)	Medium term (25 to 50 years)		
Critical benefits and services					
Wetland representativeness	Lake Albacutya represents a near-natural example of the Ramsar wetland category ‘seasonal intermittent freshwater lakes over 8 ha including floodplain lakes’. It is one of 2 subterminal lakes over 5000 ha in the Wimmera River catchment, and floods as a result of rains in southern Australia, unlike many inland wetlands which flood from rains in northern and eastern Australia. Its land-based ecological values are protected under the *Victorian National Parks Act 1975*.	Lake Albacutya and the surrounding environment are maintained in a near-natural state.	As for short term	Existing information and expert opinion.	High
Waterbird habitat	Waterbird habitat is provided by filling of the lakebed during the wet phase of the wet-dry hydrological cycle but relies on the cycle in its entirety for the quality of the habitat. The hydrological cycle maintains healthy permanent vegetation in the form of Eucalypt woodland which many waterbirds require for roosting and nesting. The food and habitat to support high numbers of waterbirds feeding and breeding is a result of aquatic fauna and flora communities which develop during flooding, depend on nutrient cycling within and between phases, and vary temporally. Habitat availability for specific waterbird species is unknown.	Not applicable, as for Eucalypt woodland above Lake Albacutya aquatic waterbird habitat is maintained in a near-natural state.	Lake Albacutya terrestrial waterbird habitat LAC is as for Eucalypt woodland above As for short term	Existing information and expert opinion.	High High
Supports threatened species	Lake Albacutya, especially the Eucalypt woodland, provides important habitat for the nationally vulnerable Regent Parrot, including roosting and nesting sites.	Not applicable, as for Eucalypt woodland above	As for Eucalypt woodland above.	Expert opinion and documented literature.	High

Additional explanatory notes for Limits of Acceptable Change

Limits of Acceptable Change are a tool by which ecological change can be measured. However, Ecological Character Descriptions are not management plans and Limits of Acceptable Change do not constitute a management regime for the Ramsar site.

Exceeding or not meeting Limits of Acceptable Change does not necessarily indicate that there has been a change in ecological character within the meaning of the Ramsar Convention. However, exceeding or not meeting Limits of Acceptable Change may require investigation to determine whether there has been a change in ecological character.

In reading the Ecological Character Description and the Limits of Acceptable Change, it should be recognised that the hydrology of many catchments in the Murray-Darling Basin is highly regulated, despite many of the wetlands forming under natural hydrological regimes that were more variable and less predictable. Many of the Ramsar wetlands of the Murray-Darling Basin were listed at a time when the rivers were highly regulated and water over allocated, with the character of these sites reflecting the prevailing conditions. When listed under the Ramsar Convention, many sites were already on a long-term trend of ecological decline.

While the best available information has been used to prepare this Ecological Character Description and define Limits of Acceptable Change for the site, a comprehensive understanding of site character may not be possible as in many cases only limited information and data is available for these purposes. The Limits of Acceptable Change may not accurately represent the variability of the critical components, processes, benefits or services under the management regime and natural conditions that prevailed at the time the site was listed as a Ramsar wetland.

Users should exercise their own skill and care with respect to their use of the information in this Ecological Character Description and carefully evaluate the suitability of the information for their own purposes.

Limits of Acceptable Change can be updated as new information becomes available to ensure they more accurately reflect the natural variability (or normal range for artificial sites) of critical components, processes, benefits or services of the Ramsar wetland.

9. THREATS

Identifying actual and likely threats to ecological character serves an important function in framing future management planning and action. They may also provide initial guidance in assessing likely impacts of potential development proposals under the EPBC Act (DEWHA, 2008a).

This chapter is not a comprehensive threat assessment. Rather, only those factors that pose a significant threat to the critical components, processes, benefits, and services, are discussed here. Some supplementary threats have also been identified.

Lower Wimmera River near Jeparit upstream of Lake Albacutya, which has been impacted by salinisation and reduced river flows (photo A. Cibilic)

9.1 Threats to the critical components and processes at Lake Albacutya

Table 9.1 Summary of threats to the ecological character of Lake Albacutya

Threat	**Potential impacts**	**Significance of threat**	**Likelihood of impacts**	**Timing of impacts**
Natural System Modifications				
River regulation	Reduced frequency and duration of flooding. Interference with migration, reproduction, regeneration and recruitment processes. Reduced habitat availability and quality for waterbirds. Declining Eucalypt woodland health.	High	High	Short term
Climate change and severe weather				
Climate change – reduced rainfall	Reduced frequency and duration of flooding. Interference with migration, reproduction, regeneration and recruitment processes. Reduced habitat availability and quality for waterbirds. Declining Eucalypt woodland health.	High	Medium	Short to long term
Ecosystem/community stresses				
Decline in Eucalypt woodland health	Reduced habitat for waterbirds and Regent Parrot	High to medium	High to medium	Short to medium term
Human intrusions and disturbance / Biological resource use				
Recreation	Recreational hunting and human activity may disturb waterbirds and Regent Parrot breeding.	Low	Unknown	Dependent upon hydrology
Invasive species				
Pests (carp, birds, bees, rabbits, foxes, cats, dogs)	Carp reduce habitat quality for fish, aquatic flora and fauna and waterbirds. Pest birds compete with waterbirds and Regent Parrot for food and habitat. Bees compete with waterbirds and Regent Parrot for tree hollows. Rabbits inhibit Eucalypt woodland recruitment. Foxes, cats and dogs may prey on waterbirds and Regent Parrot.	High for carp, medium for other pests	Unknown	Unknown
Weeds.	Degradation of Eucalypt woodland. Reduced habitat quality for waterbirds and Regent Parrot.	Medium to low	Medium to low	Short term
Pollution				
Declining surface water quality mainly due to rising saline water tables, salinisation and reduced dilution potential	Reduced habitat quality for waterbirds	Low	Medium during low flow events. Low during high flow events	Dependent upon hydrology

Note: short term = 0-25 years, medium term = 25-50 years, long term = >50 years

9.1.1 River regulation

The hydrology of Lake Albacutya has been modified since water was first diverted from the Wimmera River system in the mid 1800s. Since then water released from storages for domestic and agricultural supply increased steadily and peaked in 1982 at 226 000 ML (Figure 4.1). Over this period, storage capacity increased to a total of about 770 000 ML (Victorian Government, 2003) and the average annual volume captured in storage reservoirs between 1891 and 2008 was 178 000 ML which exceeds average flows in the lower Wimmera River. However from 1997 to 2008 this figure was reduced to an average of 38 000 ML per year as a result of an extended drought which continued at the time of writing.

Numerous hydrological studies have shown that regulation of the Wimmera River has led to changes in the hydrological regime of the Wimmera terminal lakes including Lake Albacutya. Specifically, the frequency, extent, and duration of flooding to the lake have been significantly reduced.

These changes impact upon aquatic communities including waterbirds by reducing the amount of available habitat both spatially and temporally. The reduced duration of filling events prevents the development of mature, diverse and productive aquatic ecosystems. This also reduces the availability and quality of breeding habitat for waterbird species within the region which may prevent the successful completion of breeding cycles (Scott, 1997).

Changes in the hydrological regime are also likely to disrupt nutrient cycling and successional processes of the system. For example, if flooding intervals become too long, there will be a loss of propagules of aquatic flora and fauna to colonise available habitat when flooding occurs (Ecological Associates, 2004). This may affect both on-site and upstream propagules. Reduced flooding may also interfere with the succession and recruitment of dry lakebed vegetation communities and cause them to be replaced with weed species (DSE, 2003). There is also some indication that the altered hydrology is leading to a decrease in water availability for River Red Gum in the Lake Albacutya area, leading to widespread dieback (Wouters, 1993). A lack of flooding also inhibits River Red Gum recruitment. Flood pulses are also associated with an inflow of nutrients and organic matter, and shallow ephemeral lakes are also highly productive in their own right (Gawne & Scholz, 2006); consequently reduced flooding is likely to result in reduced organic carbon and nutrient availability in dry phase lakebed soils over time, possibly also causing changes to the composition of the terrestrial vegetation communities during the dry phase.

Overall it is likely that, in the long term, reduced flooding of the lake will result in a significant loss of aquatic and terrestrial biodiversity and habitat quality.

Reduced flooding regimes and associated environmental changes will also reduce the social and economic benefits associated with Lake Albacutya. Reduced flooding means a loss of opportunity for water-based recreation activities and a loss of aesthetic, spiritual and cultural values. In turn a reduction in visitor numbers and associated economic benefits would be expected.

It is evident that the hydrological changes have already begun to impact upon the ecological character of Lake Albacutya, and if the regulation conditions of the Wimmera River continue or worsen the impacts will almost certainly become more severe (Land Conservation Council, 1991). It is expected, however, that some water savings from the Wimmera Mallee Pipeline system will become available after 2010.

Justification for funding the Wimmera River Pipeline included the contribution of water savings to improving the hydrology of the Wimmera River including the terminal lakes. The Wimmera Mallee Pipeline Business Case (Victorian Government, 2003) stated that 83 000 ML annually on average would be returned to the region’s waterways under historical inflow conditions (rainfall and runoff), with 38 500 ML being returned to the Wimmera River.

The lower Wimmera River has been a high priority for environmental water releases in Annual Watering Plans and it is anticipated that Wimmera Mallee Pipeline savings will be returned to the Wimmera River and tributaries through such measures as passing flow rules at harvesting structures. If this occurs it will improve the likelihood of higher flows reaching the terminal lakes in wetter years, however it is dependent on climatic conditions and resultant water availability. Based on climate change predictions simple modelling estimated that environmental flows as a result of water saving in the Wimmera/Glenelg Rivers could be negated by 2030, however this is indicative only, due to climate change uncertainties and the simplified modelling techniques used (Victorian Government, 2003). At the time of writing the water allocation system is being amended to allow for climate change impacts on all entitlement holders. Following this amendment, average returns to the Wimmera River will be determined under a range of inflow scenarios.

Maximum benefit to Lake Albacutya may be derived from storing water allocations over several years to accumulate and release larger volumes, however there are numerous practical constraints to this, including storage locations and outlet infrastructure, release points and channel capacities. Smaller, annual releases will, however, benefit the lower Wimmera River and possibly also Lake Hindmarsh, helping to ‘prime’ the river system so catchment runoff may extend further down the river system than occurs at present.

If catchment rainfall and environmental water releases are sufficient, the resulting improvements in flood frequency and duration should help to mitigate further impacts on the ecological character of Lake Albacutya by improving River Red Gum health and recruitment and restoring aquatic habitat and nutrient cycling.

9.1.2 Climate change

Climate describes long term trends in weather parameters in terms of their average, range and variability.

