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DEPARTMENT OF CONSERVATION  
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WESTERN AUSTRALIA

# **TOOLIBIN LAKE RECOVERY PLAN**

**Prepared by the Toolibin Lake Recovery Team and Toolibin  
Lake Technical Advisory Group**

**September 1994**

Endorsed by the Corporate Executive of the Department of Conservation and  
Land Management and the National Parks and Nature Conservation Authority in  
September 1994.

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See the contents page included with this section.  
This section, which consists of the original Recovery Plan prepared by consultants, includes technical information supporting the recovery actions.

# **PART 1**

## **BACKGROUND AND OBJECTIVES**

## INTRODUCTION

Toolibin Lake lies within a system of Class "A" nature reserves that are only separated by roadways. These nature reserves consist of Reserve Nos 9617, 14398, 24556 and 27286 (see map on page vi). The nature reserves are vested in the National Parks and Nature Conservation Authority (NPNCA) and managed by the Department of Conservation and Land Management (CALM). The total area of these reserves is 1 230 hectares.

Toolibin Lake is listed under the Ramsar Convention as a wetland of international importance. Signatories to the Convention have agreed to designate suitable wetlands within their territories for inclusion in a List of Wetlands of International Importance. They have also agreed to ensure the conservation of these wetlands and their flora and fauna, and the wise use of wetlands generally. Specific actions to protect Toolibin Lake and its environs have been taken since the mid-1970s, however, a draft Recovery Plan was not completed until late 1992.

The draft was prepared by consultants with advice from all groups involved in management of the Toolibin Lake Catchment. While the draft was not endorsed by the NPNCA until 15 January 1993, it has guided action by CALM officers since its release.

The Toolibin Lake Recovery Team first met on 9 September 1993, and at that meeting it was agreed that the catchment approach to the recovery process should be made more explicit within the Recovery Plan. This led to the writing of a new introductory section of the Plan (Part 1), with the original Plan being retained as a Recovery Action Plan (Part 2).

This Plan constitutes a set of "necessary operations" as defined under the Conservation and Land Management Act. The Plan has been formally endorsed by both the NPNCA and the Corporate Executive of CALM. It is one of a series produced with Federal assistance to protect and rehabilitate rare species and endangered habitats.

The term of this Plan is ten years from endorsement unless revised earlier with approval from the Recovery Team, NPNCA, and the Executive Director of CALM. If not revised after ten years, the Plan will continue as the endorsed guide for management until re-written.

The contents and layout of the Recovery Plan are summarised below to help the reader.

### *PART 1:*

*Introduction:* is this section, which introduces the reader to the document as a whole.

*Toolibin - Context and Goals:* this short statement provides an historical context for Toolibin and a summary of the goals that will be achieved through the implementation of the Recovery Plan. It is a succinct statement of the issues and the goals.

*Value Statement:* Toolibin Lake and its catchment have many values, and each of these affects management. It is important to understand all values to effectively manage the Lake and its environs, therefore the Recovery Team decided to include this statement in the Plan.

*Recovery Objectives, Approach and Strategies:* while the original plan describes the recovery objective, approach, and criteria, the Recovery Team expanded these to describe in more detail the catchment context and broad strategies. This section provides this detail and overlaps with similar sections in the Recovery Action Plan (original recovery plan).

*Implementation of the Plan:* in this section the responsibilities and philosophy for implementing the Plan are outlined. The importance of a flexible approach to implementation is emphasised.

## *PART 2:*

*Recovery Action Plan:* this part consists of the unaltered original plan prepared by consultants. It includes the recovery criteria, and the tasks and responsibilities for achieving the criteria. It also includes technical information which explains the selection of recovery actions.

## **TOOLIBIN - CONTEXT AND GOALS**

The decline of our wetlands was the first sign of trouble facing our agricultural lands and remnant vegetation. While some wetlands were always saline, many were fresh, and all were surrounded by healthy bush. In sixty years or less many of our wetlands have declined from healthy, biologically diverse and pleasant places to less inviting areas which now support a much less varied, but still interesting, wildlife (Figure 1).

The wheatbelt landscape will continue to degrade. Urgent action is required to conserve our remaining flora and fauna and to develop agricultural practices which are sustainable in the long term. There are many causes of the land conservation problems facing rural land managers, however, of primary concern is the imbalance in our water cycle. The effects of this are aggravated by the very high levels of salt stored in our soils and groundwater.

Our wetlands are crucial for nature conservation and a sensitive measure of the sustainability of our farming practices. If our wetlands are lost, our children will never fully understand our land, its history, and the lessons that we have learnt from our mistakes. Restoration of our wetlands will be an early sign that we are achieving both sustainable land use and a landscape that we can be proud to leave to our descendants.

There is much more at stake - if we don't restore the processes of our land, then there will be significant productivity losses in our valley agricultural systems and in parts of upper catchments. It will just take a little longer than the loss of our wetlands.

Presently there is concern amongst individual land managers that the problems they face are beyond their personal control. Awareness that solutions for catchments must involve all catchment landholders is also developing, and catchment groups are being formed. We now have an important opportunity to develop long term solutions based on our inventiveness and ability to work hard together as communities when faced by a crisis. Toolibin provides an important opportunity to show that a rural community, including its government agency members, can overcome major land degradation problems on a catchment basis.

Effective group action at Toolibin will not only protect an important wetland, it will also provide options for increasing individual farm productivity and a case study to guide action elsewhere in Australia.

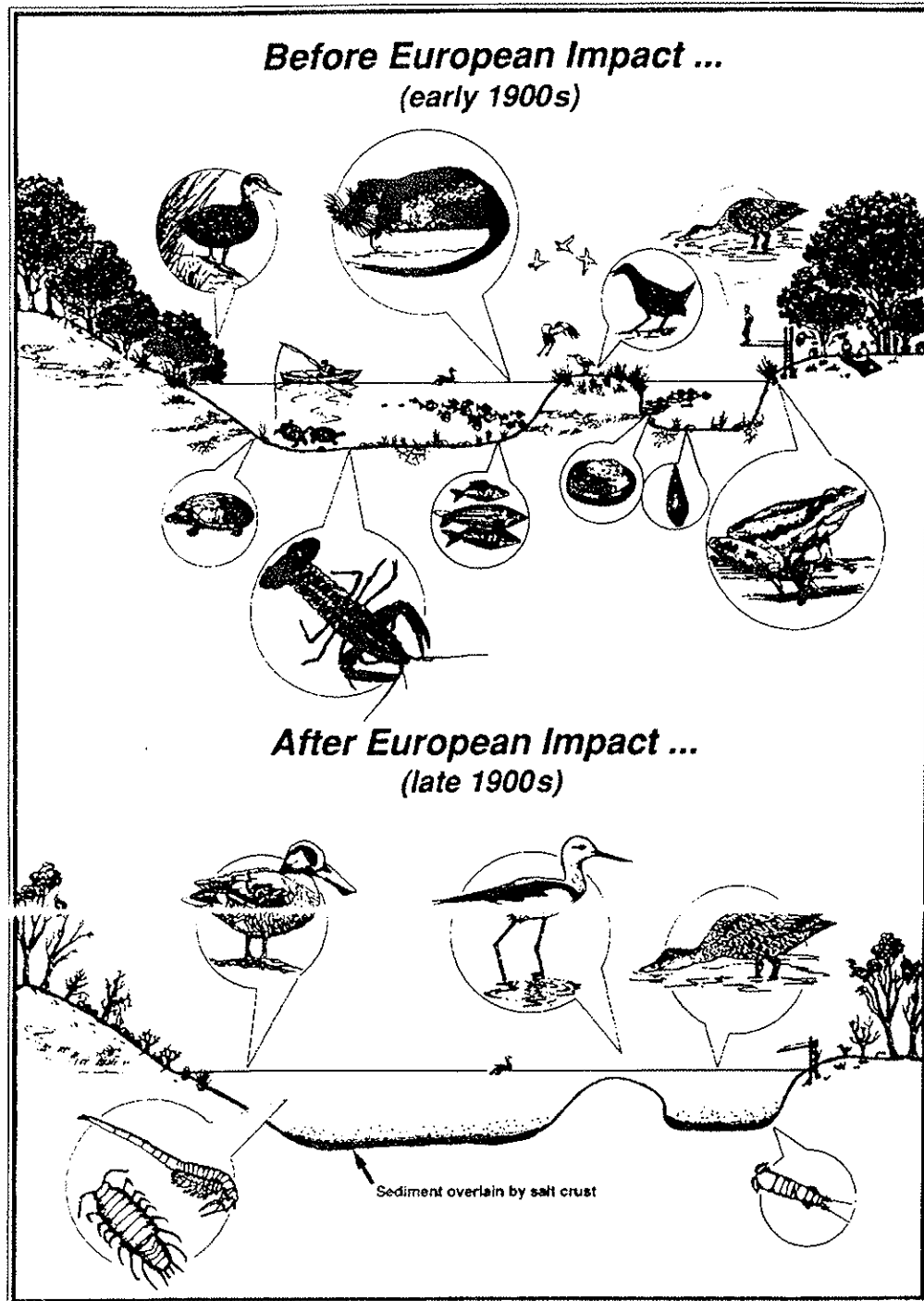


Figure 1: Diagrammatic representation of change in a wheatbelt wetland following European settlement. (Drawn by Sandra Mitchell and published in Sanders, A. 1991. *Oral Histories Documenting Changes in Wheatbelt Wetlands*, Occasional Paper 2/91, Department of Conservation and Land Management, Perth.)

In the case of Toolibin and its catchment there are five principal goals:

- to conserve Toolibin Lake and its associated wildlife as a freshwater habitat.
- to improve land use decision making and practice within the Toolibin Catchment so that land management:
  - \* is sustainable, productive and profitable in the long term (over 100 years);
  - \* reduces the current area of degraded land;
  - \* favours conservation of local wildlife.
- to demonstrate that, within a large catchment, it is possible to stabilise hydrological trends which if unchecked threaten land, water and biodiversity resources.
- to demonstrate to other land managers in Australia methods of protecting their biodiversity, land, and water resources.
- to develop mechanisms which lead to community ownership of Western Australia's natural resources including management problems and their solution.

## **TOOLIBIN LAKE AND RESERVES - VALUE STATEMENT**

Toolibin Lake is a vital community asset. The conservation of Toolibin Lake as a functioning remnant of a natural ecosystem benefits the community by:

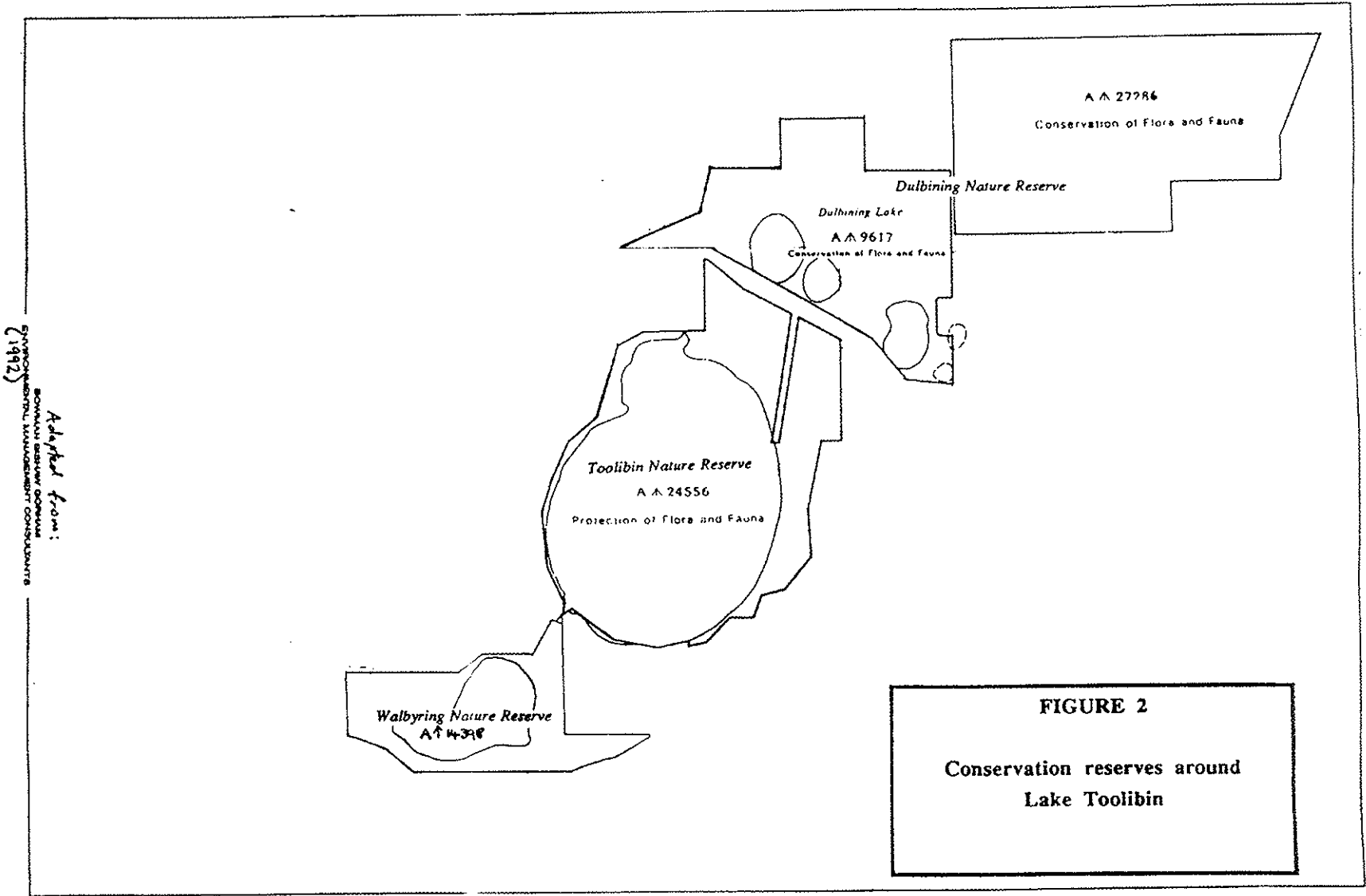
- protecting an important sample of our flora and fauna for present and future generations.
- providing opportunities for recreation and important learning experiences.
- contributing to the healthy functioning of a broad system of land uses.

Toolibin and its catchment form a subsystem within the Blackwood Catchment. Their future values are inextricably linked, and the management of the system parts will determine the long term values of the system as a whole.

Toolibin's listing under the Ramsar convention and nomination for the Register of the National Estate recognise the wetland's importance. These values are explored in more detail below.

Toolibin Lake and associated reserves are shown in Figure 2. Collectively this area is referred to below as "Toolibin".





Adapted from:  
 ENVIRONMENTAL MANAGEMENT CONSULTANTS  
 (1992)

**FIGURE 2**  
 Conservation reserves around  
 Lake Toolibin

## NATURE CONSERVATION VALUES

### The Wetland

Toolibin, a seasonal wetland, has important conservation significance as a breeding habitat for native waterbirds and is listed as a "Wetland of International Importance" under the Ramsar Convention. Toolibin is also on the Register of the National Estate.

However, the nature conservation value of Toolibin is much more than habitat for waterbirds.

Toolibin includes the only remaining examples in south-western Australia of a freshwater wetland with extensive woodlands of living *Casuarina obesa* and *Melaleuca* spp across wetland floors. This vegetation is emergent when the wetlands fill.

This type of freshwater wetland was once common within the inland south-west.

### Waterbirds

The living emergent vegetation and comparatively fresh water of Toolibin provide breeding habitat for a number of bird species - for example freckled duck, great egret and yellow-billed spoonbills - which require these conditions.

The wetlands and their environs support 24 species of breeding waterbirds, the greatest number of species for any wetland in south-western Australia. Altogether, 41 species of waterbirds have been recorded there, which is the highest species richness amongst inland wetlands of the south-west.