It is apparent that recent short-term average rainfall within the Wimmera River Catchment has been significantly less than the long-term rainfall average. The mean annual rainfall and runoff between 1997 and 2006 were 13 percent and 51 percent lower respectively than the 1895 to 2006 long-term means (CSIRO, 2007). This has potentially exacerbated the lack of flooding of Lake Albacutya caused by river regulation, however it is unlikely that Lake Albacutya would have filled through this period, even with average catchment rainfall. Given the high levels of regulation, significantly higher than average rainfall is now needed to allow Lake Albacutya to fill.

Steffen (2009) reports on recent unpublished research that attributes a significant proportion of the current drought in southern Australia to anthropogenic climate change. The research proposes that the subtropical ridge of high pressure over eastern Australia has increased in intensity as a result of climate change, resulting in rain-bearing storms that normally benefit southern Australia being pushed further south and into the southern ocean.

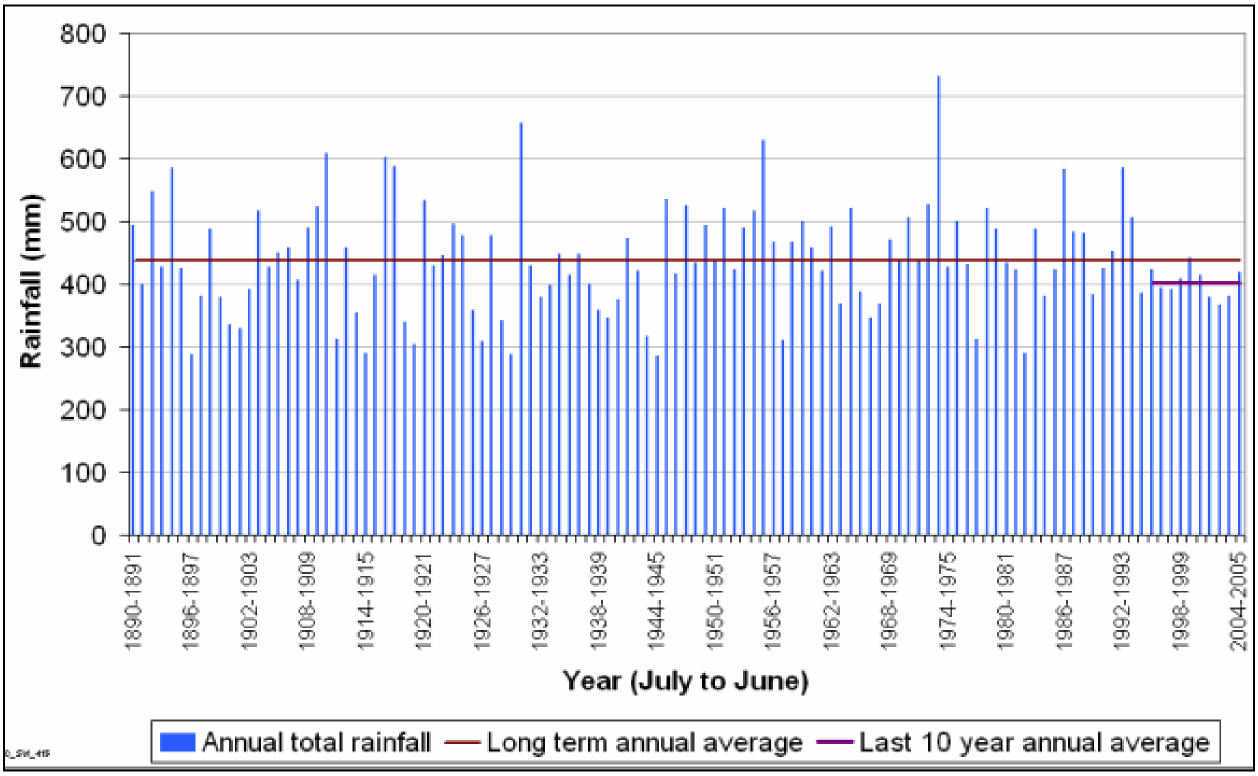


Figure 9.1 Recent and long term rainfall averages within the Wimmera-Avon Basin (National Water Commission, 2005)

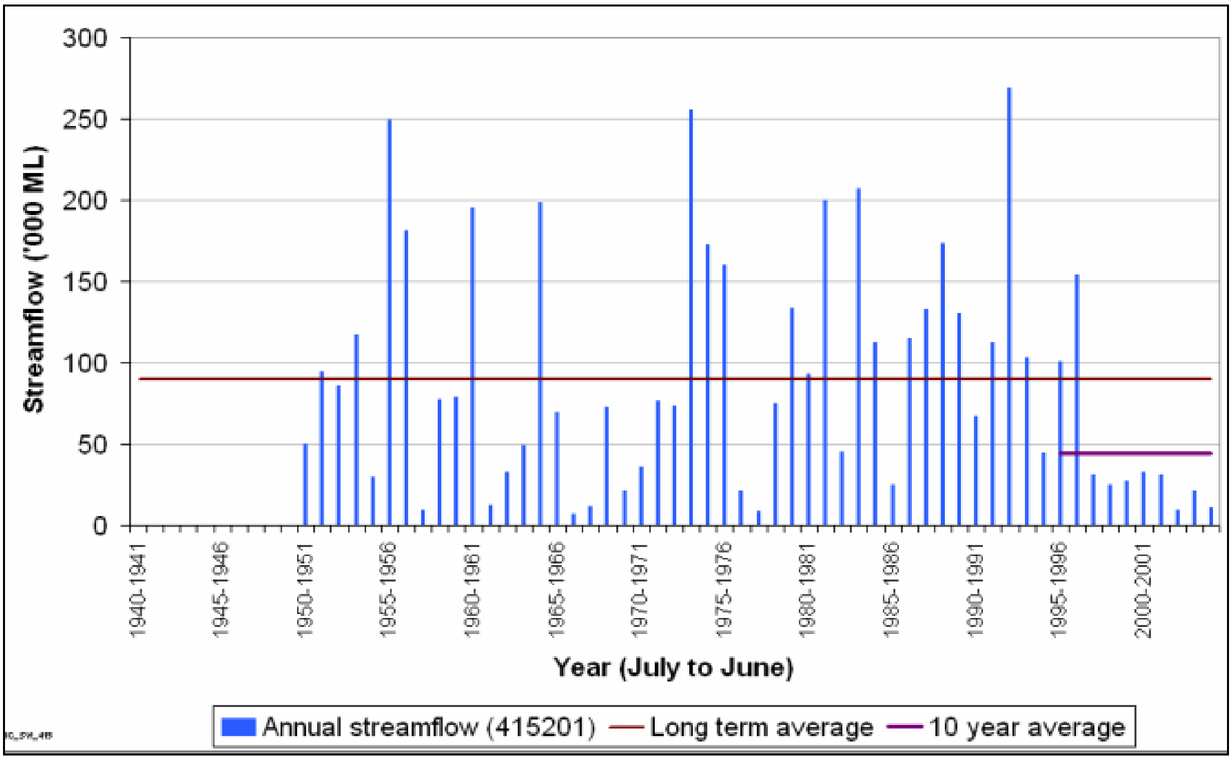


Figure 9.2 Recent and long term stream flow averages for the Wimmera River at Glenorchy Weir (National Water Commission, 2005)

Models of rainfall and run-off under various climate change scenarios predict significant impacts on Lake Albacutya (CSIRO, 2007). The vast majority of models show a decrease in run-off in the Wimmera region as a result of climate change. The median estimate predicted a 17 % reduction in mean annual run-off from 1990 to 2030. The extreme high global warming scenario was predicted to result in a decrease in run-off of up to 47 % in one model to an increase of run-off of 1 % in another. The extreme low global warming scenario was predicted by the various models to cause a reduction in run-off ranging from 0 % to 16 %. Overall there is a large range in changes predicted by various models, however the vast majority predict a significant decrease in run-off in the region. If climate change occurs as predicted it can be expected to cause major hydrological and ecological changes to Lake Albacutya through reducing run-off in the region and therefore flow in the Wimmera River.

Under both the medium and high global warming scenarios it is predicted that Lake Albacutya would be unlikely to ever fill. The lake water depth would exceed shallow only 3 % of the time compared with about 18 % as predicted under the current situation (Ecological Associates, 2004), and may remain below shallow (that is, dry or near-dry) for up to 76 years at a time compared with a maximum dry period of about 30 predicted under the current situation (Ecological Associates, 2004). Even under the low global warming scenario it is predicted that Lake Albacutya would fill less often. It is clear that climate change could pose a severe threat to the hydrological regime of the lake, which is already under significant pressure from river regulation. An increase in the occurrence of extreme weather events is also frequently predicted in climate change models. No specific information relating to the Wimmera catchment was found, however any increase in extreme rainfall events would have positive benefits for Lake Albacutya, whereas in increase in extreme droughts would be detrimental.

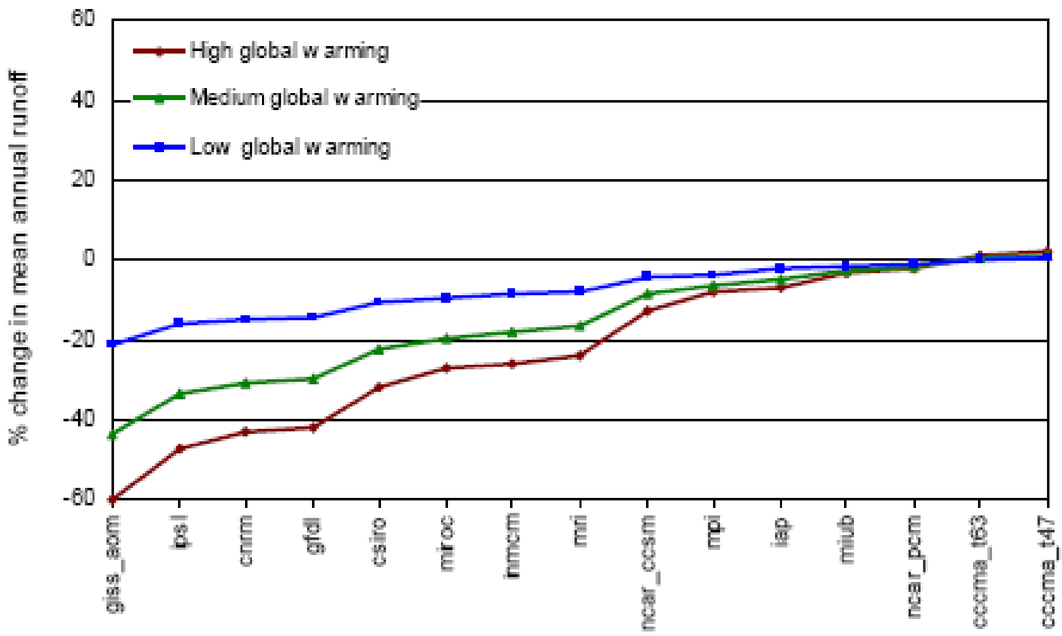


Figure 9.3 Climate change predictions for runoff in the Wimmera region for the year 2030 from a range of models (CSIRO, 2007)

9.1.3 Decline in Eucalypt woodland health

Widespread dieback of River Red Gums has been well documented in the area (Wouters, 1993) and this has been attributed to a lack of regular flooding, as has the notable lack of River Red Gum regeneration in the area. The earlier absence of recruitment may be due to sheep grazing which occurred within the Eucalypt woodland community at Lake Albacutya until the Lake Albacutya Park was gazetted in 1980. The deterioration of River Red Gum communities at the site has flow-on effects to other components of the ecosystem. Significant waterbirds and nationally vulnerable Regent Parrot will suffer from a loss of habitat, primarily tree hollows for breeding. This is more likely to occur in the longer term, as dead and dying trees may provide additional tree hollows in the short term. Aquatic faunal communities which utilise submerged trunks and fallen branches as substrate or shelter will also be negatively affected in the long term (Ecological Associates, 2004).

9.1.4 Recreation

Lake Albacutya Park generally has low visitor numbers except during infrequent periods when the lake is full (National Parks Service, 1996). During times of high visitor use, disturbance to fauna including waterbirds and the nationally vulnerable Regent Parrot may result from recreational activities. Many species of waterbird are sensitive to disturbance during roosting, feeding and nesting (DSE, 2003). Disturbance during the breeding season may pose a threat to significant species including the Freckled Duck (DSE, 2003) and Regent Parrot (Baker-Gabb and Hurley, 2010).

Recreational duck hunting is permitted at Lake Albacutya Park. Species which may be legally hunted in Victoria include Pacific Black Duck, Australasian Shoveler, Chestnut Teal, Hardhead, Mountain Duck, Pink-eared Duck and Wood Duck. Duck hunting is only permitted during an open season in autumn with season dates and duration varying from year to year depending on climatic conditions. Specified wetlands may be closed to hunting altogether in some years, and hunting of specific species may also be prohibited. Daily bag limits are set for total numbers as well as specific species which may also vary depending on conditions. For example, the daily limit for 2009 was five ducks of which at least three must be Wood Ducks. Bag limits, restrictions on species hunted, and season dates are set to ensure that hunting does not threaten the conservation status of any game species. A licence is required to hunt ducks in Victoria and all hunters must pass a waterfowl identification test before they are permitted to hunt ducks.

There is continued potential for impacts associated with use of lead shot at the lake, prior to its prohibition in 2002. Waterbirds which feed on the lake edge are at risk of poisoning from accumulated lead shot. The extent of lead contamination at Lake Albacutya is not known (DSE, 2003).

Recreational fishing is also permitted at Lake Albacutya. An easily obtainable recreational fishing licence is needed for all forms or recreational fishing in Victoria, including for fin fish, shellfish and yabbies. There are bag limits on all fish species and size limits for many species. There is also a limit on the amount and type of fishing equipment that may be used. Lake Albacutya has contained populations of Freshwater Catfish which has been introduced via stocking programs to the Wimmera River. The Wimmera River is the only system where this species may be legally taken. The legal minimum size is 30 cm with a bag limit of two fish per person. The impact of recreational fishing on the ecological values of Lake Albacutya is unknown.

When not properly managed, recreational activities have the potential to cause other impacts at the lake. Visitor numbers can increase tenfold when the lake is full and in the past this has led to problems such as litter, excessive firewood collection and soil compaction and erosion (DSE, 2003). Camping, boating and off-road driving activities in non-designated areas have damaged native vegetation and led to erosion of the foreshore and litter and sanitation problems (National Parks Service, 1980). Driving, walking, boating and hunting may all disturb waterbirds and Regent Parrot, however the impacts have not been thoroughly assessed or quantified.

9.1.5 Pests

Numerous introduced animals have been recorded at Lake Albacutya including introduced fish, rabbits, foxes, cats, birds and honey bees (DSE, 2003).

9.1.5.1 Fish

Exotic fish species recorded in the Wimmera River system include European Carp *Cyprinus carpio*, Goldfish (*Carassius auratus*), Eastern Gambusia (*Gambusia holbrooki*), Rainbow Trout (*Oncorhynchus mykiss*), Redfin (*Perca fluviatilis*), Brown Trout (*Salmo trutta*) and Tench (*Tinca tinca*) (DSE, 2003). These pest species may be introduced into Lake Albacutya during flood periods and threaten native species by direct competition for resources or by altering water quality and trophic relationships. Species such as Brown Trout are unlikely to establish in Lake Albacutya due to habitat conditions. Invasive fish may have significant impacts on aquatic fauna and flora. European Carp have been recorded at the lake (DSE, 2003). European Carp feeding habits destroy aquatic vegetation and increase turbidity which can create unsuitable habitat for aquatic biota and lead to a decline in native fish numbers (DSE, 2003).

9.1.5.2 Rabbits

Rabbits have been widespread within the park and have caused a severe impact on the native ground layer (Parks Victoria, 2000). Excessive grazing can inhibit the regeneration of woody species such as River Red Gums and native shrubs (DSE, 2003, National Parks Service, 1996). A loss of native species, especially perennials, from the understorey also occurs as a result of high grazing pressures (DSE, 2003, National Parks Service, 1996). Removal of native vegetation and soil disturbance caused by grazing may lead to the spread and proliferation of weeds (DSE, 2003, National Parks Service, 1996). Excessive grazing by rabbits has reportedly caused degradation of native vegetation and fauna habitat at Lake Albacutya including the lakebed vegetation as well as fringing woodlands (DSE, 2003). The introduction of rabbit calicivirus to control rabbit populations commenced in 1996 and has generally reduced but not eliminated threats from rabbits. There is evidence from many locations that rabbit populations in arid areas have been reduced by as much as 90 %. The initial effectiveness of rabbit calicivirus has recently been reduced in some areas due to emerging immunity within the rabbit population to the virus (DEWHA, 2008b).

9.1.5.3 Foxes, cats and dogs

Foxes, cats and dogs have been recorded at the lake and through predation may threaten waterbirds which nest or feed on the ground. Susceptible species include the Freckled Duck and Blue-billed Duck. The extent and impact of foxes, cats and dogs at the site is not known (Parks Victoria, 2000).

9.1.5.4 Introduced birds

Birds such as Starlings and Sparrows compete with native birds for food and nesting sites. There are records of introduced birds at Lake Albacutya but the likely extent and impacts of the threat is not known (Parks Victoria, 2000).

9.1.5.5 Bees

European Honey Bees have naturalized in the Lake Albacutya region from nearby hives. Feral populations may form hives in the hollows of River Red Gums reducing the availability of this important habitat resource for native species such as waterbirds and Regent Parrot which require tree hollows for breeding. Research into the possible effects of European Honey Bees on native flora and fauna to date have been inconclusive (National Parks Service, 1996).

9.1.6 Weeds

Lake Albacutya Park has a high level of weed infestation. Weeds are prolific and having a severe impact in the understorey of vegetation communities surrounding the lake, whereas in the overstorey they are scattered and are having only a moderate impact.

In 1979, when the lake contained water, Parks Victoria conducted a revegetation study of the Lake Albacutya Park and noted several weed infestations (National Parks Service, 1980). Stinkwort, Variegated Thistle, Saffron Thistle, Bathurst Burr, Asparagus, Horehound, Onion Weed, Spear Thistle, Malta Thistle, Skeleton Weed, Slender Thistle, Stemless Thistle and Five-spined Saltbush were the most notable weeds in the area, 11 of which are declared noxious weeds. These species were mostly found occurring along the lake edges, with some infestation among River Red Gum communities.

According to the DSE flora database in 2009, 78 invasive plants have been recorded within the Lake Albacutya Ramsar site (see Appendix 1 for list). Reports also exist of numerous other weed species not listed on this database occurring at the site (National Parks Service, 1980, DSE, 2003).

It is clear that significant weed infestations are already established at Lake Albacutya with introduced species invading the understorey of woodland communities surrounding the lake as well as lakebed vegetation (National Parks Service, 1980, Parks Victoria, 2000, DSE, 2003, Morton & Heislers, 1978). Weeds pose some threat to the ecological character of the site as they compete with native species, reducing opportunities for regeneration and have the potential to eventually displace native vegetation communities. By reducing recruitment, weeds may contribute to the loss of River Red Gum and other Eucalypt woodland which are crucial breeding habitat for many species of waterbird and some terrestrial fauna. Native Orache and Three-nerve wattle which colonise the dry lakebed are currently threatened by weed invasion (DSE, 2003). By changing the structure and composition of vegetation communities, weeds have the potential to impact upon fauna communities by reducing habitat quality. For example weed invasion of the dry lakebed vegetation may change the structure and composition of this community and alter its value as a habitat to aquatic communities on reflooding.

9.1.7 Declining water quality

It is possible to use water monitoring to detect a change in water quality compared with natural levels in various parameters such as electrical conductivity, dissolved oxygen, litter, and pathogens, chemical pollutants, metals, dissolved organic matter, pH, temperature, turbidity, macro invertebrates, and nutrients. As there is very little baseline data for water quality in Lake Albacutya it is currently very difficult to identify trends or quantify this threat. There is documented evidence that water quality is declining in the Wimmera River and this may result in lower water quality downstream. These changes are characterized primarily by increasing levels of salinity and an associated decrease in dissolved oxygen (EPA Victoria & Wimmera CMA, 2008). These changes have the potential to impact upon aquatic fauna, including waterbirds, as well as contributing to dieback of River Red Gum communities at the lake. However, as Lake Albacutya is filled by a major flood events which dominate water quality, the water quality in periods of low river flows and in remnant pools is probably not indicative of future water quality in the lake during lake-full-periods. Small flows entering the lake however are more likely to be of low water quality. The future environmental water releases should also reduce the likelihood and impacts of this threat.

9.2 Supplementary threats at Lake Albacutya

9.2.1 Agricultural grazing

Agricultural grazing of the lakebed by sheep probably reduces the diversity and abundance of lakebed vegetation, and the recruitment of some native species. Grazing may also promote the spread and establishment of weeds although it may also help to control some weeds. By impacting upon dry-phase lakebed vegetation, grazing may reduce the availability of habitat and nutrients for aquatic communities when the lake floods. Other potential impacts of grazing may include soil disturbance and compaction (which may also increase erosion), altered terrestrial faunal communities as a result of competition with sheep, and changes to nutrient cycling regimes.

The Lake Albacutya Ramsar site has been subject to sheep grazing for more than 160 years as the area was all freehold farmland prior to 1980 (National Parks Service, 1980). Formal grazing licences totalling 2,117.6 ha were established in 1983. This area is still grazed under licence.