### Invertebrates

The invertebrate fauna of Toolibin Lake and nearby Walbyring Lake are typical of brackish or mildly saline waters. The species present at any one time vary according to salinity. The salinities of both lakes change within a season in response to water levels and between years according to whether the systems have over-flowed and flushing of salt has occurred. Over-riding these short-term fluctuations, however, there has been a shift over the past 30 years in the species composition in the lakes that reflects increasing salinity. Large leeches, which are restricted to freshwater, have disappeared. At the same time, some ostracod species typical of moderately saline conditions (10-20 grams per litre total dissolved solids), such as *Mytilocypris mytiloides* and *Diacypris spinosa*, have appeared. The current invertebrate community probably represents a transitional fauna between fresh and saline conditions rather than a stable, brackish water community.

### Vegetation

The Toolibin wetland vegetation type has all but disappeared from the wheatbelt. The wetland vegetation at Toolibin is characterised by swamp sheoaks (*Casuarina obesa*) and paperbarks (*Melaleuca strobophylla*) fringing and growing across the Lake bed, and flooded gum (*Eucalyptus rudis*) on higher margins. In contrast, other wheatbelt lakes have retained, at best, a fringe of swamp sheoaks and melaleucas.

On deep sands adjoining the main Lake are woodlands consisting of co-dominant acorn banksia (*Banksia prionotes*) and rock sheoak (*Allocasuarina huegeliana*). This vegetation

type is not well represented on wheatbelt nature reserves. The association includes a range of understorey species including, in some parts, an attractive display of orchids in spring. The purchase of some of this vegetation type from adjoining private property has added to the conservation values of the area, and can be considered a valuable side benefit of conserving the wetlands.

The wetland surroundings also include woodlands of York gum (*Eucalyptus loxophleba*) and jam (*Acacia acuminata*). These vegetation associations are also not well represented on wheatbelt nature reserves. Again, areas including these species have been purchased to better protect the wetlands. The conservation value of this vegetation type warrants protection irrespective of the presence of the adjoining wetlands.

Similarly, salmon gum woodlands (*Eucalyptus salmonophloia*) are uncommon within wheatbelt reserves. These occur to a limited extent in the northern parts of the reserve complex.

### Floristics

The flora of Toolibin Lake and adjacent reserves is comprised of 31 families, 81 genera and 126 species. Dominant families include Poaceae, Proteaceae, Mimosaceae, Papilionaceae, Myrtaceae and Asteraceae. Twenty-one species, or 16.5% of the plants recorded, are introduced, which is a reflection of the surrounding agricultural land use. The paperbark, *Melaleuca strobophylla*, found on the lake bed is recorded as having a restricted geographic range. Further loss of populations of this species in the south-west would see it being listed as rare and endangered.

Flooded gum, *Eucalyptus rudis*, growing at Toolibin are near the eastern edge of their distribution in South-western Australia.

An obvious feature of the Toolibin vegetation is the dominance of each plant community by one or two tree species. The more diverse vegetation occurs as an understorey within the *Allocasuarina huegeliana-Banksia prionotes* community. This community grows on the sandier soils away from the lake bed.

### Ecosystem

The flora and fauna of Toolibin combined with their physical environment are a unique living system, that is, an ecosystem. This ecosystem may be readily degraded through either changes in its physical characteristics or loss of its living elements. The current trends in the physical condition of the lands surrounding the Lake will, unless redressed, lead to further degradation of the system.

At a broader level, Toolibin is part of a much larger natural system. Corridors of tree and shrub vegetation connect Toolibin with other areas of natural vegetation. With some revegetation a corridor - broken only by roads - could be established between Toolibin and the Dongolocking Nature Reserves to the south-east. At Dongolocking, members of the local community are working with government agencies to establish links within their important system of local nature reserves.

## LAND CONSERVATION VALUES

### **Water Table Control**

The vegetation within Toolibin is undoubtedly assisting to control rising groundwater and thus the spread of surface salinity within the immediate area of the reserves.

If the vegetation of Toolibin had been more extensively cleared - and some of it was bought by the State Government following chaining prior to clearing - then saline scalds and other forms of surface salinity would have been more extensive.

### **Flood Mitigation**

The system of basins within Toolibin and further downstream act as a "dam" which:

- confines water and prevents it spreading onto adjoining farmlands.
- stores and slows flood waters, and thus reduces their impact downstream.

The above values have not been measured, but they are undoubtedly important. It should be stressed that these system functions may be lost through silting as for example has occurred in parts of the Avon River.

### **Function as a Silt and Nutrient Trap**

The upstream vegetation of wetlands, provided it is sufficiently intact, will act as a silt trap and prevent wetland basins being filled with soil thus reducing their functions in flood mitigation. Also, nutrients, such as fertiliser, may be trapped and used by aquatic plants in wetlands, and thus mitigate downstream and groundwater pollution and eutrophication.

## AESTHETIC AND HERITAGE VALUES

Toolibin is a pleasant place to visit and an attractive area of remnant vegetation. Furthermore, it represents an important reminder of what the wheatbelt landscape was like before land clearing. If the Toolibin wetlands become badly degraded, future generations will never understand what the landscape was like and how it functioned. This not only affects heritage values, it also affects our ability to understand and interpret the landscape and thus plan for the future.

## TOURISM VALUES

Toolibin is already a destination for those interested in wetlands. Given increasing interest in farmstays and the nearby Facey Homestead, there is potential to increase local incomes through tourist activities.

## AGRICULTURAL VALUES OF THE TOOLIBIN CATCHMENT

The Toolibin Catchment is a valuable mixed farming area which supports 40 farming families. Agricultural values are threatened by land degradation including rising groundwater, water-

logging, and changes in soil structure. The protection of farm values and the achievement of sustainable agriculture are major challenges facing the State.

Current best estimates are that some 600 hectares of the 47 600 hectare catchment have become salinised, and that a further 5 400 hectares are likely to become salinised over the next ten to twenty years. Based on a crop rotation of one wheat and two pasture years, and assuming a wheat yield of 1.7 tonnes per hectare, the ultimate annual cost of salinisation is likely to be \$320 000 per year at today's values.

These figures emphasise the importance of developing the positive relationship between achievement of sustainable agriculture and conservation of our flora and fauna.

## OPPORTUNITY VALUES

The combined agricultural and nature conservation values of the Toolibin catchment provide an unique opportunity to pool resources and seek solutions to land degradation problems. If these combined values are insufficient to achieve an effective solution to wheatbelt hydrological problems, then the prognosis for similar areas is very poor.

The Toolibin catchment not only represents an opportunity to tackle biological aspects of sustainable agriculture and biodiversity issues, it also provides an invaluable chance to answer questions concerning drainage and other engineering solutions to land degradation issues.

## OBJECTIVES, APPROACH AND STRATEGIES

### Recovery Objective

The objective of the Recovery Plan is to ensure the long-term maintenance of Toolibin Lake and its environs as a healthy and resilient freshwater ecosystem suitable for the continued visitation and breeding success by the presently high numbers and species of waterbirds.

### Recovery Approach

To achieve this objective it will be necessary to restore the catchment of Toolibin to a hydrological condition which conserves the Lake and its environs. Establishing sustainable, high water-use agriculture within the catchment is crucial to attain this goal.

Therefore strategies for recovery of Toolibin Lake require the integration of active management and rehabilitation of the lake, associated reserves, and nearby agricultural lands. The major cause of deterioration of the Lake is salinisation and waterlogging associated with a rising saline groundwater table. To enable the lake to survive and recover requires this process to be reversed to return the system to one that is a closer reflection of the historical hydrological regime. This can only be achieved through appropriate action at the level of the whole Toolibin Catchment.

While a solution at the catchment level is essential, emergency action, such as groundwater pumping, is required in the short term to maintain and improve Toolibin Lake until longer term strategies begin to take effect.

## Recovery Strategies

While all the strategies listed are important, the first four are crucial and therefore have the highest priority. The strategies for achieving the Recovery Objective are:

- to control groundwater levels beneath Toolibin and ensure that they do not threaten the freshwater status of the Lake or its environs.
- to control surface water inflows to Toolibin and ensure that they do not threaten the freshwater status of the Lake.
- to maintain or enhance the natural vegetation in and around the Lake.
- to achieve sustainable agriculture and increased water use on agricultural lands in the catchment by:
  - \* developing and implementing commercial revegetation schemes based on woody, native vegetation.
  - \* developing and implementing revegetation which improves current agricultural production (cereal and stock). For example, by effective implementation of alley farming, shelterbelts, and rehabilitation and pastoral use of areas with surface salinity.
  - \* encouraging changes in farm practice which better utilise water "where it falls". This may include improving soil structure to enhance plant growth (and thus water use).
- to develop consultative mechanisms, models and decision-making systems with the community to ensure that potentially divisive land conservation issues, such as drainage and disposal of effluent from groundwater pumping, can be effectively resolved.
- to implement monitoring and research which allows the achievement of strategies to be evaluated.

Given that the Australian community contributes to the recovery of the Lake, it is recognised that the following strategies must also be pursued although they do not directly relate to the recovery objective:

- to improve knowledge of hydrological, farming and natural systems so that information generated through the Toolibin Catchment can be successfully applied elsewhere.
- to educate the local, State, and National communities concerning the recovery outcomes so that people are better informed concerning land use and land conservation.
- to extend the information and lessons from Toolibin to other land managers.

## IMPLEMENTATION OF RECOVERY PLAN

The biological, physical and social issues affecting the Lake are complex. Most, despite the amount of research, are poorly understood. Consequently, implementation of the Recovery Plan will be flexible so that rapid and effective responses may be made to new information, unpredictable changes in resource availability, and changes in environmental factors.

Therefore, although the NPNCA and the Corporate Executive of CALM have endorsed the Recovery Plan, its implementation will be flexible and subject to change with respect to priorities and methods. To ensure adequate consultation with stakeholders, implementation of the Plan is under the immediate control of a Recovery Team which includes representatives of appropriate agencies and the local community. Given the complexity of the technical issues surrounding Toolibin Lake, a Technical Advisory Group has also been established. The roles of these groups are outlined below.

### **Role of Recovery Team**

The functions of the Recovery Team include:

- implementing the Recovery Plan including decisions on priority actions and supervision of applications for external funding.
- reviewing and re-ranking Recovery Plan priorities.
- reporting progress annually to the Director of Nature Conservation.

The Recovery Team is responsible through the Director of Nature Conservation to CALM's Corporate Executive. CALM's Wheatbelt Regional Manager will chair the Recovery Team.

When it is necessary, the Director of Nature Conservation will take issues to the NPNCA for approval.

### **Role of Technical Advisory Group**

The functions of the Technical Advisory Group include:

- supervising research and monitoring.
- supervising the collation and analysis of technical information concerning the Lake and catchment.
- advising the Recovery Team concerning technical matters.

The Technical Advisory Group will be chaired by CALM's Wheatbelt Regional Manager and is responsible to the Recovery Team.

Membership of both the Recovery Team and Technical Advisory Group are given at the front of the Plan.

**PART 2**

**RECOVERY ACTION PLAN**



**[This section of the Recovery Plan constitutes the original Recovery Plan for Toolibin Lake as  
Approved by the National Parks and Nature Conservation Authority in 1993]  
(Produced under ANPWS Endangered Species Program 1991/92)**

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## PREFACE

Numerous studies of the hydrology and biology of Lake Toolibin have been conducted during the past fifteen years and have shown an unequivocal trend in vegetation decline, with concomitant risk to very valuable waterbird breeding habitat. The causes of the decline are extensively documented and potential solutions have been variously recommended. However, the complexity of the hydrology within and surrounding Lake Toolibin has precluded a full understanding of the processes affecting the lake and delayed determination of appropriate management strategies.

A technical workshop was convened by the Department of Conservation and Land Management (CALM) on 3 September, 1992 to attempt to develop a common understanding among research and technical practitioners regarding environmental management actions necessary to protect and enhance the lake and surrounding reserves. The participants in the workshop included the principal scientists who have contributed to previous research of Lake Toolibin, members of the Lake Toolibin Catchment Group and relevant conservation managers.

The workshop was successful in achieving a broad consensus on the following critical issues pertaining to the management of Lake Toolibin and its surrounding reserves:

- the processes that have given rise to the current hydrological and salinity status of the lake and adjoining lands;
- anticipated future changes in the hydrology of the area that are relevant to the future ecological condition of Lake Toolibin;
- the critical and urgent need for management to save the lake from an otherwise inevitable further decline; and
- proposed management actions and their priority for implementation.

The proceedings of the workshop are presented in Appendix A.

This Recovery Plan for Lake Toolibin and its surrounding reserves is based upon the consensus from the workshop. It has been prepared for CALM under the Australian National Parks and Wildlife Service Endangered Species Program 1991/92.

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**Workshop Proceedings: Recovery Plan for Lake Toolibin and surrounding Nature Reserves.**

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## SUMMARY

### Current ecological status

Lake Toolibin has extremely high conservation significance as one of the last remaining inland freshwater lakes in the south-west of Australia. It is the only remaining example in south-western Australia of a wetland with extensive woodlands of *Casuarina obesa*, and provides an important breeding habitat for numerous and diverse waterbirds, including rare species. It is classified as a 'Wetland of International Significance' under the Ramsar convention.

Secondary salinisation due to catchment clearing has caused an unequivocal decline in the condition of vegetation within and adjacent to Lake Toolibin, with concomitant risk to the waterbird breeding habitat. A Recovery Workshop for Lake Toolibin, involving relevant research and technical practitioners, highlighted the critical and urgent need for management to save the lake from an otherwise inevitable further decline, and achieved a consensus of proposed management actions necessary to achieve its recovery. This Recovery Plan is based upon the consensus that was achieved at the workshop.

### Limiting Factors

The implementation of the Recovery Plan will require a major co-operative effort by Government Agencies and the landholding community. Because the salinity and waterlogging problems that affect Lake Toolibin also extend to agricultural land in the catchment, there is a strong community commitment to co-operate in land management. The principal limitation to implementation of the Recovery Plan is the cost: it is estimated that up to \$4.5 million over 10 years will be required to achieve the recovery objectives.

### Recovery Plan Objective

The recovery objective is to ensure the long-term maintenance of Lake Toolibin and its surrounding nature reserves as a healthy and resilient freshwater ecosystem, suitable for continued waterbird usage at current high levels.

### Recovery Criteria

Recovery will be achieved when the following criteria are met:

#### Biological Criteria:

1. No further deterioration is observed in the health of the vegetation of the lake or the reserves.
2. Successful tree and shrub regeneration in the lake and reserves is established in all vegetation associations.
3. Based upon available data, the lake supports sufficient species richness and numbers of invertebrates to assure waterbird food resources.
4. The numbers and species of waterbird visitation (41 species) and breeding success (24 species) that currently occurs is maintained or improved.

Physical criteria:

1. The minimum depth to the water table beneath Lake Toolibin and Toolibin Flats in spring, when the lake is dry, should be 1.5m.
2. The maximum salinity of lake water when the lake is full should be 1,000 mg/l Total Dissolved Salts (TDS).
3. The maximum salinity of inflow to the lake, measured at the Water Authority gauging station 609 009 on the Northern Arthur River, should be 1000 mg/l TDS during the winter months when the lake is full.
4. The lake bed dries periodically by evaporation, on average once every three years.
5. The levels of nutrients within Lake Toolibin should not cause excessive growths of algae or other aquatic plants, or cause deleterious reductions in dissolved oxygen concentrations in the water. Total phosphorus levels in the water should not to exceed 100mg/l unless long-term monitoring indicates that this criterion may be modified.

**Actions Needed**

The Recovery Plan involves an integrated strategy of short-term and ongoing measures at a local and catchment scale. The principal elements of the Recovery Plan are as follows:

1. Establishment of a Recovery Team and a Technical Advisory Group to ensure efficient and adaptive implementation of the Recovery Plan.
2. Watertable drawdown by staged groundwater pumping to ensure the drawdown of the saline water table beneath the lake and reserves in the short term. .
3. Surface water drainage of the Toolibin Flats to reduce saline inflows to the lake and reduce waterlogging.
4. Lake outlet control to improve flushing efficiency.
5. Enhancement of vegetation in the lake and its adjoining reserves through grazing control, planting, and fire management, to improve regeneration and maintain waterfowl habitats.
6. Revegetation in the catchment to establish and maintain a more favourable hydrological equilibrium for the Lake Toolibin catchment in the long-term. This will be achieved through land management planning, the promotion of fodder crops, the revegetation of salt affected land and the targeted but broadscale revegetation of groundwater recharge and discharge areas.

- 7 Agronomic manipulation to maximise soil water storage.
- 8 The development of a computer-based decision support system to enable the Lake Toolibin Recovery Team to consider all available information during the implementation and on-going management of the Recovery Plan.
- 9 Monitoring and reporting to provide input to the Decision Support System, to determine the effectiveness of the recovery actions and to facilitate ongoing adaptive management.

### Implementation Schedule

TASK	Costs \$000										Total	
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002		
1. Groundwater Pumping												
1.1 Groundwater Pumping - Stage 1		263	21	21	21	21	21	21	21	21	21	431
1.2 Groundwater Pumping - Stage 2			266	25	25	25	25	25	25	25	25	441
1.3. Groundwater Pumping under Reserves	15	237	27	27	27	27	27	27	27	27	27	468
2. Surface Water Control												
2.1 Surface Water Feasibility Study	50											50
2.2 Surface Water Design	50											50
2.3 Surface Water Implementation	100	100	100	42	42	42	42	42	42	42	42	594
3. Lake Outlet Control												
3.1 Feasibility Study	30											30
3.2 Lake Outlet Control Works	100	5	5	5	5	5	5	5	5	5	5	145
4. Lake and Reserve Revegetation												
4.1 Protection from grazing				8.5	0.2	0.2	0.2	0.2	0.2	0.2	0.2	9.7
4.2 Trial gilgai mounds Stage 1					3							3
4.3 Trial gilgai mounds Stage 2								3				3
4.4 Fire management				3	3	3	3	3	3	3	3	21
5. Catchment Revegetation												
5.1 Land Management Planning												
5.2 Revegetation of Deep Sands	37.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	195
5.3 Revegetation of salt affected land	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	195
5.4 EM survey of salt affected land	37.5	56										93.5
5.5 Alley-style revegetation of Toolibin Flats	80	80	80	80	80	80	80	80	80	80	80	800
5.6 Break of slope revegetation	10	10	10	10	10	10	10	10	10	10	10	100
6. Agronomic Manipulation												
6.1 Waterlogging control of uplands	20	20	20	20	20	20	20	20	20	20	20	200
6.2 Improved soil structure on Toolibin Flats		10										10
7. Decision Support System	30											30
8. Monitoring and Reporting												
8.1 Groundwater Monitoring	5	30	30	30	30	30	30	30	30	30	30	275
8.2 Surface Water Monitoring	10	10	30	30	30	30	30	30	30	30	30	260
8.3 Vegetation		6	6	6	6	6	6	6	6	6	6	54
8.4 Invertebrates	3					3					3	9
8.5 Waterbird counts	3					3					3	9
<b>Total</b>	<b>600.5</b>	<b>864</b>	<b>632</b>	<b>344.5</b>	<b>339.2</b>	<b>342.2</b>	<b>336.2</b>	<b>339.2</b>	<b>336.2</b>	<b>342.2</b>	<b>4476.2</b>	



## 1.0 INTRODUCTION

### 1.1 Conservation Significance of Lake Toolibin

Lake Toolibin has extremely high conservation significance as one of the last remaining inland freshwater lakes in the south-west of Australia. It is the only remaining example in south-western Australia of a wetland with extensive woodlands of living *Casuarina obesa*. This vegetation association was typical of the main types of inland fresh water wetlands in the south-west before clearing for agriculture resulted in most inland wetlands becoming saline, with the concomitant death of emergent vegetation.

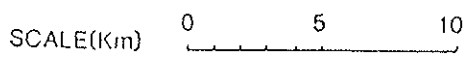
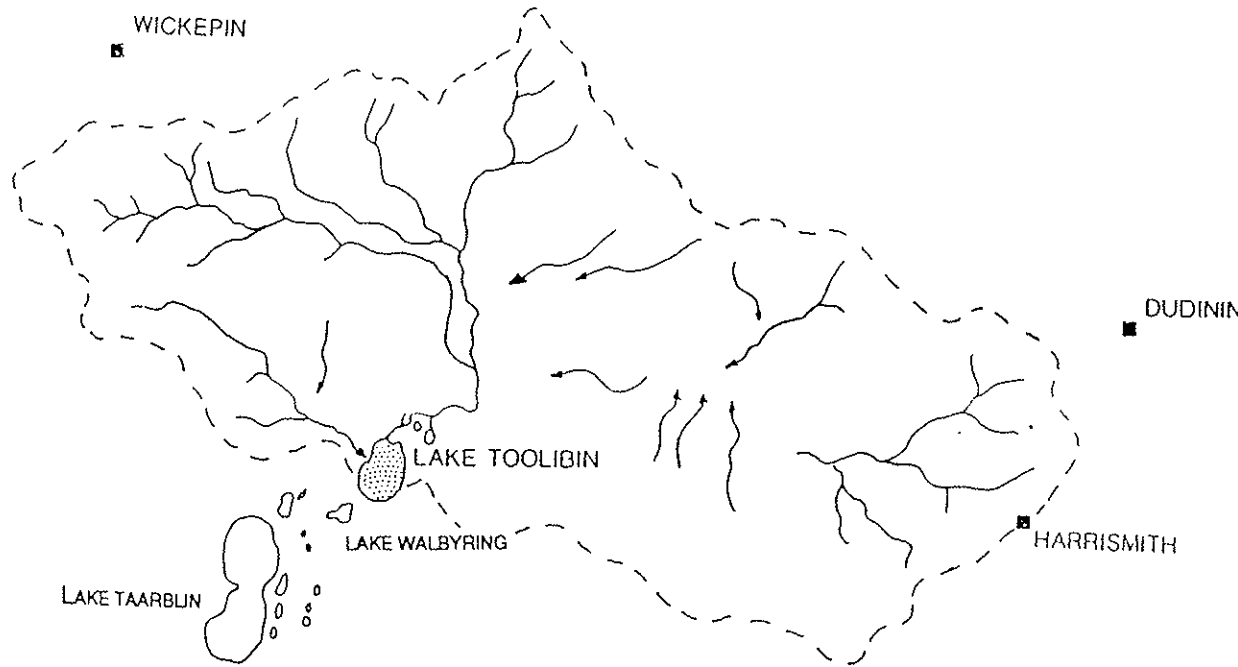
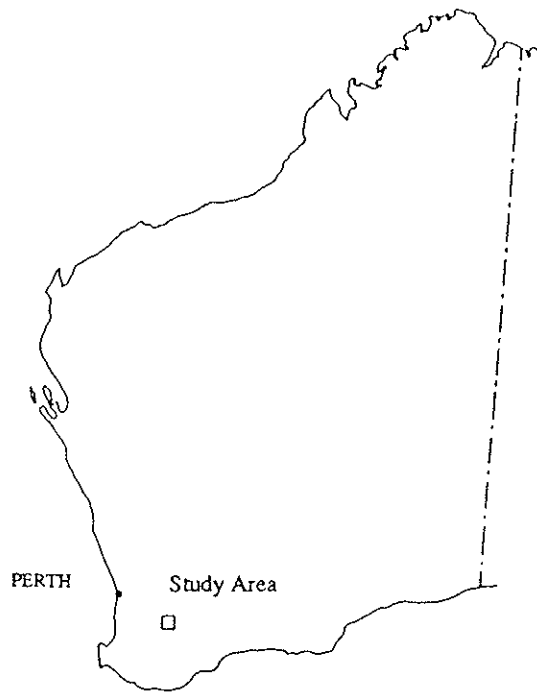
Lake Toolibin and its environs provide a vital breeding habitat for up to 24 species of waterbirds, including rare species such as the Freckled Duck. It has recorded the highest species richness of waterbirds, and supports more breeding species, than any other inland wetland in south-west Western Australia (Jaensch *et al*, 1988). It is classified as a "Wetland of International Importance" under the Ramsar convention.

### 1.2 Background

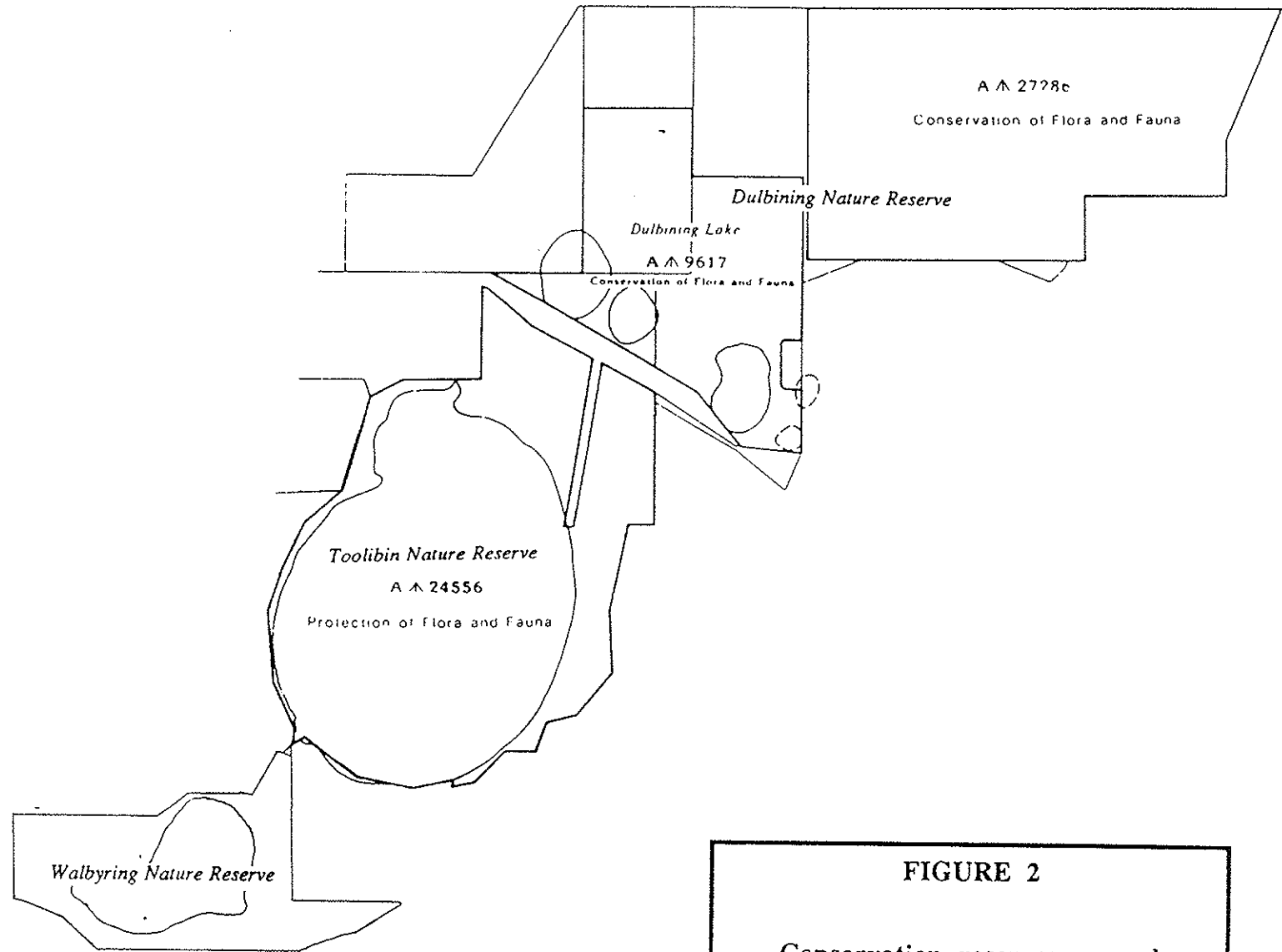
Lake Toolibin is situated approximately 200 km south-west of Perth at the head of the Northern Arthur River drainage system of the Upper Blackwood River catchment (Figure 1), and is the first in a series of nine lakes. Lake Toolibin is the only major lake in the chain which has not become saline.

The lake occurs in a low rainfall zone, with the average annual rainfall over its catchment (approximately 483km<sup>2</sup> in area) ranging from 370mm at the lake to approximately 420mm along the western divide. During dry years the lake may not fill, however during wet years the lake may be inundated continuously for several years.

The catchment has been mostly cleared for mixed grazing and cereal cropping. Only small stands of natural vegetation remain, and are limited to the more gravelly ridges or in the wetter parts of the valleys. Most of these remnant stands are now within various reserves managed by the Department of Conservation and Land Management (CALM). The remnant vegetation surrounding the lake, and within the reserves to the north-east of the lake (Dulbinning Nature Reserves 9617 and 27286) (Figure 2), are particularly significant to the survival of Lake Toolibin as valuable wildlife habitat.



**FIGURE 1**  
Location of Lake Toolibin and catchment



**FIGURE 2**  
**Conservation reserves around  
Lake Toolibin**

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Lake Toolibin was originally a perched freshwater wetland with a 15m deep water table. The salinity of the water in the lake has increased over the past three decades due to the catchment being affected by salinisation as a result of the clearing of native vegetation. The groundwater in the area is saline and the water table has risen to the lake bed. This has had a markedly detrimental effect on the vegetation of the lake and the surrounding reserves, the deterioration of which was first observed in the dry years of the late 1970's.

Following these observations, vegetation studies were initiated in 1977 with the aim of establishing base-line data for the long-term monitoring of the structure and health of the vegetation. Preliminary assessment indicated that stressed, unhealthy or dead trees were clearly associated with saline soils, particularly on the western bank of the lake (Mattiske, 1978). Further monitoring in 1982 and 1986 (Mattiske, 1982; 1986) showed evidence of a continual slow deterioration of the plant communities, particularly the *Casuarina obesa* - *Melaleuca spp* woodlands which dominate the low-lying areas of the lake.

Research conducted on the deteriorating vegetation has indicated that poor tree vigour and death is due to both increasing salinity and the antagonistic interaction with increased waterlogging of soils (Froend *et al.* 1987). Tree deaths from salinity stress are thought to be mainly caused by salting of surface soils due to the capillary rise of saline groundwater during dry periods. This exposes shallow roots to high soil osmotic potentials, particularly during low rainfall years when salt export from the system due to infiltration and lake overflow is minimal. Deep rooting vegetation that is exposed to increased soil salinity at depth is also affected.

At present, much of the healthy vegetation in the lake is located upon raised gilgai mounds, which are a series of subtle undulations up to 1.5m above the surrounding bed. These mounds provide an increased distance between the soil surface and the saline groundwater, which reduces capillary rise and soil salting. Seedling regeneration on the gilgai mounds is also enhanced due to less inundation than surrounding areas.

Further research of the vegetation in Lake Toolibin and its surrounds has suggested that seedling recruitment is impeded by herbivory (E.M. Mattiske pers. comm., 1992: Workshop Proceedings, Appendix A) to the extent that the growth of grazed seedlings on the lake floor is often too slow to enable them to reach sufficient height to withstand inundation. Poor seedling recruitment within some areas of the reserves is also thought to be exacerbated by the absence of fire.

Although considerable research has been conducted on Lake Toolibin, there is still uncertainty as to the detailed hydrology and why Lake Toolibin remains fresh. Given that soil profile salt storage is typical of the wheatbelt region of Western Australia, it appears that some hydrogeological anomaly must exist which has slowed the rate of rise of saline groundwater to the surface, thereby delaying the possible discharge of saline groundwater into the lake and the tributary streams.

In September 1992, Lake Toolibin filled and lake salinity reached 2,500mg/l, similar to inflow salinity. This is approximately double the lake salinity during overflow periods in 1983 and 1990. Any subsequent inflow this year will, in all probability, be of higher salinity than at present. Therefore, the lake may now have a salinity and salt load that is at least twice that of 1983 and 1990.

It is considered that an increase in the salinity of Lake Toolibin is inevitable under current circumstances, and that remedial action is urgent.

### **1.3 Major Processes Affecting Survival**

#### **1.3.1 Catchment Description**

The dominant landuse within the Lake Toolibin catchment is dryland agriculture to produce wool and cereal grain (wheat, barley and oats). Forty-one landholders have properties partially or completely within the catchment. By 1972, 91% of the total catchment area was cleared for agriculture. Reserves managed by CALM occupy only 3% of the catchment.

Waterlogging affects 5.5% of all agricultural land within the Lake Toolibin catchment (Wickepin Land Conservation District Registrar, 1990). In wetter years, the area affected by waterlogging is approximately 20% of the catchment. This is a major concern to the landholders: waterlogging reduces crop yields by approximately 30%. On the Toolibin Flats, where the cropping rotation is more intensive, waterlogging is more extensive.