The long history of grazing in the area has probably resulted in any impacts of this threat being evident well before the time of Ramsar listing. For example, the long history of grazing in the area probably contributed to the introduction and spread of many of the exotic plants which now dominate lakebed vegetation and fringing woodland understorey (Morton & Heislers, 1978).

There is evidence from numerous studies in uncleared savanna and grassy Eucalypt woodlands in eastern Australia that links livestock grazing to declines or disappearances in riparian wildlife, including species of ants and spiders, frogs, reptiles and mammals and birds (Lovett & Price, 2006). In most of the studies cited, the changes in wildlife were related to changes in vegetation structure caused by grazing.

Recent research has also identified that grazing by sheep was observed to have major impact on the recruitment of River Red Gum, with almost total loss of seedlings, whereas grazing by kangaroos was restricted to light pruning of seedlings without any losses (Jensen, 2008). Grazing within the Eucalypt woodland community at Lake Albacutya occurred until the Lake Albacutya Park was gazetted in 1980 and may have prevented significant River Red Gum recruitment prior to that time.

There is also some evidence to indicate that grazing by livestock alters plant communities and the animal communities which feed on them. For example, grazing can remove plant matter which decays rapidly after inundation and forms the base of the food chain for fish and birds. Midge larvae, an important food source for breeding ducks, have been found to feed on the same kind of vegetation favoured by livestock, and so grazing may affect waterbird populations (Mussared, 1997).

Terrestrial fauna may similarly be affected by grazing, through competition and habitat disturbance. For example, it has been found that heavy grazing results in more seed-eating ants compared with lightly or ungrazed sites, and that rates of predation of River Red Gum seeds are higher in the heavily grazed sites, although the key study focuses on grazing by cattle rather than by sheep (Meeson et al, 2002).

There is some suggestion that continued grazing now acts to keep the already well-established weed communities in the lakebed in check, however, to date, no formal monitoring has been carried out to determine the impacts of grazing on the lakebed (Mellington, M., 2009, pers. comm.). Conditions of grazing licences, such as weed and pest control, are in place to minimise environmental impacts as far as possible. However, it has been recommended by Parks Victoria that licensed grazing be removed from Lake Albacutya and vegetation re-establishment be monitored to allow the development of strategies for long-term restoration of the lakebed flora community (National Parks Service, 1996). Grazing is likely to continue at the site for some time as resources are not available to manage the escalating weed problem that would likely ensue if grazing was removed (Mellington, M., 2009, pers. comm.).

9.2.2 Rising groundwater and salinity

There is the potential for groundwater levels to rise in catchments with large scale loss of native vegetation communities. Native vegetation has been removed from more than 80 % of the Wimmera catchment, although drought has probably prevented groundwater rise in recent years. There is also evidence that the already high content of dissolved salts in the groundwater at Lake Albacutya is increasing due to a lack of flushing by regular floodwaters. These factors combined present the possibility of future salinisation of the area if conditions changed significantly to cause groundwater to rise to within 2 m of the ground surface which could result in widespread tree death and habitat degradation.

River red gums probably utilise groundwater during dry periods, and would be affected by rising elevations of high salinity groundwater. Although tolerant to salinity, the salt concentrations in the groundwater at Lake Albacutya have already been recorded above the toxicity tolerances for this species (Bren & Acenolaza, 2000). If the groundwater levels continues to rise, shallow rooted species would subsequently be affected as the surface becomes salinised. It has been suggested that rising salinity and groundwater levels at Lake Albacutya have played a part in the widespread River Red Gum dieback at the site. Wouters (1993) compared maps of dieback with predicted salinity risk mapping for the region, which was based on topography and groundwater, and found some correlation.

Previous reports have predicted an imminent rising of groundwater to within 2 m of the lake's surface (WCCG, 1992). Presently, however it seems that the risk of this occurring is not high in the near future, with recorded groundwater levels at Lake Albacutya being well below the surface at around 9 m below ground level (Bren & Acenolaza, 2000) and some evidence that local levels have fallen slightly in recent times due to low regional rainfall (Ecological Associates, 2004). There was no evidence of surface salinisation at the site to 1993 (Wouters 1993).

9.2.3 Agricultural cropping

The lakebed has been cropped historically, and this continued after the Lake Albacutya Park was gazetted and the Ramsar site designated. Cropping was allowed under the original licences issued by the Victorian government, and was not phased out until about 1984 (Mellington, M., 2009, pers. comm.).

The affect of cropping on the lake ecology is unknown, however is likely to include:

- Disturbance and erosion of lakebed soil and reduction in soil organic matter
- Reduction in diversity of terrestrial flora and fauna
- Reduction in post-flood nutrient pulse
- Depletion of lakebed seed and egg bank
- Initial reduction in aquatic primary productivity and faunal density

There are no known plans to re-introduce cropping to the site.

9.2.4 Fire

Although the fire susceptibility of the Ramsar site may be high in most summers, fire has occurred infrequently within the park (Parks Victoria, 2000). Regular fuel reduction burning as well as fire suppression has the potential to impact on ecological values of the park by modifying the natural fire regime (DSE, 2003). Changes in the fire regime, including frequency, intensity or season, can reduce the abundance and diversity of native vegetation resulting in a loss of fauna habitat. Culturally important sites such as scar trees may also be threatened by poorly managed fires.

9.2.5 Erosion

The lunette on the eastern side of Lake Albacutya is moving gradually further east due to prevailing winds (DSE, 2003). Wind erosion is also having pronounced effects on the western shoreline of the lake (DSE, 2003). It is evident that River Red Gum roots are being exposed in some isolated areas on the lake margins, where up to one metre of topsoil has been removed in places.

There is a possibility of wind erosion of lakebed sediment due to disturbance by sheep in some sections and the effects of prolonged drought conditions on lakebed vegetation, however there is no evidence that significant impacts of this threat currently occurring. Lunette formation and the occurrence of other aeolian deposits in the area suggest that erosion caused by wind is relatively common, although it may be of relatively low intensity over long periods of time. Deflation basin lakes are a feature of the Murray Darling Basin. Bed sediments of ephemeral lakes are frequently an important source of nutrients and possibly organic matter after flooding, and so any erosion of the lakebed has the potential to reduce aquatic productivity.

Erosion at Lake Albacutya (photo A. Cibilic)

9.2.6 Flow blockages

There is the potential for flow paths in Outlet Creek between Lake Hindmarsh and Lake Albacutya to become blocked by sand drifts or vegetation. This may prevent flow from reaching Lake Albacutya and delay or prevent potential filling events (Ecological Associates, 2004).

9.3 Driver-stressor model

Driver-stressor models are designed to portray significant physical, chemical, and biological elements of the environment that, when changed by human or other activities, can result in degradation to wetlands. Information about stressors can be used to help establish monitoring programs, identify specific risks and impacts, and inform management approaches (Ramsar Convention Secretariat, 2007a).

The following driver-stressor model has been developed to highlight the most significant threats to Lake Albacutya, their potential ecological effect, and the indicators that may be monitored to identify the level of risk.

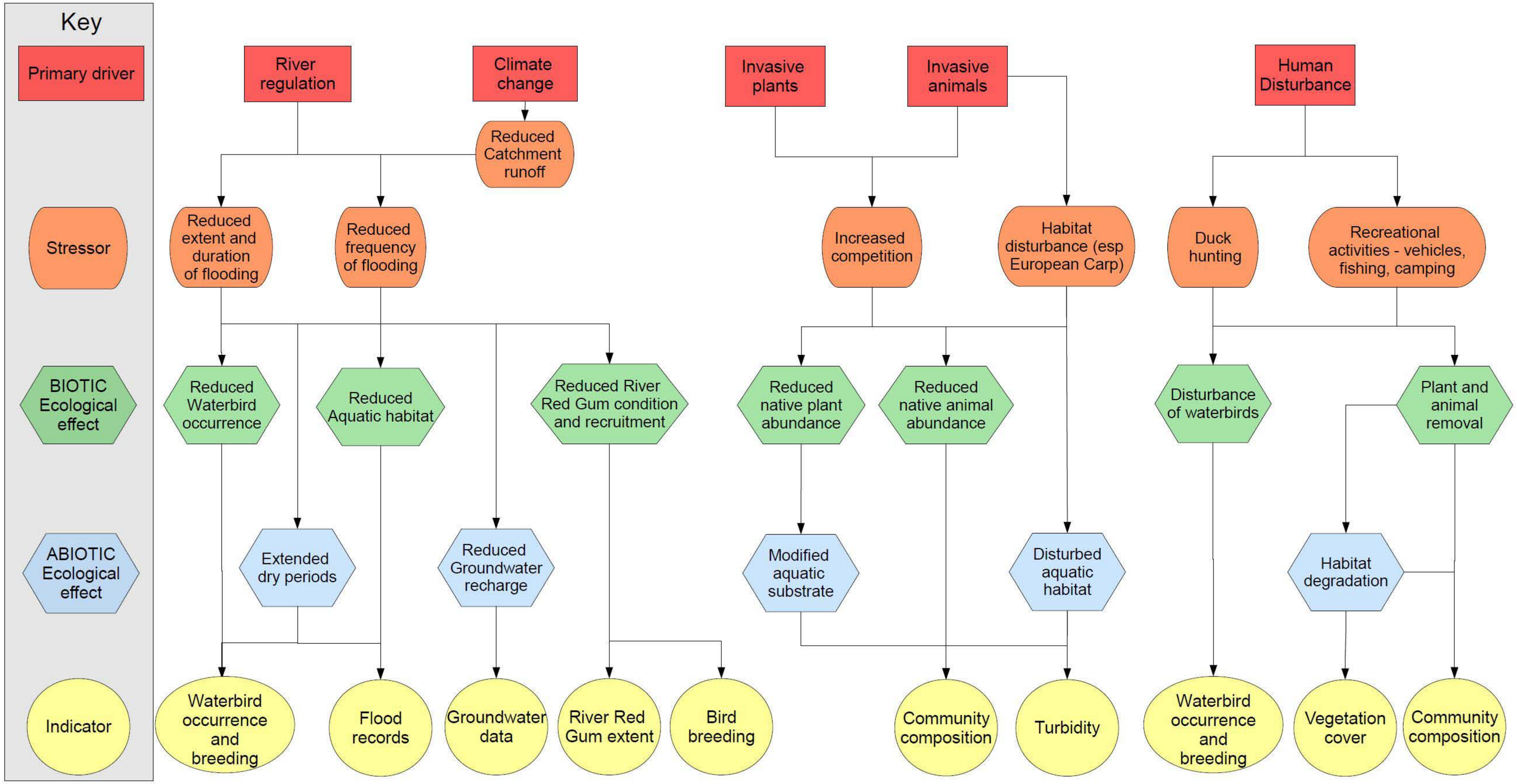


Figure 9.4 Driver-stressor model for Lake Albacutya

10. KNOWLEDGE GAPS

Throughout the Ecological Character Description numerous knowledge gaps have been identified. Adequate data is required to fully quantify and describe components and processes of the system and to understand the interactions between them. Comprehensive data over reasonable timeframes is also essential for determining natural variability of the system and setting limits of acceptable change. There are many elements of the Lake Albacutya Ramsar site which have only limited data or which are yet to be thoroughly described or investigated. Knowledge gaps which assist in describing and maintaining the ecological character of the system are the most vital and are summarised below.