Salinity is an increasing problem on the Toolibin Flats. Since clearing natural vegetation for agriculture, a high proportion of rainfall recharges saline groundwater aquifers. The effect of increased recharge is for groundwater levels to rise. When the watertable is less

than 1.5 meters below the ground surface, capillary rise leads to increasing concentration of soil salinity.

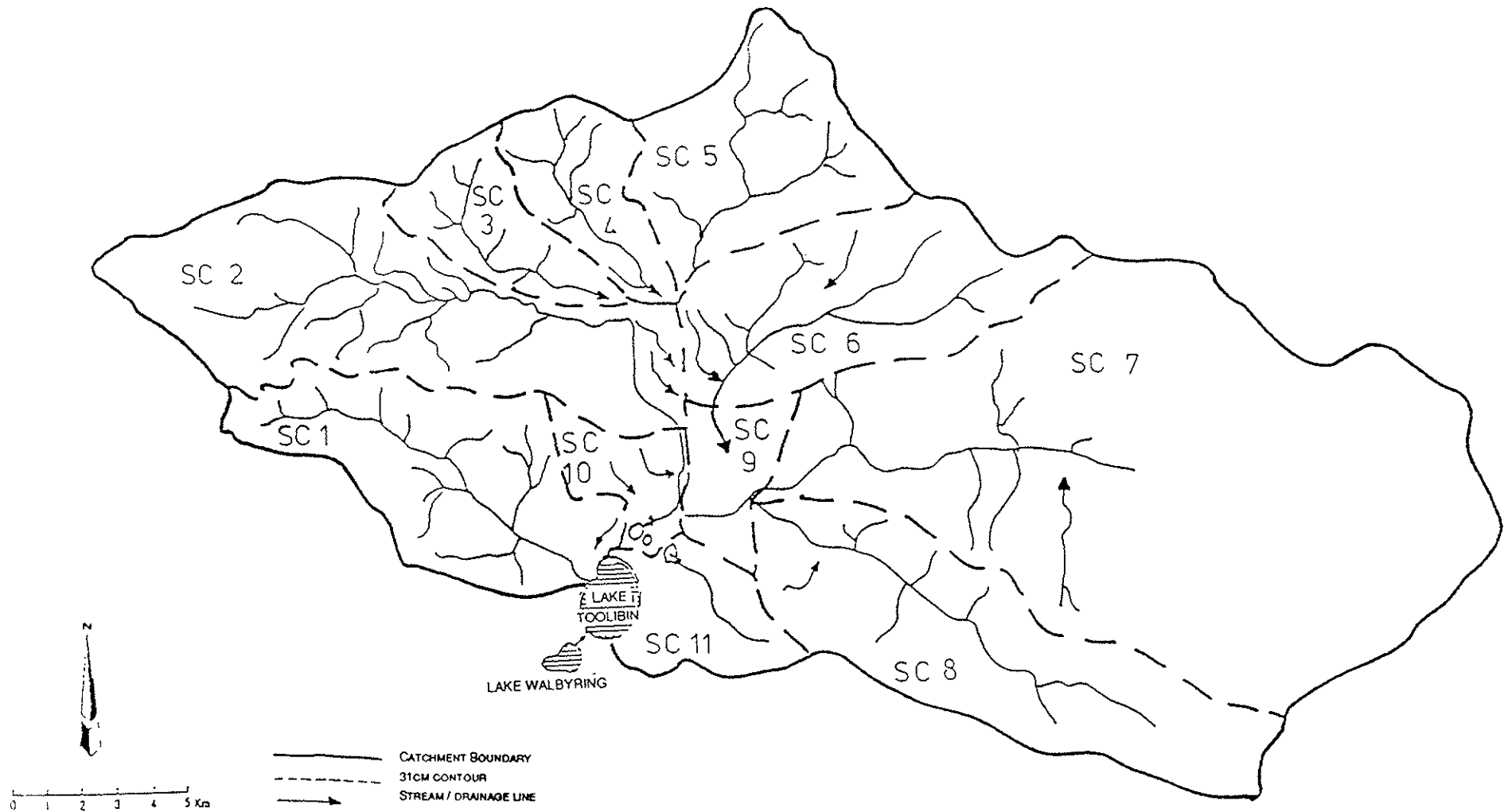
Groundwater recharge may occur in both the uplands and the Toolibin Flats (McFarlane, *et al.*, 1989). An estimate of 15 percent of total catchment recharge may occur through the Deep Sands of the uplands (Workshop Proceedings - Appendix A). At present, groundwater discharge (seeps) and streamflow from the uplands is generally fresh but may become more saline. It is unclear whether increasing groundwater in the uplands is a contributing cause to groundwater rise under Toolibin Flats. The conductivity of groundwater aquifers is probably quite low so the influence of upland groundwater on Toolibin Flats groundwater may be correspondingly low. However, catchment hydrology has not yet established a new equilibrium since clearing. Increased recharge to upland groundwater will significantly increase groundwater aquifers beneath the Toolibin Flats before this equilibrium is established. The period of time required for hydrological equilibrium to be established is not known.

Groundwater recharge beneath the Toolibin Flats is estimated to be 45 mm/yr (McFarlane *et al.*, 1989). This is equivalent to  $4.5 \times 10^2$  m<sup>3</sup>/ha recharge each year. The opportunity for groundwater recharge is greater when the soil profile is saturated (waterlogged) or surface water is ponded.

Eleven sub-catchments have been delineated within the Lake Toolibin catchment (Figure 3). The respective areas of each are shown in Table 1. The Toolibin Flats occupy more than 40 percent of the areas of sub-catchments 9,10 and 11, and more than 10 percent of the areas of sub-catchments 1,6 and 8. The other sub-catchments contain only small areas of Toolibin Flats.

Sub-catchments 9 and 10 have the highest proportion of salt-affected land (35% of all salt-affected land). Sub-catchment 6 has the greatest area of salt-affected land (29% of the total).

Observation wells established across the Toolibin Flats have shown that in most areas not yet salt-affected, the unconfined saline groundwater was 2.5 m or less below the surface (Hearn, 1988). This suggests that a substantial proportion of the flats may become salt-affected in the future. Sub-catchments 9 and 11 have saline streamflow (>6000 mg/l). Sub-catchments 1,7,8 and 10 have brackish streamflow (1200-6000 mg/l). Increasing



**FIGURE 3**

**Sub-catchments of the Lake Toolibin catchment**  
(adapted from unpub. report by Greenbase Consulting Pty Ltd, 1991)

soil and water salinity are reducing agricultural productivity, as well as threatening the Lake Toolibin ecological system. With reducing productivity, the potential to utilize soil and groundwater is correspondingly reduced in marginally affected areas.

**Table 1**

**The sub-catchment areas of Lake Toolibin**

Sub-Catchment Code	Area (ha)	Percentage of Catchment
SC - 1	4,415	9.1
SC - 2	6,913	14.3
SC - 3	1,675	3.5
SC - 4	1,822	3.8
SC - 5	3,388	7.0
SC - 6	4,318	8.9
SC - 7	16,528	34.2
SC - 8	5,740	11.9
SC - 9	1,088	2.3
SC - 10	977	2.0
SC - 11	1,437	3.0
<b>TOTAL</b>	<b>48,300</b>	<b>100</b>

**1.3.2 Hydrological Processes**

The main surface water inflow to the lake is from the north-east via the Northern Arthur River. Surface flow also enters the lake via the Northwest Creek. The surface inflow to the lake is gauged and Total Dissolved Salts (TDS) have been measured since the late 1970's. During this period, major inflow and lake filling occurred in 1983, 1990 and in 1992. Despite the apparent trend towards increasing salinity that is indicated by the vegetation decline, neither the inflow TDS data nor the occasional record of lake water TDS have indicated a sustained increase in salinities. However, measurement in September, 1992 of the inflow and lake water salinities of 2500mg/l, approximately



double the lake salinity during 1983 and 1990, provides a strong indication that the salt load in the lake may have substantially increased.

Water table elevation and piezometric head in monitored bores around the lake have not been recently measured and the current water table elevation is not reliably known. Saline shallow groundwater (0.3m below surface) was measured in Reserve 9617 along Brown Road in August, 1992 and warrants immediate monitoring of all available bores. Relatively fresh surface runoff subsequently occurred across Brown Road into the reserve. During prolonged inundation, waterlogging of vegetation may occur. In addition, recharge may occur despite the high water table. Freshening of groundwater in other shallow bores over the winter period has been observed. Given the low hydraulic conductivities, concentration of salts does not occur rapidly.

Groundwater discharge into the lake and increase in salt load is probably inevitable if the existing management continues.

### 1.3.3 Biological Processes

The current understanding of the vegetation of Lake Toolibin and surrounding reserves is summarized as follows:

#### **Lake Vegetation**

Lake Toolibin typifies the natural status of all of the lakes of the system. It is dominated by dense woodland and thickets of *Casuarina obesa* (sheoak), *Melaleuca spp* (paperbacks) and *Eucalyptus spp*, interspersed with small areas of open water. The immediate perimeter of Lake Toolibin is bordered by dense growth of *Casuarina* trees.

#### **Lake Toolibin Nature Reserve**

The vegetation surrounding Lake Toolibin consists of open woodlands as follows:

- *Eucalyptus loxophleba* (York Gum) occur on the higher ground north and east of Lake Toolibin and within Reserve 9617.
- Low open forest of *Banksia attenuata* - *B. prionotes* - *Allocasuarina huegeliana* occurs to the north-east of the lake, and into Reserve 9617.
- Woodlands of *Melaleuca strobophylla* (Paperbark)- *Casuarina obesa* (Sheoak) occur in all areas of the lake system.

- Open woodlands of *Eucalyptus rudis* (Flooded Gum ) with herbfield of *Wilsonia rotundifolia* occur in seasonally inundated areas.

#### Reserve 9617

The lakes to the area north of Toolibin contain the same perimeter and in-lake vegetation as Toolibin. The surrounding vegetation is on slightly higher ground and supports different communities. Pockets of open heath dominated by species of the families Proteaceae, Leguminosae and Myrtaceae occur to the south of Lake Dulbining. A halophytic complex composed of *Halosarcia indica* ssp. *bidens* and *H. lepidosperma* occurs to the west and the east of this reserve.

#### Reserve 27286

Reserve 27286 to the north-east of Lake Toolibin contains the following vegetation types:

- Open woodlands of *Eucalyptus salmonophloia* (Salmon Gum) with dense understorey of *Melaleuca* spp.
- Open woodlands of *E. salmonophloia* mixed with *E. wandoo* (Wandoo or White Gum).
- Closed scrub of *Melaleuca lateriflora*.
- Areas of dense *E. salmonophloia* regrowth.

#### Lower Catchment

Lakes Toolibin and Taarblin are 3.5 km apart and are connected by a system of creeks and smaller shallow lakes. The discharge stream from Lake Toolibin flows for a distance of 600 metres through an area of open woodland of *Casuarina obesa* and scattered *E. loxophleba* to Lake Walbyring. Lake Walbyring has a light covering of live and dead *Casuarina* and *Melaleuca* and is mostly covered with water. Downstream from Lake Walbyring the watercourse is less defined. A relatively deep stream flowing to Taarblin passes through agricultural land and through a delta of dense scrub.

#### Condition of Vegetation

The decline of vegetation is still occurring. Most young seedlings of *C. obesa* that were established on the surface of Lake Toolibin in the 1980's and again in the summer of 1991/1992 have now died, coincident with grazing by herbivores and extensive crusting of dead algae on the seedlings and the lake surface. The implications from this observation are that grazing has stunted seedling growth and that the seedlings have been

submerged within a eutrophic water column. Seedling mortality has probably been due to the combined effects of depletion of oxygen and direct smothering.

The health of the vegetation of Toolibin Nature Reserve, and Dulbining Nature Reserves 9617 and 27286 is critical for the conservation value and continued health of Lake Toolibin. These reserves are important for any interception of rainwater and evapotranspiration of groundwater. The reserves also act as a buffer zone for weed invasion.

The low open forest of *Banksia attenuata* - *B. prionotes* - *Allocasuarina huegeliana* to the north-east of the lake, and into the upstream Reserve 9617 contains many senescent trees of *Banksia* spp. Factors thought to be mainly responsible for the deterioration of this vegetation are:

- lack of seedling recruitment due to the absence of fire.
- lack of seedling recruitment due to herbivory.

At present, no information is available to ascertain the fire intensity or frequency required to manage these areas.

The health and vigour of vegetation associations in Reserve 27286 are deteriorating due to the following:

- *Melaleuca* sp. and *Acacia acuminata* associations. Saline seepage and drainage is thought to be responsible for unhealthy and dead *Melaleuca* and the lack of regeneration of the *Acacia*. Some regeneration of *Melaleuca* has been observed and this association appears to be stabilising.
- *E. salmonophloia* (Salmon Gum) woodlands. Extensive ring-barking in the past is responsible for considerable numbers of dead Salmon Gum trees, although stressed vegetation occurs in areas which experience surface run-off from upstream Toolibin Flats.

Woodlands of *E. loxophleba* - *Acacia acuminata* on the fringes of Lake Toolibin are declining. Areas of *E. salmonophloia* - *E. wandoo* - *E. loxophleba* woodlands in Reserve 9617 which support dense undergrowth and which are unburnt are declining. In contrast, areas that have been previously burnt show significant regrowth of *Eucalyptus*

and *Acacia* species, with the majority of trees having persisted and grown to 7-9 metres. The heath community has maintained vigorous growth over the years of monitoring.

#### **1.4 Prognosis**

The long-term viability of Lake Toolibin as a freshwater habitat is at high risk due to the inevitable salinisation of the catchment. At present, it is uncertain why Lake Toolibin has remained fresh, or for how long it may continue to do so. Recent data, although inconclusive, suggests that the salinity load into the lake may be increasing. The consensus among researchers on Lake Toolibin is that there is a high risk that this may occur rapidly and with catastrophic effects. Accordingly, recovery actions for Lake Toolibin are considered to be urgent.

Short-term actions applied to the recovery process are likely to be effective, provided that groundwater drawdown under the lake is implemented as soon as the lake is sufficiently dry to allow drilling rig access, and provided that the salinity of the surface water inflow into the lake does not increase rapidly. The implementation of groundwater drawdown pumping to lower the water table beneath the lake bed offers an opportunity to reduce salting of the lake surface and the continuing decline of the lake vegetation. Provided inflows to the lake remain fresh they assist by flushing the lake of salt and allowing downward 'leakage' of salt through the lake bed. The fresh water 'head' above the saline groundwater also prevents upward salt movement during the winter months. A rapid increase in the salinity of the surface inflow would overturn this system, possibly irreversibly.

In the long term, control of salinity relies upon management practices applied throughout the whole catchment, so requires the co-operation and active participation of the landholders. Because the salinity and waterlogging problems that affect Lake Toolibin also extend to agricultural land in the catchment, there is a strong incentive for, and an active desire by, the local landholders to co-operate in land management. The landholders in co-operation with the Department of Agriculture are currently preparing an overall Catchment Management Plan. This plan will investigate requirements for revegetation and possible opportunities to improve current agronomic practices.

At present, sufficient information and community initiative is available to commence the long-term recovery of the lake, and the limiting factor to recovery is the speed at which the recovery process is implemented. Additional information requirements can be acquired coincident with the implementation of the Recovery Plan, which can then be adapted on an ongoing basis.

### **1.5 Existing Conservation Measures**

The following measures have been undertaken by CALM:

- In 1977, 177 ha of partially cleared and chained private land in the Toolibin catchment was purchased and subsequently revegetated.
- Land along the eastern side of Lake Toolibin was also purchased in 1979 to conserve bushland critical to the protection of the lake.
- The Northern Arthur River Wetland Rehabilitation Committee (NARWRC) was established and has undertaken a large amount of work funded by constituent government agencies, which has provided essential knowledge concerning Lake Toolibin's environment and measures required to protect the lake. Many of the management actions proposed in this Recovery Plan are based upon NARWRC recommendations.
- In 1988, a 128 ha area of private land along the southern and western sides of the lake was purchased, and has been subsequently fenced.
- About 35,000 tree seedlings have been raised and planted into cleared land purchased in 1977 and 1988;
- Other management activities related to conserving the lake and its environs have included an experimental burn at one site, diversion of an interceptor bank, monitoring various environmental conditions, and obtaining an ANPWS grant to

assess the environmental impacts of proposed drainage systems from farmland to the north of the reserves.