Table 10.1 Knowledge gaps in the ecological character of Lake Albacutya
Highlighted knowledge gaps are priorities for management of the Ecological Character of the site.

Component	Subcomponent	Identified knowledge gaps	Recommended monitoring/action to address gap
Hydrology	Volume and timing of inundation	Details on depths, volumes, area inundated, duration of inundation and inflows over time are lacking.	Inflow, outflow, depth and extent gauging and recording; review of historical flow data; develop new hydrological model which incorporates the recent water supply pipelines. Develop long-term historical flood record based on analysis of tree rings or sediments or using other methods.
	Impact of climate change	Impacts of predicted changes in rainfall and run-off on the hydrology of Lake Albacutya.	Analyse hydrological changes to determine the contribution of climate change.
	Water quality	Very little information is available to establish a baseline condition for water quality.	Water sampling when the lake contains water.
Flora	Eucalypt woodland	Changes to health of the community related to area compared to 1993 data. Contribution of shallow floods to Eucalypt woodland health.	Monitoring of River Red Gum health, age structure and area and comparison to 1993 data. Assessment of tree hollows and relative importance to waterbird breeding. Establish a benchmark for Eucalypt woodland as soon as possible after 1982, e.g. area and extent. Assess the capacity of Eucalypt woodland to benefit from a range of flood events both shallow and lake full.

Component	Subcomponent	Identified knowledge gaps	Recommended monitoring/action to address gap
Flora	Aquatic vegetation	Aquatic vegetation assessments – species composition, density, distribution, succession, changes.	Surveys of aquatic vegetation (including algae and phytoplankton) during flood events; preferable to also survey dry lakebed substrate annually for propagules. Confirmation of listed Myriophyllum species, including assessment of extent with the Ramsar site.
	Lakebed vegetation	The impact of the current sheep grazing regime on the ecology of the lakebed vegetation is unknown.	Asses the impacts of sheep grazing on the lakebed flora and fauna and resulting aquatic community, e.g. comparison of grazed and ungrazed areas.
Fauna	Waterbirds	Availability of habitat required for feeding roosting and nesting of individual species. Preferred depth/extent of inundation required to support key breeding events. Seasonal and annual movement of waterbirds between habitat areas and relative significance of Lake Albacutya.	Monitor resource partitioning, habitat preferences, frequency and duration of use. Monitor breeding success during inflow events. Maintenance and analysis of waterbird numbers throughout population ranges and in relation to flood events within the range.
	Threatened species	Comprehensive data on Regent Parrot numbers and breeding at Lake Albacutya.	Regular monitoring for Regent Parrot numbers, breeding and breeding success at Lake Albacutya.
	Aquatic fauna	Comprehensive data on the composition, abundance and distribution of aquatic fauna.	Regular sampling of the aquatic community when the lake holds water - timed to reflect key hydrological phases – e.g. on filling, when full and during drying.
	Terrestrial and water dependent fauna.	Species data for Lake Albacutya is patchy, especially for reptiles, amphibians and invertebrates.	Fauna surveys of the lake area in both empty and full states; preferable to also survey dry lakebed substrate annually for propagules.
Groundwater	Water quality and water level.	No comprehensive long-term data on the quality and level of groundwater.	Regular groundwater monitoring of depth and salinity.
	Groundwater recharge and dilution	The mechanisms and rates of groundwater recharge and dilution at Lake Albacutya are not well understood.	Study of the stratigraphy and groundwater recharge processes at the lake including identification and analysis of any freshwater lens and perched aquifers, in relation to both lake full and shallow events.
General	Ecosystem resilience	Impact of anthropogenic disturbance on the ecosystem resilience of Lake Albacutya and implications for limits of acceptable change.	Asses the effects of multiple cumulative impacts on the resilience of the ecology to further change.

11. KEY MONITORING NEEDS

Inventory, assessment and monitoring of wetlands are fundamental tools that provide the basis for many aspects of successful implementation of the Ramsar Convention (Ramsar Convention Secretariat, 2007b).

The Ramsar Convention Secretariat (2007b) distinguishes between inventory, assessment and monitoring as follows:

- ***Wetland inventory***: the collection and/or collation of core information for wetland management, including the provision of an information base for specific assessment and monitoring activities.
- ***Wetland assessment:*** the identification of the status of, and threats to, wetlands as a basis for the collection of more specific information through monitoring activities.
- ***Wetland monitoring:*** the collection of specific information for management purposes in response to hypotheses derived from assessment activities, and the use of these monitoring results for implementing management. The collection of time-series information that is not hypothesis-driven from wetland assessment is here termed *surveillance* rather than monitoring.

As applied in Australia, the distinction between inventory and monitoring is not always explicit. Monitoring can be used to establish baseline information, set limits of acceptable change, address knowledge gaps, or detect changes in ecological character. Identifying important monitoring requirements provides input to the management and monitoring program and ensures that these are linked to the ecological character of the site (DEWHA, 2008a).

As a result of the intermittent wet phase, monitoring at Lake Albacutya has also been intermittent and compounded by isolation. Little baseline information exists, most of it collected in one major lake-full event extended by minor events from 1974 through to 1984, and also during minor fill-events in 1993 and 1996. The lake has not experienced inflows since 1996 and very little reliable earlier information exists.

For this reason it is essential that a monitoring program be developed to collect and analyse information necessary to better establish baseline condition, detect changes in ecological character, and inform management decisions.

In addition to monitoring designed to fill key knowledge gaps as listed in Table 10.1 further monitoring would increase understanding and benefit management of the site, and the recommendations are listed at Table 11.1.

Table 11.1 Monitoring requirements for Lake Albacutya

Component/ process	Monitoring objective	Indicator	Frequency	Priority
Hydrology	Keep a comprehensive record of inflows - flow commencement, depth, volume, extent (area), date, season, duration. Can be used to improve hydrology models and to quantify any changes in hydrology over time and inform release of environmental water allocations. Monitor environmental releases.	Flows and volume at the point of entry into Lake Albacutya. Lake depth and area. Flow, volume, duration, timing and downstream penetration of environmental allocation releases.	Flows and volume – daily. Depth and area – at least monthly. Environmental releases – each release.	High
Flora – Eucalypt woodland including River Red Gum	Detect and quantify any changes/trends in the health of the Eucalypt woodland including River Red Gum community (which may assist in determining the exact cause of dieback). Keep records of recruitment events and monitor recruitment and seedling survival.	Percentage and area of trees with severe, moderate, slight or no dieback. Number and success of recruitment events. Age structure of community.	Every 5 years	High
Surface water – water quality	Establish a baseline for water quality and detect any change.	Salinity, pH, dissolved oxygen, turbidity, nutrients, organic carbon, chlorophyll.	At least monthly when the lake holds water.	Medium
Groundwater	Determine if groundwater in the Parilla Sands aquifer is rising or becoming more saline. Can also help to increase understanding of groundwater recharge and dilution processes.	Depth to groundwater. Groundwater salinity. Extent, depth and persistence, of freshwater lens or perched aquifer at multiple locations.	At least biannually when dry and at least monthly (or preferably by data logger) when the lake holds water.	High
Fauna – pest animals	To determine impacts of European Carp on the ecology of Lake Albacutya	European carp number, size and distribution in relation to water quality and hydrological parameters (e.g. depth).	At least every 6 months when the lake holds water.	Medium

12. COMMUNICATION, EDUCATION AND PUBLIC AWARENESS MESSAGES

The Ramsar Convention's Program on Communication, Education, Participation and Awareness (CEPA) was established to help raise awareness of wetland values and functions. Australia's CEPA National Action Plan (2001 – 2005) supported this by recognising education in its broadest sense, encouraging strong partnerships and information exchange between and among groups, and emphasising participation and empowerment. As well as providing a national focus the 2001 CEPA Plan was also designed to develop networks, tools and guidelines.

In Australia, partnerships help deliver CEPA activities at scales from local to national.

The Victorian Government has implemented a number of CEPA activities at the state level including:

- providing easy access to the Lake Albacutya Ramsar Information Sheet and the Strategic Management Plan via download from the Department of Sustainability and Environment website
- providing information on the Ramsar Convention and Victoria's Ramsar wetlands through the Parks Victoria website
- printing and distributing a Lake Albacutya Park visitors guide
- providing species and best practice information to duck hunters and ensuring licensed hunters can recognise target and non-target species
- providing species and best practice information to recreational fishers.

Consistent with Australia's CEPA Plan, other government and non-government groups also provide community access to Ramsar-related and site information relevant to the Lake Albacutya Ramsar site. This includes assessments, monitoring results, studies, reports and updates from groups such as:

- Murray Darling Basin Authority
- Wimmera CMA
- CSIRO
- WetlandCare Australia
- Australian Native Plants Society
- Greening Australia
- Birds Australia.

At the local and regional level, most CEPA activities are provided by several key groups.

- The Wimmera Catchment Management Authority:
  - offering an annual regional World Wetlands Day event
  - since 1994, supporting the Wimmera Community Waterwatch Program which offers education and training to the local community and schools on water quality, the Wimmera River system, landforms, and water life

- developing and distributing wetland information including field guides for birds, frogs, and other flora and fauna
- developing and distributing to local schools and the wider community, the DVD "Long Time Wet, Long Time Dry" which profiles the Wimmera River system, including Lake Albacutya and other subterminal lakes
- delivering on-farm wetland demonstration days in the Lake Albacutya catchment, and a whole farm planning approach that encourages integration of sustainable wetland management practices into farming
- supporting community Landcare activities
- offering periodic events highlighting the benefits of environmental water releases and broader river health to the community
- raising awareness of the important role of wetlands in sustaining indigenous communities over thousands of years and recognising the strong community and cultural links to Lake Albacutya by offering information sessions on indigenous food, travel routes, trade and community life.

– Parks Victoria:
  - providing the Lake Albacutya Park visitor's guide, Birds of the Mallee brochure, and interpretive signage for visitors
  - supporting Friends of Albacutya volunteer group which helps provide improved facilities for park visitors
  - involving volunteers and the Rainbow Landcare group in vegetation regeneration activities
  - supporting monitoring such as bird counts, flora surveys, groundwater data collection, and water levels (should the lake fill)
  - Providing assistance and information to Park visitors through local Rangers.
  - providing information to local schools through visits and other activities
  - supporting local groups like Waterwatch and Landcare.

Maintaining the Ramsar CEPA message through the dry phase of the lake provides many challenges. Some of the significant CEPA messages relating to values and threats are outlined below.