- A test production bore has been constructed, pumped and monitored to investigate the feasibility of a borefield to de-water sediments and lower saline groundwater levels beneath the lake.
- An application has been made to the ANPWS for funding for a preliminary geophysical survey, the preparation of a de-watering borefield design, and the establishment of a second production bore.

The following measures have been undertaken by the Lake Toolibin catchment landholders:

- Wickepin Land Conservation District formed in 1984.
- Surface water drainage plans prepared for individual properties by the Western Australian Department of Agriculture (WADA) during 1985-1987.
- 'Toolibin Flats Project' initiated by WADA.
- 57,000 trees planted on saltland during 1985 to 1987, with a 40% survival rate.
- 30,000 trees planted on uplands during 1986 and 1987.
- Support from Greening Australia and Alcoa for tree planting.
- Formation of the Lake Toolibin Catchment Committee, with financial and technical assistance from Alcoa in 1989.
- More than 34,000 trees planted in 1990.
- Tagasaste establishment trials initiated in 1990.
- More than 51,000 trees planted in 1991.

- More than 20,000 trees planted in 1992.
- Tree survey to identify factors affecting survival.
- Waterlogging survey by landholders, with assistance from CSIRO.
- Woodlot trials (3 sites, with 2ha established on each site).

## 1.6 Strategy for Recovery

The strategy for recovery of Lake Toolibin requires the integration of management strategies at the whole catchment level with active management and rehabilitation of the lake and reserves. The major cause of deterioration of the lake is secondary salinisation and waterlogging associated with a rising saline groundwater table. To enable the lake to survive and recover requires this process to be reversed to return the system to one that is a closer reflection of the historical hydrological regime. This can only be achieved through appropriate action at the whole catchment level.

Deterioration of vegetation within Lake Toolibin and its surrounding reserves has been exacerbated by more local issues, such as high grazing pressure and insufficient active conservation management, which can be remedied wholly within CALM reserves.

### 1.6.1 Water Management

The two principal management goals for Lake Toolibin are to lower the saline groundwater table beneath the lake and its surrounding reserves and to prevent increasingly saline inflows from the catchment. Research suggests that the only short-term (<5 years) measure capable of achieving the first goal is by groundwater pumping. Groundwater extraction from the lake and the northern reserves is proposed, to reduce the saline water table to at least 1.5m below ground surface.

Surface water drainage for Toolibin Flats offers a potential means to indirectly increase transpiration by reducing waterlogging and thereby allowing increased agricultural

production. If it helps stop the Toolibin Flats from becoming more saline, surface water drainage may also offer an important means of controlling saline inflows to the lake. However uncertainties regarding the appropriate design of the drainage works and the possible implications of additional water input to Lake Toolibin attach significant risks to current drainage proposals. It is unlikely that the objectives for surface drainage can be achieved by a gravity drainage system alone. Moreover, it is reasonably foreseeable that drainage works may have a detrimental impact upon the lake, particularly if the drainage water becomes more saline in the future, or as a consequence of drainage construction.

Therefore the proposed strategy for surface drainage includes feasibility and design assessment prior to implementation, and strongly recommends against the construction of drainage through CALM reserves until feasibility and design have been ascertained.

The desire by local landholders to augment the surface water drainage from Toolibin Flats, and the possible risk to continuing community support for the Recovery Plan if there is an unreasonable delay in implementing a surface water drainage scheme, are acknowledged. It is recommended that the feasibility and design phases for surface water drainage be undertaken with utmost urgency, followed by immediate construction once feasibility is affirmed.

In the event that inordinant delays to the implementation of the Recovery Plan or other reasons result in a decision to allow construction of drainage prior to the completion of the recommended feasibility and design studies, then it is recommended that drainage works should only proceed subject to the following:

- CALM to have full authority to remove, block, divert or otherwise nullify any drainage to or within CALM reserves if CALM determines, on the basis of reasonable scientific evidence, that such drains may be causing adverse impact to Lake Toolibin or the reserves.
- A binding commitment from the affected landholder(s) to specified revegetation on their properties, consistent with the recommendations of the Recovery Plan.
- Prior to the commencement of construction, CALM in consultation with the Lake Toolibin Catchment Committee to establish definite strategies and criteria for the implementation, monitoring and contingent removal of any drainage works, acceptable to the National Parks and Nature Conservation Authority (NPNCA).



Revegetation of cleared land within the catchment is critical to the long term (>10 years) management of Lake Toolibin. Specific areas recommended for revegetation include the Toolibin Flats, the "break-of-slope" landform between the uplands and Toolibin Flats, and salt affected land. Cultivation of the fodder crop, Tagasaste, is also recommended through areas of deep sand soils. As an indication of the scale of revegetation required to maintain an hydrological equilibrium in the long term, it is estimated that at least 25% and possibly as much as 50% of the Toolibin Flats, together with all areas of Deep Sands and major drainage lines will need to be revegetated.

The desirability of increasing the drainage efficiency out of Lake Toolibin, to provide for increased salt export, is also recognised. Subject to an initial brief investigation to confirm its feasibility, outlet control is proposed as a high priority.

#### 1.6.2 Habitat Management

In addition to the revegetation proposals outlined in Section 1.6.1, recovery actions proposed to protect and enhance the habitat values within Lake Toolibin include protection of *Casuarina obesa* seedlings from grazing, construction and planting of gilgai mounds to enhance habitat and seedling survival, and appropriate fire management to enhance seedling recruitment.

#### 1.6.3 Agronomic Manipulation

Proposed actions by the Lake Toolibin Catchment Committee and landholders in consultation with the Department of Agriculture aimed to control waterlogging and improve the soil structure within the Toolibin Flats, are supported.

#### 1.6.4 Catchment Management

A Recovery Team and a Technical Advisory Group are proposed to be established to co-ordinate the Recovery Plan, and to implement recommended monitoring studies and adaptive management. A decision support system will be developed to assist the Recovery Team to apply and adapt the recovery strategy to assure timely and appropriate management of control measures, such as lake level control and groundwater pumping.

The Recovery Plan will initially extend for a ten year period from 1993 to 2002 inclusive. This time frame may need to be extended, depending mainly on the extent of revegetation that is determined to be necessary to assure the long term accomplishment of lake recovery.

## **2.0 RECOVERY OBJECTIVE AND CRITERIA**

### **2.1 Recovery Objective**

The objective of the Recovery Plan is to ensure the long-term maintenance of Lake Toolibin and its environs as a healthy and resilient freshwater ecosystem suitable for the continued visitation and breeding success by the presently high numbers and species of waterfowl.

### **2.2 Recovery Criteria**

The recovery criteria are the basis by which the success or failure of the total recovery process will be measured. They are not criteria for implementation of the individual management actions, but rather the long term criteria which should be met.

Recovery will be achieved when the following criteria are met:

#### **2.2.1 Biological Criteria**

1. No further deterioration is observed in the health of the vegetation of the lake or the reserves.
2. Successful tree and shrub regeneration in the lake and reserves is established in all vegetation associations.
3. Based upon available data, the lake supports sufficient species richness and numbers of invertebrates to assure waterbird food resources.
4. The numbers and species of waterbird visitation (41 species) and breeding success (24 species) that currently occurs is maintained or improved.

### 2.2.2 Physical criteria

1. The minimum depth to the water table beneath Lake Toolibin and Toolibin Flats in spring, when the lake is dry, should be 1.5m.
2. The maximum salinity of lake water when the lake is full should be 1,000 mg/l Total Dissolved Salts (TDS).
3. The maximum salinity of inflow to the lake measured at the Water Authority gauging station 609 009 on the Northern Arthur River should be 1000 mg/l TDS during the winter months when the lake is full.
4. The lake bed dries periodically by evaporation, on average once every three years.
5. The levels of nutrients within Lake Toolibin should not cause excessive growths of algae or other aquatic plants, or cause deleterious reductions in dissolved oxygen concentrations in the water. Total phosphorus levels in the water not to exceed 100mg/l unless long-term monitoring indicates that this criterion may be modified.

### **3.0 RECOVERY ACTIONS**

Recovery actions for Lake Toolibin are detailed in this section. All costs are calculated in 1992 dollars without allowance for future inflation. Administration costs are incorporated into individual funding items.

The Plan requires project personnel to be employed at various stages to undertake the research and monitoring phases outlined in some sections.

#### **3.1 Appointing the Recovery Team**

**Objective:**

Management of the Recovery Plan.

**Justification:**

To ensure implementation of the Recovery Plan, securing and allocation of funding, integration of expertise, assessment of monitoring and application to management directions, reporting of results.

**Description:**

A recovery team will be appointed to co-ordinate the implementation of this Recovery Plan. The team will comprise representatives from CALM, the Lake Toolibin Catchment Committee, the Western Australian Department of Agriculture, the Water Authority of Western Australia, ANPWS, and others who may be involved with implementing this plan. It is recommended that a Technical Advisory Group be set up as a sub-section of the recovery team in order to regularly review monitoring results, and to initiate actions indicated by a decision support system. The members of the Technical Advisory Group should consist of at least a project hydrologist, ecologist, and botanist, who will report to the recovery team when necessary. The recovery team will report annually to CALM's Corporate Executive on implementation of the plan.

**Priority:**

Essential

**Responsibility:**

CALM

**Estimated Cost:**

Costs required for non-government members of the Technical Advisory Group.

**3.2 Water table drawdown by groundwater pumping****3.2.1 Groundwater Pumping Stage 1** ✓**Objective**

To drawdown the saline, regional water table beneath salinised areas on the western shoreline of the lake to at least 1.5m below soil surface in spring, and thereby to prevent salinisation of the vegetation root zone.

**Justification**

Implementation of groundwater pumping Stage 1 beneath the lake (Martin 1990) is essential as this is the only action which will drawdown the saline water table beneath the salinised western shoreline of the lake in the short term.

**Description**

Stage 1 comprises the siting, drilling, construction, test pumping, equipping and commissioning of a sufficient number of production bores together with associated pumps and pipeline to meet the objective. Production bores are to be located within salinised areas of the lake bed at approximately 300m spacing and the estimated number of bores, in addition to the existing bore, is eight. The actual number of production bores required may be greater or less than eight depending on the results of test pumping each additional bore after it is completed. Based on and including the existing production bore the total pumping rate will be 180 m<sup>3</sup>/d, with each additional bore being pumped continuously at 20 m<sup>3</sup>/d.

The required bore depth is estimated to be 35 m, and bores are to be completed with 150 mm Class 6 UPVC, slotted from approximately 2m to total depth. To prevent downward movement of lake water, the annulus between the production casing and 195mm Class 6 UPVC surface casing is to be cement grouted.

Geophysical survey will be used to select the preferred sites for production bores, in order to maximise the recovery rate of saline groundwater from each bore.

Stage 1 includes all pumps, pipes and necessary fittings to discharge the pumped water to Lake Taarblin.

### Priority

Essential: At present (November 1992) the lake is full, with the water level at approximately 198mAHD. Therefore, current discharge of saline groundwater into the lake is probably minimal. In addition the costs associated with drilling under present conditions from a platform in the lake would at least double the total drilling contract price. However, as the lake bed dries by evaporation, Stage 1 groundwater pumping will become a high priority. The drilling program should therefore be deferred until the lake is dry (approximately 196.5mAHD). Assuming negligible inflow from now on, the earliest date that the lake will be dry and that Stage 1 can be commenced is anticipated to be January 1994.

If the status of lake and fringing vegetation deteriorates rapidly due to soil salinity prior to the lake drying, then production bores should be drilled at accessible sites around the lake perimeter, rather than waiting for the lake to dry. If the cone of drawdown from perimeter bores does not extend for a sufficient distance beneath the lake to completely protect the salinised areas, bores within the lake may be preferred. Cost estimates presented below are for implementation of a bore field within the dry lake bed.

### Responsibility

CALM

### Estimated Costs

Estimated Capital Costs (from Rockwater 1991) ✓

(i)	Geophysical Surveys (ground based)	\$4,350
(ii)	Production bore (8 bores @ \$4500)	\$36,000
(iii)	Monitor bores (20 bores @ \$1360)	\$27,200
(iv)	Supply and installation of pumps, tanks, pipeline etc. from bores to collection tank	\$36,900
(v)	Supply and installation of pumps, tanks, pipeline etc. from collection tank to Lake Taarblin	\$130,000
(vi)	Supervision and reporting	<u>\$28,120</u>
<b>TOTAL CAPITAL COST</b>		<b>\$262,570</b>

<u>Estimated Annual Cost:</u>	
(i) Maintenance (assumed 5% of capital cost)	\$13,000
(ii) Power (6 kW @ 15.5 c/kWH)	<u>\$8,100</u>
<b>TOTAL ANNUAL COST</b>	<b>\$21,100</b>

### Monitoring

Monitoring requirements are included in Section 3.9.1.

### 3.2.2 Groundwater Pumping Stage 2

*not applicable at this stage*

### Objective

To drawdown the saline regional water table beneath salinised areas of the lake bed (except along the western shoreline) to at least 1.5 m below soil surface in the spring.

### Justification

Implementation of groundwater pumping Stage 2 beneath the lake is essential as this is the only action which will drawdown the saline water table in the short term (Martin, 1990) and prevent salinisation of the vegetation root zone.

### Description

Stage 2 comprises the siting, drilling, construction, test pumping, equipping and commissioning of a sufficient number of production bores together with associated pumps and pipeline to meet the objective. Production bores are to be located within salinised areas of the lake bed at approximately 300 m spacing and the estimated number of bores is sixteen. The actual number of production bores required may be greater or less than sixteen depending on the results of test pumping each additional bore after it is completed. Based on the existing production bore, the total pumping rate will be 320 m<sup>3</sup>/d, with each bore being pumped continuously at 20 m<sup>3</sup>/d.

Bore depths and construction are as for Stage 1, described in Section 3.2.1.

Geophysical survey will be used to select preferred sites for production bores, in order to maximise the recovery rate of saline groundwater from each bore.

Stage 2 includes all pumps, pipes and necessary fittings to discharge the pumped water to Lake Taarblin.

**Priority**

Stage 2 groundwater pumping is medium priority. As for Stage 1, the drilling program should be deferred until the lake bed is dry, unless rapid deterioration of lake vegetation due to salting occurs .

**Responsibility**

CALM

**Estimated Cost**Estimated Capital Cost (Rockwater 1991):

(Note: Geophysical Survey included in Stage 1 cost estimate)

(i)	Production bores (16 bores @ \$4500)	\$72,000
(ii)	Monitor bores (40 bores @ \$1360)	\$54,400
(iii)	Supply and installation of pumps, tanks, pipeline etc. from bores to collection tank	\$73,800
(iv)	Supply and installation of pumps, tanks, pipeline etc. from collection tank to Lake Taarblin	\$10,000
(v)	Supervision and reporting	<u>\$56,000</u>
<b>TOTAL CAPITAL COST</b>		<b>\$266,200</b>

Estimated Annual Cost:

(i)	Maintenance (assumed 5% of capital cost)	\$13,300
(ii)	Power (9 kW @ 15.5 c/kWh)	<u>\$12,000</u>
<b>TOTAL ANNUAL COST</b>		<b>\$25,300</b>

**Monitoring**

Monitoring requirements are included in Section 3.9.1.

3.2.3 Groundwater Pumping under Reserves

*not applicable*

**Objective**

To drawdown the saline, regional water table beneath Reserves 27286 and 9617 to at least 1.5m below the soil surface in the spring to ensure that vegetation in these reserves does not decline rapidly by salinisation of the root zone.



### **Justification**

Implementation of groundwater pumping beneath the reserves is essential as this is the only action which will drawdown the saline water table in the short term and prevent salinisation of the vegetation root zone.

### **Description**

Groundwater pumping under the reserves comprises the siting, drilling, construction, test pumping, equipping and commissioning of a sufficient number of production bores together with associated pumps and pipeline to meet the objective. This includes an initial exploratory bore program to map the depth of the saline water table beneath the reserves, in order to quantify and monitor the problem.