- Lake Albacutya is a listed Ramsar site due to its unique ecological character and waterbird habitat and must be used and managed wisely to protect its ecological values.
- Lake Albacutya represents a unique intermittent subterminal lake wetland which supports threatened species and large numbers of waterbirds, many of which have regional, national and international significance.
- The ecological character of Lake Albacutya depends on intermittent floods in the Wimmera River and Outlet Creek, and these are threatened by long term droughts and river regulation which diverts water for agricultural and domestic use.
- The River Red Gum community at Lake Albacutya is genetically unique with high tolerance to drought and salinity. It provides important faunal habitat and nesting sites. The health and regeneration of the community depends on regular flooding and available groundwater that is not too saline.
- Lake Albacutya is part of the Wimmera River system with high cultural significance to the Wotjobaluk indigenous community and contains numerous culturally important sites. The area is part of a native title determination.
- Visitors and recreational use can disturb wildlife and impact the ecological values of Lake Albacutya. Negative impacts can be minimised by users of the lake.

- To ensure the successful management of Lake Albacutya, State and Local Government agencies, water users and managers, private landholders, and the indigenous and wider community must take a shared role and a co-operative approach to meet Australia’s international obligations and objective of wise use. Key directions include: managing environmental flows to support the recommended flooding regime, and implementing measures to protect water quality, minimise salinity and vegetation dieback, and protect wildlife and wildlife habitat.

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APPENDICES

Appendix 1 – Species lists for the Lake Albacutya Ramsar site

Please note that the following species lists consist of records from the Victorian Department of Sustainability and Environment's flora and fauna databases and are not exhaustive species lists.

Waterbirds recorded at or around the Lake Albacutya Ramsar site (DSE, 2009b)

Common name	Latin name	Count (max)	Breeding	VAL	FFG	TR
Australasian Grebe	*Tachybaptus novaehollandiae*		Breeding			
Australasian Pipit	*Anthus novaeseelandiae*	6				
Australasian Shoveler	*Anas rhynchotis*	1000		VU		
Australian Pelican	*Pelecanus conspicillatus*					
Australian Shelduck	*Tadorna tadornoides*	3000	Breeding			
Australian Spotted Crake	*Porzana fluminea*					
Australian White Ibis	*Threskiornis molucca*					
Australian Wood Duck	*Chenonetta jubata*	2000				
Banded Stilt	*Cladorhynchus leucocephalus*	100000				
Bar-tailed Godwit	*Limosa lapponica*	2				CJR
Black Swan	*Cygnus atratus*	50				
Black-fronted Dotterel	*Elseyornis melanops*					
Black-tailed Godwit	*Limosa limosa*			VU		CJR
Black-tailed Native-hen	*Gallinula ventralis*					
Black-winged Stilt	*Himantopus himantopus*	100	Breeding			
Blue-billed Duck	*Oxyura australis*			EN	L	
Caspian Tern	*Hydroprogne caspia*			NT	L	CJR
Chestnut Teal	*Anas castanea*					
Common Greenshank	*Tringa nebularia*					CJR
Common Sandpiper	*Actitis hypoleucos*			VU		CJ
Curlew Sandpiper	*Calidris ferruginea*					CJR
Darter	*Anhinga novaehollandiae*		Breeding			

Double-banded Plover	*Charadrius bicinctus*					
Dusky Moorhen	*Gallinula tenebrosa*					
Eastern Great Egret	*Ardea modesta*			VU	L	CJ
Eurasian Coot	*Fulica atra*	3000				
Freckled Duck	*Stictonetta naevosa*	1000		EN	L	
Glossy Ibis	*Plegadis falcinellus*	1		NT		C
Great Cormorant	*Phalacrocorax carbo*					
Great Crested Grebe	*Podiceps cristatus*					
Grey Teal	*Anas gracilis*	20000	Breeding			
Gull-billed Tern	*Gelochelidon nilotica*			EN	L	
Hardhead	*Aythya australis*	1500		VU		
Hoary-headed Grebe	*Poliocephalus poliocephalus*		Breeding			
Intermediate Egret	*Ardea intermedia*			CR	L	
Little Black Cormorant	*Phalacrocorax sulcirostris*	1				
Little Egret	*Egretta garzetta*			EN	L	
Little Pied Cormorant	*Microcarbo melanoleucos*		Breeding			
Marsh Sandpiper	*Tringa stagnatilis*	6				CJR
Masked Lapwing	*Vanellus miles*	100	Breeding			
Musk Duck	*Biziura lobata*			VU		
Nankeen Night Heron	*Nycticorax caledonicus*			NT		
Pacific Black Duck	*Anas superciliosa*	3000	Breeding			
Pied Cormorant	*Phalacrocorax varius*			NT		
Pink-eared Duck	*Malacorhynchus membranaceus*	30				
Purple Swamphen	*Porphyrio porphyrio*					
Red-capped Plover	*Charadrius ruficapillus*		Breeding			
Red-kneed Dotterel	*Erythrogonys cinctus*	20	Breeding			
Red-necked Avocet	*Recurvirostra novaehollandiae*	50				
Red-necked Stint	*Calidris ruficollis*					CJR
Ruddy Turnstone	*Arenaria interpres*	3				CJR
Sharp-tailed Sandpiper	*Calidris acuminata*					CJ
Silver Gull	*Chroicocephalus novaehollandiae*	200				
Straw-necked Ibis	*Threskiornis spinicollis*	30				
Swamp Harrier	*Circus approximans*					
Whiskered Tern	*Chlidonias hybridus*			NT		
White-bellied Sea-eagle	*Haliaeetus leucogaster*			VU	L	C
White-faced Heron	*Egretta novaehollandiae*	1	Breeding			
White-necked Heron	*Ardea pacifica*	100				
Yellow-billed Spoonbill	*Platalea flavipes*	100				

Legend: VAL = Victorian Advisory List, FFG = Flora & fauna guarantee Act, TR = International treaties, NT = near threatened, VU = vulnerable, EN = endangered, CR = critically endangered, L = listed, C = CAMBA, J = JAMBA, R = ROKAMBA.

Terrestrial birds recorded at or around the Lake Albacutya Ramsar site (DSE, 2009b)

Common name	Latin name	Count (max)	Breeding	EPBC	VAL	FFG
Australian Bustard	*Ardeotis australis*	1			CR	L
Australian Hobby	*Falco longipennis*					
Australian Magpie	*Gymnorhina tibicen*		Breeding			
Australian Owlet-nightjar	*Aegotheles cristatus*					
Australian Raven	*Corvus coronoides*		Breeding			
Australian Ringneck	*Barnardius zonarius zonarius*	2				
Australian Spotted Crake	*Porzana fluminea*					
Azure Kingfisher	*Alcedo azurea*				NT	
Banded Lapwing	*Vanellus tricolor*		Breeding			
Black Falcon	*Falco subniger*	3			VU	
Black Kite	*Milvus migrans*	1				
Black-chinned Honeyeater	*Melithreptus gularis*				NT	
Black-eared Cuckoo	*Chrysococcyx osculans*				NT	
Black-eared Miner	*Manorina melanotis*	1		EN	EN	L
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*					
Black-faced Woodswallow	*Artamus cinereus*					
Black-shouldered Kite	*Elanus axillaris*		Breeding			
Black-tailed Native-hen	*Gallinula ventralis*					
Blue Bonnet	*Northiella haematogaster*	4				
Blue-winged Parrot	*Neophema chrysostoma*	4				
Brown Falcon	*Falco berigora*					
Brown Goshawk	*Accipiter fasciatus*					
Brown Songlark	*Cincloramphus cruralis*					
Brown Treecreeper (south-eastern ssp.)	*Climacteris picumnus victoriae*		Breeding		NT	
Brown-headed Honeyeater	*Melithreptus brevirostris*	1				
Budgerigar	*Melopsittacus undulatus*					
Buff-rumped Thornbill	*Acanthiza reguloides*					
Bush Stone-curlew	*Burhinus grallarius*		Breeding		EN	L
Chestnut Quail-thrush	*Cinclosoma castanotus*				NT	
Chestnut-rumped Thornbill	*Acanthiza uropygialis*	2				
Clamorous Reed Warbler	*Acrocephalus stentoreus*					
Cockatiel	*Nymphicus hollandicus*					
Collared Sparrowhawk	*Accipiter cirrhocephalus*					
Common Bronzewing	*Phaps chalcoptera*	100				
Crested Bellbird	*Oreoica gutturalis*				NT	L
Crested Pigeon	*Ocyphaps lophotes*	6				
Crimson Chat	*Epthianura tricolor*	2				
Diamond Dove	*Geopelia cuneata*	2			NT	L
Diamond Firetail	*Stagonopleura guttata*				VU	L
Dusky Woodswallow	*Artamus cyanopterus*					
Eastern Rosella	*Platycercus eximius*					

Emu	*Dromaius novaehollandiae*	6				
Fairy Martin	*Hirundo ariel*		Breeding			
Fan-tailed Cuckoo	*Cacomantis flabelliformis*					
Flame Robin	*Petroica phoenicea*					
Galah	*Eolophus roseicapilla*	100				
Gilbert's Whistler	*Pachycephala inornata*					
Golden Whistler	*Pachycephala pectoralis*					
Grey Butcherbird	*Cracticus torquatus*	1				
Grey Currawong	*Strepera versicolor*		Breeding			
Grey Fantail	*Rhipidura albiscarpa*					
Grey Shrike-thrush	*Colluricincla harmonica*		Breeding			
Hooded Robin	*Melanodryas cucullata*		Breeding		NT	L
Horsfield's Bronze-Cuckoo	*Chrysococcyx basalis*					
Horsfield's Bushlark	*Mirafra javanica*					
Inland Thornbill	*Acanthiza apicalis*					
Jacky Winter	*Microeca fascinans*	1				
Laughing Kookaburra	*Dacelo novaeguineae*	2				
Letter-winged Kite	*Elanus scriptus*					
Little Button-quail	*Turnix velox*				NT	
Little Corella	*Cacatua sanguinea*	125				
Little Friarbird	*Philemon citreogularis*					
Little Grassbird	*Megalurus gramineus*					
Little Raven	*Corvus mellori*					
Long-billed Corella	*Cacatua tenuirostris*	2				
Magpie-lark	*Grallina cyanoleuca*		Breeding			
Major Mitchell's Cockatoo	*Lophocroa leadbeateri*				VU	L
Mallee Emu-wren	*Stipiturus Mallee*			VU	EN	L
Mallee Ringneck	*Barnardius zonarius barnardi*		Breeding			
Malleefowl	*Leipoa ocellata*		Breeding	VU	EN	L
Masked Woodswallow	*Artamus personatus*					
Mistletoebird	*Dicaeum hirundinaceum*					
Mulga Parrot	*Psephotus varius*					
Musk Lorikeet	*Glossopsitta concinna*					
Nankeen Kestrel	*Falco cenchroides*					
New Holland Honeyeater	*Phylidonyris novaehollandiae*					
Noisy Miner	*Manorina melanocephala*					
Orange Chat	*Epthianura aurifrons*	35				
Pacific Barn Owl	*Tyto javanica*					
Pallid Cuckoo	*Cuculus pallidus*					
Peaceful Dove	*Geopelia striata*					
Peregrine Falcon	*Falco peregrinus*	3	Breeding			
Pied Butcherbird	*Cracticus nigrogularis*	1				
Purple-crowned Lorikeet	*Glossopsitta porphyrocephala*					
Purple-gaped Honeyeater	*Lichenostomus cratitius*				VU	
Rainbow Bee-eater	*Merops ornatus*		Breeding			
Red Wattlebird	*Anthochaera carunculata*					
Red-backed Kingfisher	*Todiramphus pyrrhopygia*	2			NT	