Production bores are to be located within areas of the reserves where the depth to the spring water table is less than 2.0m. The present best estimate of the required number of bores is twenty.

The actual number of production bores required may be greater or less than twenty depending on the results of the monitor bore program and test pumping of each production bore after it is completed. Based on the existing production bore beneath the lake, the total pumping rate will be 400 m<sup>3</sup>/d, with each bore being pumped continuously at 20 m<sup>3</sup>/d.

Bore depths and construction are as for Stage 1, described above.

Geophysical survey will be used to select preferred sites for production bores, in order to maximise the recovery rate of saline groundwater from each bore. As vehicle access in the reserves is restricted, hand-held instruments will be used.

This program includes all pumps, pipes and necessary fittings to discharge the pumped water to Lake Taarblin.

### **Priority**

The groundwater pumping under the reserves is medium priority. Unlike groundwater pumping Stages 1 and 2, this program could be commenced immediately as sites are accessible even though Lake Toolibin is full. The initial exploratory bore program should therefore proceed immediately, results reviewed and the production bore program implemented if necessary.

**Responsibility**

CALM

**Estimated Cost**Estimated Capital Cost

(i)	Geophysical Surveys	\$5,000
(ii)	Exploratory bores (20 bores @ \$500)	\$10,000
(iii)	Production bores (20 bores @ \$4500)	\$90,000
(iv)	Monitor bores (20 bores @ \$1360)	\$27,200
(v)	Supply and installation of pumps, tanks, pipeline etc. from bores to collection tank	\$50,000
(vi)	Supply and installation of pumps, tanks, pipeline etc. from collection tank to Lake Taarblin	\$20,000
(vii)	Supervision and reporting	<u>\$50,000</u>
<b>TOTAL CAPITAL COST</b>		<b>\$252,200</b>

Estimated Annual Cost:

(i)	Maintenance (assumed 5% of capital cost)	\$12,600
(ii)	Power (11 kW @ 15.5 c/kWH)	<u>\$14,700</u>
<b>TOTAL ANNUAL COST</b>		<b>\$27,300</b>

**Monitoring**

Monitoring requirements are included in Section 3.9.1.

**3.3 Feasibility, Design and Implementation of Surface Water Control for Toolibin Flats****3.3.1 Feasibility Investigation of Surface Water Control****Objectives**

To determine the feasibility of a surface drainage scheme for Toolibin Flats, incorporating gravity drainage and pumping as necessary, which alleviates waterlogging of agricultural land and which prevents more saline surface runoff from entering Lake Toolibin.

## Justification

There have been several desk studies on proposals for improved surface drainage of the Toolibin Flats (McIntosh 1990, Negus 1990, GHD 1992, Greenbase 1992). However, while all reports agree that improved surface drainage would alleviate waterlogging and allow increased agricultural production (and therefore increased transpiration), none are based on adequate site investigation or survey to demonstrate the feasibility of the drainage systems proposed. This applies particularly to those drainage proposals which assume that drains can be excavated to carry saline surface runoff around Lake Toolibin to discharge further downstream. Those proposals which include pumping of saline surface drainage around the lake do not contain any cost estimates, nor do they indicate what proportion of the total salt load will be prevented from entering the lake.

This situation has arisen because no funding has been available for a detailed site investigation and assessment of the feasibility of surface drainage as a means of protecting Lake Toolibin from saline surface runoff. Rather, the emphasis has been on removing excess water from agricultural land, with the disposal of such water being of secondary concern.

Previous investigations have used measured salinity levels of different drains and creeks in 1990-91 (McIntosh 1990) as a basis for deciding whether surface drainage should be led into the lake or diverted downstream. The developing salinity problem with time and the fact that water quality in drains and creeks may rapidly deteriorate, appears not to have been addressed.

Given this lack of understanding of the potential for rapid increase in stream salinity, it is assumed that the Toolibin Flats are liable to become saline (Appendix A) and any runoff generated from the flats may become saline, possibly in the short term.

Toolibin Flats currently experiences extensive waterlogging and inundation during years of greater than average winter rainfall, resulting in lower than optimum agricultural yields. This means that transpiration rates are below optimum, leading to high potential recharge rates and increasing water table elevation (NARWRC 1987, McFarlane *et al.* 1989).

It is desirable that excess surface water should be removed from the Flats by improved surface drainage. However, before these drainage works can be implemented it is necessary to ensure that the net effect will be positive for Lake Toolibin.

The underlying concern is that increased surface runoff is already occurring into Lake Toolibin following agricultural clearing, and that surface drainage works will increase this further. There are no data showing that increased duration and depth of inundation of the lake is beneficial to the vegetation within the lake (GHD 1992).

### Description

The feasibility study will include survey to obtain 0.5m contours over a 20m width either side of proposed routes of gravity drains over both CALM Reserves and agricultural land. This topographic data will allow the gradient of proposed drains to be estimated and the earthworks involved to be quantified and costed. Drainage options to be included are those proposed by Negus (1991). Options which include the diversion of more saline surface runoff around Lake Toolibin will be given priority in the feasibility study.

Specifically, the following options should be subject to feasibility study, in order of priority:

- (i) Diversion of the saline north-west creek around the western side of Lake Toolibin.
- (ii) Diversion of the saline flow from catchments to the north-east of the lake around the eastern side of Lake Toolibin.
- X (iii) Diversion of the saline flow from catchments to the north-east of the lake around the eastern side of Lake Toolibin.
- (iv) Diversion of the Northern Arthur River around the western side of Lake Toolibin.

For all options, diversion is only required when water salinity exceeds a nominated threshold value. At other times flow into Lake Toolibin would be acceptable. The threshold value will need to be specified for each creek separately, as more saline water can be discharged into the lake if the total volume, and therefore the salt load, is low relative to the total salt load entering the lake.

A salinity criterion for surface water entering the lake after implementation of any such surface drainage scheme, based on the sampling of McIntosh (1990; 1992), should be established prior to the feasibility study. A tentative criterion is that the estimated average annual lake inflow salinity following implementation of a surface drainage scheme should

not exceed 1000 mg/l TDS. This value compares with 550 mg/l in 1983 and 1230 mg/l in 1981/82 (Stokes and Sheridan, 1985).

It is essential that the brief for this study specifies that drainage options are developed to the extent that typical drain dimensions are shown and costed in sufficient detail to allow comparisons to be made. Both capital cost and annual cost breakdowns will be presented.

It is also essential that estimates are made of the changes which would occur to inflow volume and salt load to Lake Toolibin if a drainage proposal were implemented.

### **Priority**

This surface water control feasibility study is urgent and essential, and should be completed immediately funding is available, preferably by 31 March, 1993.

### **Responsibility**

CALM, with the permission of landholders on Toolibin Flats.

### **Estimated Cost**

(i) Topographic survey	\$20,000
(ii) Feasibility study	<u>\$30,000</u>
<b>TOTAL</b>	<b>\$50,000</b>

### **Monitoring**

Not applicable.

## **3.3.2 Design of Surface Water Control Scheme**

### **Objective**

To design a surface drainage scheme for Toolibin Flats which alleviates waterlogging of agricultural land and which prevents more saline surface runoff from entering Lake Toolibin.

**Justification**

Justification for a feasibility study of surface drainage options is presented in Section 3.3.1. This design exercise is the logical next step, providing the feasibility of at least one drainage scheme is demonstrated.

**Description**

The design of a surface water drainage scheme will be commenced once feasibility has been established, as described in Section 3.3.1 above, and is approved by the NPNCA and the Environmental Protection Authority (EPA) if appropriate.

The design document will include drawings for gravity drains showing plans, and cross sections of open channel sections and drain diversion details together with long sections. For pumped drainage, drawings will show plans and long sections with pipes, pump and valve locations and hydraulic grade lines.

Design drawings should be of tender document standard and the design report should include preparation of contract documents for calling of tenders.

**Priority**

The design of a surface water drainage scheme is urgent and essential, and should be completed immediately feasibility is established and funding is available.

**Responsibility**

CALM, in liaison with affected landholders.

**Estimated Cost**

(assuming feasibility is demonstrated)

\$50,000

**Monitoring**

Not applicable.

### 3.3.3 Implementation of Surface Water Control

#### **Objective**

To implement a surface water control scheme, which has been subject to feasibility study and design, as described in sections 3.3.1 and 3.3.2 above.

#### **Justification**

Justification for a feasibility study of surface drainage options and subsequent design is presented in Sections 3.3.1 and 3.3.2. Assuming these two phases are successfully completed, implementation of the drainage scheme is required to alleviate water logging of agricultural land on Toolibin Flats and to allow some control of water quantity and quality entering Lake Toolibin.

#### **Description**

It is not possible to describe the works in detail until completion of the previous two stages. However it is likely that the surface drainage works will include the excavation of open channels, building of control gates, laying of pipes, installation of pumps and installation of power supply.

As an interim measure, and to reduce inundation and waterlogging of agricultural land, a flow path through reserves 27286 and 9617 should be created by clearing away all fallen debris over a width of approximately 50m. Given the lake's present full condition and the low salinity of ponded water, it is likely that lake salinity will be reduced rather than increased if this clearing was performed.

#### **Priority**

Implementation of the surface drainage works is urgent and essential, and should proceed once feasibility and design are complete. It is likely that most of the works program will be completed in the summer months due to difficult ground conditions in winter.

#### **Responsibility**

CALM, and landholders on Toolibin Flats.

## **Estimated Cost**

### Estimated Capital Cost:

In the range \$100,000 to \$500,000; \$300,000 assumed in the implementation schedule in Section 4.0.

## **Monitoring**

Monitoring requirements are included in Section 3.9.2.

## **3.4 Lake Outlet Control**

### **3.4.1 Feasibility Study**

#### **Objective**

To determine the possibility of temporarily increasing outlet flows from Lake Toolibin, Walbyring and Lake Taarblin by modification to the connecting channels.

#### **Justification**

Temporary increase of outlet flows from Lake Toolibin would allow more frequent flushing of accumulated salt in the lake, thereby reducing the lake salt load and limiting the maximum salinity reached as the lake dries by evaporation.

#### **Description**

The outlet level from Lake Toolibin is controlled by a high point on the overflow channel leading to Lake Walbyring. When both lakes are full, the Lake Toolibin outlet is controlled by the general water level gradient between the lakes. The overflow level from Lake Walbyring may at times be higher than from Lake Toolibin, depending on erosion and deposition in the connecting channels.

Therefore works on the overflow channel alone will only change the outflow from Lake Toolibin during times when Lake Walbyring is not causing a 'backwater'. Lake Walbyring is small relative to Lake Toolibin so that overflow from Toolibin rapidly fills Walbyring and the overflow channel from Lake Toolibin is then controlled by the outlet from Lake Walbyring, or further downstream.



It follows that outlet control for Lake Toolibin requires that Lake Walbyring, and possibly lakes further downstream, be analysed jointly. Relative levels between lake outlets have been established (Greenbase, 1992). A lake water management study is required to assist with design of enhancement options, and to derive operation rules for lake releases which will be derived in consultation with interested parties. This study is required prior to any works on the ground being implemented.

The study includes survey of the invert of connecting channels between the lakes, together with cross sections at approximately 200 m intervals and at changes in grade, and survey of all culverts, roads and railways. Relative levels will be determined (to AHD) and long sections plotted. Backwater modelling will be performed to allow water surface profiles to be calculated for various flow rates between the lakes. Options for altering the existing connecting channels and artificial features (roads, culverts etc) will be investigated and the effect of any proposed alteration will be illustrated by backwater modelling to show the effect on water surface profiles.

Operation of lake outlet control works will be subject to agreement of all interested parties with decisions made by a local operating committee comprising representatives of CALM and local landholders. The derivation of control rules to guide decision making will be part of the study and will require liaison with all interested parties as identified by CALM.

### Priority

This study has a high priority as it is low cost and is considered to have a high chance of a successful outcome in terms of an improvement in lake water quality.

### Responsibility

CALM.

### Estimated Cost

(i) Survey	\$5,000
(ii) Study	<u>\$25,000</u>
TOTAL	<b>\$30,000</b>

### Monitoring

Monitoring requirements are included in Section 3.9.2.

### 3.4.2 Lake Outlet Control Works

**Objective**

To implement works identified in the Lake Outlet Control Feasibility Study to temporarily increase outlet flows from Lake Toolibin, Walbyring and Lake Taarblin by modification to the connecting channels.

**Justification**

See Section 3.4.1 above.

**Description**

The works will be defined in the preceding study and will probably include earthworks to alter lake connecting channels and gated structures to control lake outflow rates.

**Priority**

This work has a high priority once the Lake Outlet Control Feasibility Study is complete.

**Estimated Cost**

In the range \$50,000 to \$150,000; \$100,000 used for the implementation schedule in Section 4.0.

**Monitoring**

Monitoring requirements are included in Section 3.9.2.

### 3.5 Enhancement of Lake and Reserve Vegetation

#### 3.5.1 Protection from grazing.

**Objectives:**

To protect seedlings from grazing

**Justification:**

Grazing of established seedlings of *Casuarina obesa* have been observed in the lake and reserves. It is thought that continuous grazing (as well as higher than normal lake levels) is responsible for the seedlings in the lake not reaching sufficient height to withstand

inundation. Rapid and vigorous regeneration of seedlings in the reserves will increase the transpiration potential and the overall health of the vegetation.

**Description:**

Rabbit control is currently being undertaken by baiting with 1080 by CALM, however the extent to which kangaroos are contributing to grazing is unknown. The establishment of temporary 'exclusion zones' by fencing around new seedlings following burning or other regeneration trials will occur in conjunction with monitoring, to establish the extent of this problem.

**Priority:**

Medium

**Responsibility:**

Fencing would be installed by contract under the supervision of CALM District staff. Regular inspections and maintenance will be required.

**Estimated Cost:**

Estimated Capital Costs

Electrical Fencing	@ cost/km	\$800
Power Source		\$500

Estimated Annual Cost

Maintenance Costs		\$200
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**Monitoring Requirements:**

Monitoring of seedling recruitment would occur in the exclusion zones and in comparable control plots as part of the on-going vegetation monitoring program. The results of monitoring will determine the management actions required.

3.5.2 Construction and planting of gilgai mounds

**Objective:**

To improve the probability of recruitment, survival and growth of seedlings, and the health of established trees in the lake bed.

**Justification:**

Most of the remaining healthy vegetation and successful regeneration in the lake is located upon raised gilgai mounds which are thought to provide an increased distance between the soil surface and the saline groundwater. Previous trials have demonstrated that tree establishment on mounds is more successful than without mounding (R. George pers. comm., 1992). If feasible, the construction and planting of artificial gilgai mounds would augment waterbird habitat and increase evapotranspiration.

**Description:**Stage 1:

Prior to establishing artificial mounds in Lake Toolibin, it has been recommended that feasibility trials be conducted elsewhere (Workshop Proceedings - Appendix A). Whilst Lake Walbyring was suggested as a suitable location, it has since been noted that Lake Walbyring is also a possible discharge zone for saline groundwater. Trial gilgai mounds will therefore be constructed in Lake Dulbining.

Seedlings of *Casuarina obesa* will be hand-planted on the gilgai mounds and in control plots adjacent to the mounds, in the autumn of 1993 after the first winter rains. Monitoring of their establishment should occur for three years prior to making any decisions on the success of the trial.

Stage 2:

Following a positive outcome of the above trials, artificial mounds will be constructed in Lake Toolibin, with a similar replanting program.

**Priority:**

Medium priority, increasing to high priority if the deterioration of Lake Toolibin vegetation accelerates.

**Responsibility:**

CALM

**Estimated Cost:**Stage 1:

Construction	\$2,000
Planting	<u>\$1,000</u>
TOTAL	<b>\$3,000</b>

<u>Stage 2:</u>	
Construction	\$2,000
Planting	<u>\$1,000</u>
TOTAL	<b>\$3,000</b>

### **Monitoring Requirements:**

#### Stage 1:

Monitoring plots will be constructed with sufficient replication and controls to permit sound statistical analysis of the success of the seedling recruitment and survival for implementation of Stage 2.

#### Stage 2:

Monitoring of seedling survival on any artificial mounds in Lake Toolibin will occur as part of the ongoing vegetation monitoring program.