Red-capped Robin	*Petroica goodenovii*		Breeding			
Red-rumped Parrot	*Psephotus haematonotus*		Breeding			
Redthroat	*Pyrrholaemus brunneus*				EN	L
Regent Parrot	*Polytelis anthopeplus*	50	Breeding	VU	VU	L
Restless Flycatcher	*Myiagra inquieta*		Breeding			
Rufous Songlark	*Cincloramphus mathewsi*					
Rufous Whistler	*Pachycephala rufiventris*		Breeding			
Sacred Kingfisher	*Todiramphus sanctus*					
Scarlet Robin	*Petroica boodang*					
Shining Bronze-Cuckoo	*Chrysococcyx lucidus*					
Shy Heathwren	*Calamanthus cautus*	2				
Silvereye	*Zosterops lateralis*					
Singing Honeyeater	*Lichenostomus virescens*	1				
Slender-billed Thornbill	*Acanthiza iredalei*				NT	L
Southern Boobook	*Ninox novaeseelandiae*					
Southern Scrub-robin	*Drymodes brunneopygia*	2				
Southern Whiteface	*Aphelocephala leucopsis*					
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*		Breeding			
Splendid Fairy-wren	*Malurus splendens*		Breeding			
Spotted Harrier	*Circus assimilis*	2			NT	
Spotted Pardalote	*Pardalotus punctatus*					
Striated Pardalote	*Pardalotus striatus*	2				
Striped Honeyeater	*Plectorhyncha lanceolata*		Breeding			
Stubble Quail	*Coturnix pectoralis*					
Sulphur-crested Cockatoo	*Cacatua galerita*	2				
Superb Fairy-wren	*Malurus cyaneus*					
Tawny Frogmouth	*Podargus strigoides*		Breeding			
Tawny-crowned Honeyeater	*Phylidonyris melanops*					
Tree Martin	*Hirundo nigricans*		Breeding			
Varied Sittella	*Daphoenositta chrysoptera*					
Variegated Fairy-wren	*Malurus lamberti*	100				
Wedge-tailed Eagle	*Aquila audax*	2				
Weebill	*Smicrornis brevirostris*	6				
Welcome Swallow	*Hirundo neoxena*		Breeding			
Western Gerygone	*Gerygone fusca*					
Whistling Kite	*Haliastur sphenurus*	1				
White-backed Swallow	*Cheramoeca leucosternus*					
White-breasted Woodswallow	*Artamus leucorynchus*					
White-browed Babbler	*Pomatostomus superciliosus*	100				
White-browed Woodswallow	*Artamus superciliosus*		Breeding			
White-eared Honeyeater	*Lichenostomus leucotis*					
White-faced Heron	*Egretta novaehollandiae*	1	Breeding			
White-fronted Chat	*Epthianura albifrons*	100				
White-fronted Honeyeater	*Phylidonyris albifrons*					

White-plumed Honeyeater	*Lichenostomus penicillatus*		Breeding			
White-winged Chough	*Corcorax melanorhamphos*		Breeding			
White-winged Triller	*Lalage sueurii*					
Willie Wagtail	*Rhipidura leucophrys*		Breeding			
Yellow Thornbill	*Acanthiza nana*					
Yellow-plumed Honeyeater	*Lichenostomus ornatus*					
Yellow-rumped Pardalote	*Pardalotus xanthopygus punctatus*		Breeding			
Yellow-rumped Thornbill	*Acanthiza chrysorrhoa*		Breeding			
Yellow-throated Miner	*Manorina flavigula*		Breeding			
Zebra Finch	*Taeniopygia guttata*					

Legend: EPBC = Environment and biodiversity protection Act, VAL = Victorian Advisory List, FFG = Flora & fauna guarantee Act, NT = near threatened, VU = vulnerable, EN = endangered, L = listed,

Mammals recorded at or around the Lake Albacutya Ramsar site (DSE, 2009b)

Common name	Latin name	VAL
Common Brushtail Possum	*Trichosurus vulpecula*	
Little Pygmy-possum	*Cercartetus lepidus*	NT
Mitchell's Hopping-mouse	*Notomys mitchelli*	NT
Short-beaked Echidna	*Tachyglossus aculeatus*	
Silky Mouse	*Pseudomys apodemoides*	NT
Western Grey Kangaroo	*Macropus fuliginosus*	

Legend: VAL = Victorian Advisory List, NT = near threatened

Reptiles recorded at or around the Lake Albacutya Ramsar site (DSE, 2009b)

Common name	Latin name
Boulenger's Skink	*Morethia boulengeri*
Central Bearded Dragon	*Pogona vitticeps*
Common Long-necked Turtle	*Chelodina longicollis*
Large Striped Skink	*Ctenotus robustus*
Marbled Gecko	*Christinus marmoratus*
Nobbi Dragon	*Amphibolurus nobbi coggeri*

Fish recorded at or around the Lake Albacutya Ramsar site (DSE, 2009b)

Common name	Latin name	VAL	FFG
Freshwater Catfish	*Tandanus tandanus*	EN	L

Legend: VAL = Victorian Advisory List, FFG = Flora & fauna guarantee Act, EN = endangered, L = listed,

Terrestrial invertebrates recorded at or around the Lake Albacutya Ramsar site (DSE, 2009b)

Common name	Latin name
Sciron Skipper	*Trapezites sciron eremicola*

Flora within the Lake Albacutya Park (DSE, 2009c)

Common name	Latin name	VAL	FFG	EPBC	Family
Annual Bluebell	*Wahlenbergia gracilenta s.l.*				Campanulaceae
Annual Cudweed	*Euchiton sphaericus*				Asteraceae
Austral Bugle	*Ajuga australis*				Lamiaceae
Australian Carrot	*Daucus glochidiatus*				Apiaceae
Australian Hollyhock	*Malva preissiana s.l.*				Malvaceae
Berry Saltbush	*Atriplex semibaccata*				Chenopodiaceae
Black Box	*Eucalyptus largiflorens*				Myrtaceae
Black Mallee-box	*Eucalyptus porosa*				Myrtaceae
Black Roly-poly	*Sclerolaena muricata*				Chenopodiaceae
Blue Boronia	*Boronia coerulescens subsp. coerulescens*				Rutaceae
Blue Rod	*Morgania glabra spp. agg.*				Scrophulariaceae
Box Mistletoe	*Amyema miquelii*				Loranthaceae
Bristly Wallaby-grass	*Austrodanthonia setacea*				Poaceae
Broad-leaf Desert Cassia	*Senna form taxon 'coriacea'*				Caesalpiniaceae
Clustered Everlasting	*Chrysocephalum semipapposum*				Asteraceae
Common Bow-flower	*Millotia muelleri*				Asteraceae
Common Early Nancy	*Wurmbea dioica*				Colchicaceae
Common Grass-sedge	*Carex breviculmis*				Cyperaceae
Common Heliotrope	*Heliotropium europaeum*				Boraginaceae
Common Spike-sedge	*Eleocharis acuta*				Cyperaceae
Common Wallaby-grass	*Austrodanthonia caespitosa*				Poaceae
Common Woodruff	*Asperula conferta*				Rubiaceae
Cotton Fireweed	*Senecio quadridentatus*				Asteraceae
Crassula	*Crassula spp.*				Crassulaceae
Cup Wattle	*Acacia cupularis*	r			Mimosaceae
Dense Crassula	*Crassula colorata*				Crassulaceae
Desert Grevillea	*Grevillea pterosperma*				Proteaceae
Desert Jasmine	*Jasminum didymum subsp. lineare*	v			Oleaceae
Desert Phebalium	*Phebalium bullatum*				Rutaceae
Desert Spear-grass	*Austrostipa eremophila*				Poaceae
Dissected New Holland Daisy	*Vittadinia dissecta s.l.*				Asteraceae
Dock	*Rumex spp.*				Polygonaceae
Dumosa Mallee	*Eucalyptus dumosa*				Myrtaceae
Dwarf Daisy	*Brachyscome goniocarpa*				Asteraceae
Earth Cress	*Geococcus pusillus*				Brassicaceae
Erect Bluebush	*Maireana pentatropis*				Chenopodiaceae
Fine-hairy Spear-grass	*Austrostipa puberula*	r			Poaceae
Finger Rush	*Juncus subsecundus*				Juncaceae
Flame Heath	*Astroloma conostephioides*				Epacridaceae
Flannel Cudweed	*Actinobole uliginosum*				Asteraceae
Flat Spurge	*Chamaesyce drummondii*				Euphorbiaceae
Fuzzy New Holland Daisy	*Vittadinia cuneata*				Asteraceae
Gaunt Rice-flower	*Pimelea stricta*				Thymelaeaceae
Glaucous Goosefoot	*Chenopodium glaucum*				Chenopodiaceae