### 3.5.3 Fire management

#### **Objectives:**

To initiate regeneration through the use of fire.

#### **Justification:**

Absence of fire has been suggested as one reason for the deterioration of the overall condition of some of the vegetation associations in the reserves, and it has been recommended that fire be used as a management tool for promoting seedling recruitment (NARWRC, 1978; Mattiske 1982, 1986). Preliminary trials by CALM and monitoring of other areas which have been burnt, indicate that controlled burning results in successful regeneration of some communities. It is considered that fire management is required urgently to regenerate some senescent vegetation communities (Workshop Proceedings - Appendix A).

The reluctance to instigate fire management practices in the past has been due to concerns regarding the initial loss of evapotranspiration capacity of the vegetation when burnt, and its associated effects on groundwater levels. With the implementation of groundwater pumping under Lake Toolibin, controlled fire management is less risky.

**Description:**

Fire management is not recommended for all communities, and trials will be required to establish the appropriate fire regime for each community. Information to date indicates that fire management will be successful in the mixed woodlands of *Eucalyptus loxophleba* (York Gum), *E. wandoo* and *Acacia acuminata* (Jam), and to some extent in the *Banksia* and *Allocasuarina* communities. Controlled burns only are not recommended for the *Eucalyptus salmonophloia* (Salmon Gum) communities, in which ashbed establishment and direct replanting techniques will be required.

**Priority:**

High priority following establishment of groundwater pumping.

**Responsibility:**

CALM

**Estimated Cost:**

Design of trials	<b>\$3,000</b>
Annual implementation of trials	<b>\$3,000</b>

**Monitoring Requirements:**

The regeneration success of vegetation in the trials will be monitored as part of the on-going vegetation monitoring program.

Additional attention to groundwater levels will be required following burning to assess the impacts of these management procedure on groundwater levels. Monitoring of groundwater levels will occur as part of the on-going bore monitoring program.

**3.6 Revegetation of Catchment**

Catchment revegetation is required to expedite the establishment of hydrological equilibrium for the Lake Toolibin catchment. Groundwater levels below the Toolibin Flats and the lake need to be lowered to reverse the processes of salinisation, and these conditions should be maintained in equilibrium. Increased utilization of soil moisture in potential recharge areas and groundwater in potential discharge areas is required.

Many initiatives previously undertaken or currently underway are consistent with the requirements for increased soil and groundwater use. The 'Toolibin Flats Project' and tree planting coordinated by the Lake Toolibin Catchment Committee with support from Alcoa Australia are examples. The Recovery Plan provides a set of tasks for catchment revegetation that are consistent with these initiatives.

The demonstration of treebelts at Boundain, 30 km west of Lake Toolibin provides an indication of the potential for revegetation. Adequate water-table drawdown is achieved with relatively low planting densities (Anon, 1991). Conditions on the Toolibin Flats that differ from the Boundain are the higher clay content of soils, and high groundwater salinity.

### 3.6.1 Land Management Planning

#### **Objective**

To complete individual property plans, integrated on a catchment basis, that provide the information required to locate, design and provide economic analysis for revegetation, drainage and agronomic management.

#### **Justification**

Planning is required to ensure revegetation is fully integrated within agricultural land management strategies (including soil management, crop and pasture management, stock management and drainage). Plans also encourage consistent implementation between properties.

#### **Description**

Land management plans for individual properties that are integrated on a sub-catchment basis are required. The plans are to identify natural resources and land management hazards for appropriate design and location of revegetation strategies. Development and evaluation of the plans should demonstrate the economic and environmental benefits of revegetation, drainage and improved soil and agronomic management.

#### **Priority**

Initial farm plans have been prepared for all properties by the W.A. Department of Agriculture. The planning process is being further developed with support from the

National Landcare Program (NLP). Planning should be completed for all properties with high priority.

The priority for planning in sub-catchments should be as follows:

SC-9, SC-10, SC-11, SC-8, SC-1, SC-7, SC-6, SC-2, SC-5, SC-4, SC-3  
(refer Figure 3)

### **Responsibility**

- (1) Lake Toolibin Catchment Committee
- (2) Landholders
- (3) W.A. Department of Agriculture (N.L.P. Project)

### **Estimated Cost**

Previous arrangement.

### **Monitoring**

A register of planning should be maintained.

## **3.6.2 Revegetation of Deep Sands**

### **Objective**

To minimize groundwater recharge through deep sands by the establishment of perennial fodder shrubs.

### **Justification**

An estimated 15 percent of annual catchment recharge may occur through the Deep Sands (Workshop Proceedings - Appendix A). Annual pastures are poor and utilize minimal soil water. Tagasaste (*Chamaecytisics palmensis*) is deep rooted and utilizes more water over a longer period. Economic returns justify establishment costs.

### **Description**

The full establishment of the fodder shrub Tagasaste on the estimated 2,000ha of Deep Sand is required. An economic evaluation of utilization of Tagasaste within an integrated farming system using an established demonstration farm is required. A short term project



engaging an extension officer to provide detailed site and economic evaluation for all suitable sites is required.

**Priority**

High priority

**Responsibility**

- (1) Lake Toolibin Catchment Committee
- (2) Landholders
- (3) W.A. Department of Agriculture

**Estimated Cost**

1750ha at \$100ha will cost \$175,000 (over 250ha previously established).  
NOTE - A low interest loan scheme may be considered.

The extension Program will cost approximately \$20,000

**Monitoring**

A register of establishment is required.

### 3.6.3 Revegetation of Salt-Affected Land

**Objective**

To minimize evaporation from surface soils and lower groundwater levels beneath salt-affected land.

**Justification**

Salt affected surface soil is the primary cause of increasing salinity of stream flow into Lake Toolibin. Vegetation will reduce surface evaporation and lower groundwater by evapotranspiration.

**Description**

Land identified on property plans as salt-affected should be fenced and established with salt-tolerant fodder shrubs in association with partial tree planting.

An electrical conductivity survey (EM38) of specific sites is required prior to revegetation. This will provide a guide to the establishment of suitable species. For example:

Sites with EC readings > 200 mSm<sup>+</sup>

- halophytic shrubs (*Altriplex spp.*, *Maireana brevifolia*)

Sites with EC readings 100-200 mSm<sup>+</sup>

- halophytic shrubs with partial plantings of trees (*Eucalyptus occidentalis*, *E. loxophleba*, *Casuarina obesa*, *Acacia saligna*)

Sites with EC readings < 100 mSm<sup>+</sup>

-partial planting with trees and shrubs (as above) with additional establishment of suitable pasture species.

**Priority**

Existing program to be extended and advanced with high priority.

**Responsibility & Involvement**

- (1) Lake Toolibin Catchment Committee
- (2) Landholders
- (3) W.A. Department of Agriculture

**Estimated Cost**

1300ha at \$150/ha will cost \$195,000 (approximately 200ha previously established)

**Monitoring**

A register of establishment should be maintained. Observation wells should be established at each site.

**3.6.4 Electrical Conductivity (EM) Survey of Potential Salt-Affected Land****Objective**

To provide a map of areas with high, medium and low soil profile salt storage.

**Justification**

The alluvial and colluvial soils of the Toolibin Flats have areas with varying potential to become salt-affected. The survival and productivity of trees is partially determined by soil salinity. Knowledge of the distribution of potential salinity on the Toolibin Flats will

enable the selection of suitable tree species and location of tree planting to maximize productivity and water use.

### **Description**

Ground or airborne survey of potentially salt-affected land to be undertaken in two stages.

#### Stage One

The area with slope less than 1 percent North of the Wickepin - Harrismith Road and South of the South Wogolin Road (estimated to be 3,000ha)

#### Stage Two

Other areas of the Toolibin Flats (approximately 14,000ha)

The survey should provide information for the top 5 metres of the soil profile. Existing ground survey equipment will provide this information. Airborne survey systems with similar capability are being developed.

### **Priority**

Stage One: High Priority

Stage Two: Medium Priority

### **Responsibility**

- (1) Department of Conservation and Land Management
- (2) Landholders
- (3) Lake Toolibin Catchment Committee

### **Estimated Cost**

#### Stage One

Air Survey (100m lines)	<b>\$8,000</b>
Ground survey (100m lines)	<b>\$37,500</b>

#### Stage Two

Air Survey	14,000ha @ \$4/ha	<b>\$56,000</b>
Ground survey	14,000ha @ 20/ha	<b>\$280,000</b>

### 3.6.5 Alley-Style Revegetation of Toolibin Flats

#### **Objective**

To maintain groundwater levels at least 1.5m below the ground surface of Toolibin Flats without loss of farm productivity.

#### **Justification**

Groundwater levels are 1.5m to 2.5m below the ground surface in marginally saline areas. Alley-style tree planting strategies have demonstrated that groundwater can be maintained below 2.0m. If this is not achieved, considerable areas of Toolibin Flats may become salt-affected causing increased salinity of streamflow and reduced agricultural production.

#### **Description**

Establish multiple row treebelts (width of approximately 15 metres) with an inter - row (width of 25-50 metres) for crop and pasture production. A stem density of 120/ha is suggested. The spacing and density of plantings should vary according to EM survey information and site specific groundwater evaluation.

Plantings are to be with species suitable for eucalyptus oil production (e.g. *Eucalyptus plenissima*, *E. kochii*, *E. loxophleba*, *E. polybractea*, *E. oleosa*). Final species selection should be made on the basis of soil profile information from EM survey.

CALM will establish a trial area of approximately 50ha to determine the most suitable species and planting design. A total of 4000ha should be established within 10 years. This is approximately 25 percent of the potentially salt affected area of Toolibin Flats. CALM will evaluate the economic feasibility of a cost-share agreement scheme with landholders.

#### **Priority**

The area of Toolibin Flats within sub-catchments 9 and 10 should be established with high priority.

#### **Responsibility**

- (1) Department of Conservation and Land Management.
- (2) Lake Toolibin Catchment Committee.

- (3) Landholders.
- (4) W.A. Department of Agriculture.

**Estimated Cost**

- 4000ha at \$200/ha will cost \$800,000 to establish.
- Annual maintenance costs to be determined by CALM.
- Returns following harvest to be determined by CALM.

**Monitoring**

- A register of establishment should be maintained.
- Regular monitoring of groundwater observation wells.

**3.6.6 Break-Of-Slope Revegetation****Objective**

To establish a broad belt of trees around the margin of the Toolibin Flats.

**Justification**

The break-of-slope between the uplands and the Toolibin Flats is of generally lower relief and has greater potential for groundwater discharge than adjacent areas.

**Description**

Establish trees in a series of co-ordinated belts or blocks in the break-of-slope landscape position. Priority, position and species selection should be determined by site-specific EM survey.

**Priority**

High priority.

**Responsibility**

- (1) Department of Conservation and Land Management
- (2) Lake Toolibin Catchment Committee
- (3) Landholders

**Estimated Cost**

Approximately 500ha at \$200/ha will cost \$100,000 to establish.

### **Monitoring**

- A register of tree planting should be maintained.
- Regular measures of groundwater observation wells.

## **3.7 Agronomic Manipulation**

### **3.7.1 Control of Waterlogging**

#### **Objective**

To increase the use of soil water by crops and pastures, by improving the soil drainage.

#### **Justification**

Waterlogged soils have increased potential for groundwater recharge. Crop and pasture productivity is reduced by waterlogging so water use potential is correspondingly reduced.

#### **Description**

Earth structures will be constructed to prevent inundation and waterlogging of the Toolibin Flats. These structures are to be co-ordinated with the catchment-scale surface water drainage requirements.

Interception drainage will be constructed for potentially waterlogged areas of duplex profile soils in the uplands. Drainage should be co-ordinated through established waterways to surface water drainage requirements on the Toolibin Flats.

The location and design of surface water and interception drainage is to be determined by property planning and subsequent field survey.

Extension of the economic benefits to be derived from waterlogging control is required.

#### **Priority**

Medium priority.

#### **Responsibility & Involvement**

- (1) Lake Toolibin Catchment Committee.
- (2) Landholders.
- (3) W.A. Department of Agriculture.

**Estimated Cost**

\$250-\$400 per kilometer of graded drainage (construction by grader)

**Monitoring**

- A register of earth structure construction to be maintained.
- Evaluation of satellite imagery for monitoring areas of waterlogging in association with CSIRO and/or the Western Australian Department of Land Administration (DOLA).

**3.7.2 Soil Structure Improvement on the Toolibin Flats****Objective**

To develop agricultural systems that improve soil structure.

**Justification**

Poor soil structure limits productivity (and hence water use) of crops and pastures. Rainfall infiltration rates will be increased with improved soil structure.

**Description**

Demonstration sites should be established that measure the effect on soil structure and productivity of combinations of the following agricultural system components:

- minimum tillage
- deep tillage
- stubble retention
- gypsum application
- increased nitrogenous fertilizer applications
- reduced stocking of saturated soils

**Priority**

Medium priority

**Responsibility**

- (1) Lake Toolibin Catchment Committee
- (2) Landholders
- (3) W.A. Department of Agriculture

**Estimated Cost**

Approximately \$10,000 for the costs of establishing and monitoring demonstration sites.

**Monitoring**

A register of the adoption of agricultural system components should be maintained.

**3.8 Development of a Decision Support System****Objective**

To develop a computer-based decision support system to enable the Lake Toolibin Recovery Team to consider all available information during implementation and on-going management of the Recovery Plan.

**Justification**

The combination of information required to make management decisions is complex. Managers of Lake Toolibin and the surrounding environment will be assisted by computer software that incorporates data from monitoring all parts of the environmental system with specific management objectives.

**Description**

A Decision Support System is to be developed for use by the Lake Toolibin Technical Advisory Group and technical staff to assist with ongoing management requirements. The system will incorporate the following components:

- Groundwater levels beneath Lake Toolibin
- Groundwater levels beneath Toolibin Flats
- Lake water levels in Lake Toolibin
- Lake inflow volume
- Lake inflow water quality
- Period of inundation

The Decision Support System will assist with management decisions upon the following issues:

- Installation of additional groundwater pumping bores.
- Temporary or permanent cessation of groundwater pumping.



- Diversion of surface water into, or away from Lake Toolibin.
- Increasing or decreasing outflow from Lake Toolibin.

**Priority**

High priority.

**Responsibility**

- (1) Department of Conservation and Land Management.
- (2) Lake Toolibin Technical Advisory Group (Recovery Team).

**Estimated Cost**

**\$30,000**

**3.9 Monitoring and Reporting**

Monitoring is required for several reasons, namely:

- The collection of baseline data. This is essential to enable an understanding of the health and condition of the system.
- To assess the effectiveness of the recovery actions implemented.
- The results of management actions which incorporate experimental trials are required for feedback into management decisions and the Decision Support System.

The development of a monitoring schedule will be required to prevent duplication of effort. It is of utmost importance that the results of the monitoring be analysed and interpreted in a timely manner to enable the appropriate response and adaptation of the Recovery Plan. It is recommended that this function be undertaken by a Technical Advisory Group set up as an adjunct to the Recovery Team. Overall monitoring requirements are listed below.

### 3.9.1 Groundwater monitoring

#### **Objective**

To monitor and report on groundwater data to allow efficient implementation of the Recovery Plan and to gauge the degree of success against the recovery criteria stated in Section 2.2.2.

#### **Justification**

Monitoring of groundwater is essential to provide information on the hydrological processes, to determine the degree of success of various recovery actions and to assess the need, and timing, for other recovery actions to be implemented.

#### **Description**

Monitoring of groundwater levels in all existing and future monitor bores in Lake Toolibin and reserves will be performed on a monthly basis. In addition, pumped volumes and water quality from production bores will be monitored monthly. A monthly report will be prepared on a calendar month basis and submitted to the Recovery Team by a fixed date each month to assist decision making.

#### **Priority**

High.

#### **Responsibility**

CALM.

#### **Estimated Cost**

Cost depends largely on the number of bores to be monitored, sampled and reported on. Monitoring of the existing bores is presently not funded and an allowance of \$5,000/year should be established immediately to cover the existing bores, increasing to approximately \$30,000/year when Groundwater Pumping Stages 1, 2 & 3 are implemented.

### 3.9.2 Surface Water monitoring

#### **Objective**

To monitor and report surface water data to allow efficient implementation of the Recovery Plan and to gauge the degree of success against the recovery criteria stated in Section 2.2.2.