Gold-dust Wattle	*Acacia acinacea s.l.*				Mimosaceae
Granite Bluebell	*Wahlenbergia graniticola s.l.*				Campanulaceae
Grass Cushion	*Isoetopsis graminifolia*				Asteraceae
Grassland Wood-sorrel	*Oxalis perennans*				Oxalidaceae
Grey Copperburr	*Sclerolaena diacantha*				Chenopodiaceae
Grey Mulga	*Acacia brachybotrya*				Mimosaceae
Hairy Burr-daisy	*Calotis hispidula*				Asteraceae
Hakea Wattle	*Acacia hakeoides*				Mimosaceae
Hard-head Daisy	*Brachyscome lineariloba*				Asteraceae
Heart-leaf Beard-heath	*Leucopogon cordifolius*				Epacridaceae
Heath-myrtle	*Micromyrtus ciliata*				Myrtaceae
Heathy Phyllota	*Phyllota pleurandroides*				Fabaceae
Honey-myrtle	*Melaleuca spp.*				Myrtaceae
Hooked Needlewood	*Hakea tephrosperma*				Proteaceae
Inland Pomaderris	*Pomaderris paniculosa subsp. paniculosa*	v			Rhamnaceae
Kidney-weed	*Dichondra repens*				Convolvulaceae
Kneed Wallaby-grass	*Austrodanthonia geniculata*				Poaceae
Knobby Club-sedge	*Ficinia nodosa*				Cyperaceae
Leafless Bitter-pea	*Daviesia brevifolia*				Fabaceae
Leafy Templetonia	*Templetonia stenophylla*				Fabaceae
Lesser Sea-spurrey	*Spergularia marina s.s.*				Caryophyllaceae
Little Club-sedge	*Isolepis marginata*				Cyperaceae
Mallee Aotus	*Aotus subspinescens*				Fabaceae
Mallee Bitter-bush	*Adriana urticoides var. hookeri*				Euphorbiaceae
Manna Wattle	*Acacia microcarpa s.l.*				Mimosaceae
Moonah	*Melaleuca lanceolata subsp. lanceolata*				Myrtaceae
Moss Sunray	*Hyalosperma demissum*				Asteraceae
Native Flax	*Linum marginale*				Linaceae
Native Orache	*Atriplex australasica*				Chenopodiaceae
Native Scurf-pea	*Cullen australasicum*	e	L		Fabaceae
Nealie	*Acacia rigens*				Mimosaceae
Nigger-heads	*Enneapogon nigricans*				Poaceae
Nodding Beard-heath	*Leucopogon woodsii*	r			Epacridaceae
Nodding Saltbush	*Einadia nutans subsp. nutans*				Chenopodiaceae
Pale Rush	*Juncus pallidus*				Juncaceae
Pigmy Purslane	*Calandrinia granulifera*				Portulacaceae
Pink Bindweed	*Convolvulus erubescens spp. agg.*				Convolvulaceae
Pink Zieria	*Zieria veronicea subsp. veronicea*	r			Rutaceae
Plains Sedge	*Carex bichenoviana*				Cyperaceae
Poached-eggs Daisy	*Polycalymma stuartii*				Asteraceae
Pointed Twin-leaf	*Zygophyllum apiculatum*				Zygophyllaceae
Prickly Cudweed	*Stuartina hamata*	r			Asteraceae
Prickly Geebung	*Persoonia juniperina*				Proteaceae
Prickly Saltwort	*Salsola tragus*				Chenopodiaceae
Prickly Saltwort	*Salsola tragus subsp. tragus*				Chenopodiaceae
Pygmy Sunray	*Rhodanthe pygmaea*				Asteraceae
Rayless Starwort	*Stellaria multiflora*				Caryophyllaceae
Red Water-milfoil	*Myriophyllum verrucosum*				Haloragaceae

Ridged Water-milfoil	*Myriophyllum porcatum*	v	L	V	Haloragaceae
River Red-gum	*Eucalyptus camaldulensis*				Myrtaceae
Rohrlach's Bluebush	*Maireana rohrlachii*				Chenopodiaceae
Rough Burr-daisy	*Calotis scabiosifolia var. scabiosifolia*				Asteraceae
Rough Raspwort	*Haloragis aspera*				Haloragaceae
Ruby Saltbush	*Enchylaena tomentosa var. tomentosa*				Chenopodiaceae
Saltbush	*Atriplex spp.*				Chenopodiaceae
Scrub Cypress-pine	*Callitris verrucosa*				Cupressaceae
Short-leaf Bluebush	*Maireana brevifolia*				Chenopodiaceae
Sieber Crassula	*Crassula sieberiana s.l.*				Crassulaceae
Slaty Sheoak	*Allocasuarina muelleriana subsp. muelleriana*				Casuarinaceae
Slender Cypress-pine	*Callitris gracilis subsp. murrayensis*				Cupressaceae
Slender Rice-flower	*Pimelea linifolia subsp. linifolia*				Thymelaeaceae
Slender-fruit Saltbush	*Atriplex leptocarpa*				Chenopodiaceae
Slender-leaf Mallee	*Eucalyptus leptophylla*				Myrtaceae
Small Cooba	*Acacia ligulata*				Mimosaceae
Small Purslane	*Calandrinia eremaea*				Portulacaceae
Small-leaved Clematis	*Clematis microphylla s.l.*				Ranunculaceae
Soft Millotia	*Millotia tenuifolia var. tenuifolia*				Asteraceae
Sow Thistle	*Sonchus spp.*				Asteraceae
Spear Grass	*Austrostipa spp.*				Poaceae
Spiny Flat-sedge	*Cyperus gymnocaulos*				Cyperaceae
Sticky Hop-bush	*Dodonaea viscosa*				Sapindaceae
Supple Spear-grass	*Austrostipa mollis*				Poaceae
Tall Bluebell	*Wahlenbergia stricta subsp. stricta*				Campanulaceae
Tangled Burr-daisy	*Calotis erinacea*				Asteraceae
Tangled Lignum	*Muehlenbeckia florulenta*				Polygonaceae
Three-nerve Wattle	*Acacia trineura*	v			Mimosaceae
Tiny Bow-flower	*Millotia perpusilla*				Asteraceae
Twiggy Beard-heath	*Leucopogon costatus*				Epacridaceae
Twiggy Guinea-flower	*Hibbertia virgata*				Dilleniaceae
Variable Daisy	*Brachyscome ciliaris*				Asteraceae
Variable Sida	*Sida corrugata*				Malvaceae
Wallaby Grass	*Austrodanthonia spp.*				Poaceae
Wattle	*Acacia spp.*				Mimosaceae
Weeping Pittosporum	*Pittosporum angustifolium*				Pittosporaceae
White Cryptandra	*Stenanthemum leucophractum*				Rhamnaceae
White Everlasting	*Chrysocephalum baxteri*				Asteraceae
Wingless Bluebush	*Maireana enchylaenoides*				Chenopodiaceae
Wirewort	*Asteridea athrixioides*				Asteraceae
Wiry Podolepis	*Podolepis capillaris*				Asteraceae
Woolly New Holland Daisy	*Vittadinia gracilis*				Asteraceae
Yellow Gum	*Eucalyptus leucoxylon*				Myrtaceae

Legend: EPBC = Environment and biodiversity protection Act, VAL = Victorian Advisory List, FFG = Flora & fauna guarantee Act, v = vulnerable, r = rare, e = endangered, L = listed, V = vulnerable.

Introduced fauna at Lake Albacutya (DSE, 2009b)

Common Name	Latin Name	Species type
Common Blackbird	*Turdus merula*	Birds
Common Starling	*Sturnus vulgaris*	Birds
European Goldfinch	*Carduelis carduelis*	Birds
European Hare	*Lepus europeaus*	Mammals
European Rabbit	*Oryctolagus cuniculus*	Mammals
European Skylark	*Alauda arvensis*	Birds
Goat (feral)	*Capra hircus*	Mammals
House Sparrow	*Passer domesticus*	Birds
Red Fox	*Vulpes vulpes*	Mammals

Introduced flora at Lake Albacutya (DSE, 2009c)

Common name	Latin name	Family
Silvery Hair-grass	Aira caryophyllea	Poaceae
Cape Weed	Arctotheca calendula	Asteraceae
Bearded Oat	Avena barbata	Poaceae
Wild Oat	Avena fatua	Poaceae
Oat	Avena spp.	Poaceae
Mediterranean Turnip	Brassica tournefortii	Brassicaceae
Great Brome	Bromus diandrus	Poaceae
Madrid Brome	Bromus madritensis	Poaceae
Red Brome	Bromus rubens	Poaceae
Winged Slender-thistle	Carduus tenuiflorus	Asteraceae
Skeleton Weed	Chondrilla juncea	Asteraceae
Perennial Veldt-grass	Ehrharta calycina	Poaceae
Small Goosegrass	Galium murale	Rubiaceae
Chalkwort	Gypsophila tubulosa	Caryophyllaceae
Northern Barley-grass	Hordeum glaucum	Poaceae
Barley-grass	Hordeum leporinum	Poaceae
Sea Barley-grass	Hordeum marinum	Poaceae
Barley-grass	Hordeum murinum s.l.	Poaceae
Smooth Cat's-ear	Hypochoeris glabra	Asteraceae
Prickly Lettuce	Lactuca serriola	Asteraceae
Perennial Rye-grass	Lolium perenne	Poaceae
Horehound	Marrubium vulgare	Lamiaceae
Little Medic	Medicago minima	Fabaceae
Burr Medic	Medicago polymorpha	Fabaceae
Barrel Medic	Medicago truncatula	Fabaceae
Bokhara Clover	Melilotus albus	Fabaceae
Bristle Poppy	Papaver aculeatum	Papaveraceae
False Hair-grass	Pentaschistis airoides subsp. airoides	Poaceae
Velvety Pink	Petrorhagia dubia	Caryophyllaceae
Sand Plantain	Plantago arenaria	Plantaginaceae
Prostrate Knotweed	Polygonum aviculare s.l.	Polygonaceae
Annual Beard-grass	Polypogon monspeliensis	Poaceae
False Sow-thistle	Reichardia tingitana	Asteraceae
Annual Cat's-tail	Rostraria cristata	Poaceae
Tiny Bristle-grass	Rostraria pumila	Poaceae

Curled Dock	Rumex crispus	Polygonaceae
Arabian Grass	Schismus barbatus	Poaceae
London Rocket	Sisymbrium irio	Brassicaceae
Rough Sow-thistle	Sonchus asper s.l.	Asteraceae
Common Sow-thistle	Sonchus oleraceus	Asteraceae
Red Sand-spurrey	Spergularia rubra s.l.	Caryophyllaceae
Narrow-leaf Clover	Trifolium angustifolium var. angustifolium	Fabaceae
Hare's-foot Clover	Trifolium arvense var. arvense	Fabaceae
Cluster Clover	Trifolium glomeratum	Fabaceae
Woolly Clover	Trifolium tomentosum var. tomentosum	Fabaceae
Squirrel-tail Fescue	Vulpia bromoides	Poaceae
Wall Fescue	Vulpia muralis	Poaceae
Rat's-tail Fescue	Vulpia myuros f. myuros	Poaceae
Fescue	Vulpia spp.	Poaceae

Appendix 2 – Definition of Eucalypt dieback categories

The following definitions have been adapted from Wouters (1993), and refer to the map of River Red Gum dieback at Lake Albacutya (Figure 4.6).

Slight dieback

- presence of some exposed limbs
- some loss of crown fullness
- some loss of tree vigour
- any individual not greatly affected

Moderate dieback

- presence of exposed limbs throughout crown
- crown density and/or size reduced
- loss of tree vigour characteristic of stand overall
- some dead trees may be present

Severe dieback

- presence of dead trees common
- presence of exposed limbs on most remaining live trees
- crowns generally broken and severy defoliated

Regrowth

- dense stands
- pole like trees less than 2m in height
- vigourous growth in crowns

Healthy forest

- full crown
- vigourous growth
- exposed limbs uncommon