#### **Justification**

Monitoring of surface water data is essential to provide information on the hydrological processes, to determine the degree of success of various recovery actions and to assess the need, and timing, for other recovery actions to be implemented.

#### **Description**

The Water Authority has agreed to support the continued operation of the Northern Arthur River gauging station (No. 610090). Apart from this, monitoring of surface water in all existing and future natural creeks and constructed drains in Lake Toolibin and reserves will be performed on a monthly basis. Monitoring will include flow rates measured by the velocity-area method using a current meter and E.C. A monthly report will be prepared on a calendar month basis and submitted to the Recovery Team by a fixed date each month to assist decision making. Nutrient analyses, particularly total phosphorus and total nitrogen, should be performed at least twice per year of Lake Toolibin water and of selected drains as necessary to determine possible nutrient sources.

#### **Priority**

Regular monitoring and reporting is a high priority.

#### **Responsibility**

Water Authority, CALM.

#### **Estimated Cost**

Cost depends to some extent on the number of locations to be sampled and reported on. Monitoring of the existing creeks and drains is presently performed by ALCOA. The present arrangement is estimated to cost \$10,000/year. An expanded monitoring program once a surface drainage scheme is implemented may cost \$30,000/year.

### 3.9.3 Vegetation

#### **Objective**

To monitor the condition of the vegetation of Lake Toolibin and surrounding reserves.

#### **Justification**

Monitoring of the health and status of the vegetation is required to determine the extent to which the Recovery Plan is succeeding, and to monitor the success of management actions for integration into the decision support system. This involves determining the rate of any further deterioration, the impacts of the groundwater pumping program, the success of the grazing management program, the success of germination and planted seedling establishment on the artificial mounds, and the results of the fire management trials.

#### **Description**

##### Overall vegetation condition

At present, general monitoring of vegetation occurs at four yearly intervals. With the indication that salinity levels may be rising after a period of stability and the risk of further deterioration of the vegetation, more intensive monitoring may be required at more regular intervals, depending upon the results of groundwater quality monitoring. Monitoring schedules will be decided by the Recovery Team.

##### Impacts of groundwater pumping

It is currently assumed that groundwater pumping underneath the lake and the reserves will be beneficial to the vegetation. It is not known, however, where *C. obesa* obtains water during dry spells, or whether groundwater pumping during the summer months will have a detrimental effect upon the vegetation. Regular monitoring of the vegetation condition upon the commencement of groundwater pumping will be required, particularly in the summer months, until the appropriate pumping periods are established.

##### Assessment of success of grazing management

Temporary electrical fences will be constructed around fire management trial areas. Monitoring of the success of the electrical fencing program to prevent herbivory will occur within the overall vegetation monitoring program.

Assessment of the success of regeneration trials

Monitoring of germination (if any) and the establishment success of handplanted seedlings on artificial gilgai mounds in Lake Dulbining will be required at yearly intervals for a minimum of three years.

Based on the results of the above, the recovery team will decide whether to implement the construction of gilgai mounds in Lake Toolibin.

Regeneration following fire management trials

Monitoring of fire management trials will be required on an yearly basis. Monitoring will include the success of seedling recruitment, the extent of herbivory and the occurrence of weed invasion. Weed control measures will be decided by the recovery team.

**Priority**

High.

**Responsibility**

CALM.

**Estimated Cost**

\$6,000/yr

**\$54,000**

**3.9.4 Invertebrate levels****Objective**

To assess the quality of the food resources (invertebrate species diversity and numbers) available to breeding waterbirds.

**Justification**

Invertebrate species and levels are important wetland components for breeding waterfowl. In addition, they are often sensitive indicators of water quality change. Although the recovery actions described above are considered to be sufficient for the recovery of Lake Toolibin, monitoring of invertebrate levels will be useful to indicate whether recovery criteria are met.

**Description**

An initial survey of invertebrate species diversity and levels in Lake Toolibin will be required for comparison with other wetland systems, and for the establishment of baseline data for recovery criteria. Monitoring is then recommended twice over the period of recovery, or more frequently depending upon the rate at which change is observed in the system (either deterioration or improvement).

**Priority**

Monitoring is essential to determine whether the lake is meeting recovery criteria. However, the priority is low relative to other tasks.

**Responsibility**

CALM.

**Estimated Cost**

Initial data collection and analysis		\$3,000
Monitoring at year 5 and year 10	@\$3,000/yr	\$6,000

## 3.9.5 Waterbird monitoring

**Objective**

To establish the numbers, species diversity and breeding success of waterbirds visiting Lake Toolibin.

**Justification**

A major reason for the establishment of a Recovery Plan for Lake Toolibin is its importance as a breeding area and habitat for waterbirds. Although it is currently assumed that the implementation of all recovery actions will enable preservation of the current habitat values of the lake, the ultimate measure of successful recovery will be the maintenance or improvement of waterbird use of the lake.

**Description**

Although sufficient baseline data are available by which to establish recovery criteria, a survey of the numbers, species and breeding success of waterbirds which visit and breed in the lake will be undertaken at Years 1, 5 and 10 during the recovery schedule.

**Priority**

High.

**Responsibility**

CALM.

**Estimated Cost**

Initial monitoring survey

**\$3,000**

Monitoring at years 5 and 10

@\$3,000/yr

**\$6,000**

#### 4.0 IMPLEMENTATION SCHEDULE

(\*Priority 1 = Essential; 2 = High; 3 = Medium)

(\*\*LH= landholders; WADA = Western Australian Department of Agriculture; LTCC = Lake Toolbin Catchment Committee; CALM=Department of Conservation and Land Management)

TASK	Priority*	Feasible	Responsible Party**	Costs \$000										Total
				1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	
1. Groundwater Pumping														
1.1 Groundwater Pumping - Stage 1	1	100%	CALM		263	21	21	21	21	21	21	21	21	431
1.2 Groundwater Pumping - Stage 2	3 <sup>a</sup>	100%	CALM			266	25	25	25	25	25	25	25	441
1.3. Groundwater Pumping under Reserves	3	100%	CALM	15	237	27	27	27	27	27	27	27	27	468
2. Surface Water Control														
2.1 Surface Water Feasibility Study	1	80%	CALM, LH	50										50
2.2 Surface Water Design	1	80%	CALM, LH	50										50
2.3 Surface Water Implementation	1	80%	CALM, LH	100	100	100	42	42	42	42	42	42	42	594
3. Lake Outlet Control														
3.1 Feasibility Study	2	80%	CALM	30										30
3.2 Lake Outlet Control Works	2	50%	CALM	100	5	5	5	5	5	5	5	5	5	145
4. Lake and Reserve Revegetation														
4.1 Protection from grazing	3	100%	CALM				8.5	.2	.2	.2	.2	.2	.2	9.7
4.2 Trial gilgai mounds Stage 1	2	100%	CALM					3						3
4.3 Trial gilgai mounds Stage 2	3	100%	CALM								3			3
4.4 Fire management	2	100%	CALM				3	3	3	3	3	3	3	21
5. Catchment Revegetation														
5.1 Land Management Planning	2	100%	LH, WADA, LTCC											
5.2 Revegetation of Deep Sands	2	100%	LH, WADA, LTCC	37.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	17.5	195
5.3 Revegetation of salt affected land	3	100%	LH, WADA, LTCC	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	19.5	195
5.4 EM survey of salt affected land	2	100%	LH, WADA, LTCC	37.5	56									93.5
5.5 Alley-style revegetation of Toolbin Flats	2	80%	LH, WADA, LTCC, CALM	80	80	80	80	80	80	80	80	80	80	800
5.6 Break of slope revegetation	2	100%	LH, WADA, LTCC	10	10	10	10	10	10	10	10	10	10	100

a) Stage 1 and 2 Groundwater Pumping cannot be implemented until Lake Toolbin dries (see Sections 3.2.1 and 3.2.2)



TASK	Priority	Feasible	Responsible Party	Costs \$000										Total	
				1993	1994	1995	1996	1997	1998	1999	2000	2001	2002		
6. Agronomic Manipulation															
6.1 Waterlogging control of uplands	2	80%	LH, LTCC	20	20	20	20	20	20	20	20	20	20	20	200
6.2 Improved soil structure on Toolbln Flats	3	100%	LH, WADA, LTCC		10										10
7. Decision Support System	2	100%	CALM	30											30
8. Monitoring and Reporting															
8.1 Groundwater Monitoring	2	100%	CALM	5	30	30	30	30	30	30	30	30	30	30	275
8.2 Surface Water Monitoring	2	100%	CALM	10	10	30	30	30	30	30	30	30	30	30	260
8.3 Vegetation	2	100%	CALM		6	6	6	6	6	6	6	6	6	6	56
8.4 Invertebrates	3	100%	CALM	3						3				3	9
8.5 Waterbird counts	3	100%	CALM	3						3				3	9
<b>Total</b>				600.5	864	632	344.5	339.2	342.2	336.2	339.2	336.2	342.2	4476.2	

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**APPENDIX A**

**WORKSHOP PROCEEDINGS**

**Recovery Plan for Lake Toolibin  
and surrounding Nature Reserves**

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WORKSHOP PROCEEDINGS

RECOVERY PLAN FOR LAKE TOOLIBIN  
AND SURROUNDING NATURE RESERVES

SEPTEMBER 1992

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NOTE: SINCE THE WORKSHOP, LAKE TOOLIBIN HAS FILLED AND LAKE SALINITY IN SEPTEMBER 1992 HAS REACHED 2,500MG/L, SIMILAR TO INFLOW SALINITY. THIS IS APPROXIMATELY DOUBLE THE LAKE SALINITY DURING THE OVERFLOW PERIOD IN 1983 AND 1990.

## 1.0 INTRODUCTION

### 1.1 Historical Background

Lake Toolibin has extremely high conservation significance as a habitat for native waterbirds and is a registered "Wetland of International Importance" under the Ramsar Convention. The status of the lake as one of the few remaining inland, freshwater lakes with a healthy emergent vegetation is now threatened by secondary salinisation. The loss or damage to the structure and function of the natural aquatic ecosystem of the lake has serious implications to the maintenance of a diverse waterbird population in the inland areas of the South West.

Numerous studies of the hydrology and vegetation of Lake Toolibin have been conducted during the past fifteen years, and have shown an unequivocal trend of vegetation decline, with concomitant risk to waterbird breeding habitat. The causes of this decline are extensively documented and potential solutions have been variously recommended. These have been summarised by the Northern Arthur Rivers Rehabilitation Committee in 1987, which put forward recommendations on lake and reserve management, some of which have since been adopted and implemented.

An active Catchment Management Committee has been established to tackle the land management issues in the catchment. Particular concern is focussed on waterlogging and inundation of agricultural land of low elevation around the lake, and the potential for development of secondary salinity.

The Department of Conservation and Land Management (CALM) has considered the environmental impact on the lake of improved drainage of agricultural land into the lake and the impact of a proposed groundwater pumping scheme using bores within the lake.

### 1.2 Recovery Plan Objectives

Bowman Bishaw Gorham, Jim Davies & Associates and Rural Planning have been commissioned by CALM to prepare a detailed Recovery Plan for the protection and rehabilitation of Lake Toolibin and its environment as a freshwater ecosystem. Protection and rehabilitation of the lake ecosystem also requires detailed consideration of requirements for protection and rehabilitation of the total catchment management.

### 1.3 Workshop Objectives

A technical workshop was convened by CALM on 3 September 1992 to develop a common understanding among research and technical practitioners regarding the physical and ecological processes affecting Lake Toolibin. The specific objectives of the Workshop were to obtain consensus on:

- the processes that have given rise to the current hydrological and salinity status of Lake Toolibin and adjoining lands;
- anticipated future changes in the hydrology of the area that are relevant to the future ecological condition of Lake Toolibin; and
- proposed management actions and their priority for implementation.

The Workshop was conducted at CALM's Headquarters in Como, Perth. A list of Workshop participants is presented in Appendix A.

### 1.4 Workshop Description

The Workshop was facilitated by Mr Viv Read (Rural Planning) and initiated with presentations by, Mr Jim Davies (Jim Davies & Associates), Mr Michael Elliott (Western Australian Department of Agriculture) and Ms Beverley Walker (Bowman Bishaw Gorham), to describe the physical and biological processes affecting the Lake Toolibin Reserve and particularly the lake itself. The presentations were followed by group discussion which aimed towards reaching consensus on the causes of biological deterioration, the extent to which the hydrology of the lake has changed, and "why" and "how" Lake Toolibin has survived as a relatively freshwater lake given the demise of all other large wheatbelt lakes.

Following the morning session, the Workshop participants met in specialist groups which were asked to consider and address predefined issues that were relevant to their areas of expertise. These issues were related to the development of management options for the lake, its environs, and the Toolibin catchment, in the context of the Recovery Plan objective of retaining the lake as a freshwater waterbird habitat consistent with the Ramsar Classification.



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At the end of the group session the Workshop reconvened, and Dr. Don McFarlane and Dr. Elizabeth Mattiske, both of whom have conducted extensive research on lake and catchment hydrology and vegetation respectively, presented their summary views

The Workshop then concluded with a plenary session in which the outcomes of the day were summarised.

### **1.5 Format of Proceedings**

The Proceedings generally reflect the chronological order of the Workshop itself. The format followed is that comments made during discussion sessions are reported but not attributed to individuals. Proceedings were tape recorded by Mary Taylor of the Lake Toolbin Catchment Group.

## 2.0 HYDROLOGICAL PROCESSES

### 2.1 Description

The catchment to Lake Toolibin is about 483km<sup>2</sup> in area. The average annual rainfall over the catchment ranges from about 370mm at the lake to about 420mm along the Western Divide. The lake lies at the head of a chain of lakes forming the headwaters of the Arthur River. The lake chain occupies a broad flat valley which has been infilled with fluvial and aeolian deposits, on which the playa lakes and associated dunes have developed.

Lake Toolibin is the last remaining freshwater lake in the West Australian wheatbelt with a *Casuarina/Melaleuca* sp. vegetation association. In other similar lakes, these communities have died as a result of saline groundwater rising to the near-surface root zone.

The regional water table beneath the lake was at a depth of about 15m during the early part of this century, but has since risen to the lake bed in response to increased recharge following catchment clearing for agriculture.

Hydrogeological investigation between 1987 and 1990 was confined to the western side of the lake. Downward head and recharge have been measured on several dates but upward heads and discharge, although expected, have not been measured. Readings of bores on the western side of the lake in August 1992 show that the water table is at approximately 297m AHD, or 1m above the lake bed. The lake may now be part of a groundwater discharge zone.

Groundwater discharge appears, on the basis of available data, to occur in lakes Walbyring and Taarblin further downstream.

Recharge occurs throughout the catchment but inundation of the Flats, particularly in wet years, together with proximity to the lake probably means that the Flats contribute most to catchment recharge which has affected the lake vegetation so far. Groundwater flow direction is dominantly vertical rather than horizontal.

The main surface water inflow to the lake is from the north-east via the Northern Arthur River. Surface flow also enters the lake via the Northwest Creek which has a catchment of 41km<sup>2</sup>. The surface inflow is gauged and measurements of total dissolved solids are available since the late 1970's. During this period major inflow and lake filling occurred in 1983, 1990 and in 1992. These data do not indicate any sustained increase in inflow salinity. In addition, the available data on salinity of the lake water do not show any marked change over the period of record.

Both of these findings are contrary to the regional picture, as depicted by the stream flow gauging station network maintained by the Water Authority and as observed from inspection of catchments in the wheatbelt. The mystery of the uniqueness of fresh water in Lake Toolibin to the present time remains unsolved. Given that soil profile salt storage is typical of the wheatbelt, it appears that some hydrogeological anomaly exists which has slowed the rate of rise of saline groundwater to the surface thereby delaying the possible discharge of saline groundwater both into the lake and into the tributary streams.

### 2.2 Discussion

In subsequent discussion the following statements were agreed to:

- LAKE TOOLIBIN WAS ORIGINALLY A PERCHED FRESHWATER WETLAND WITH A DEEP WATER TABLE.
- CATCHMENT CLEARING GENERALLY RESULTS IN:
  - (i) INCREASED RECHARGE
  - (ii) RISING SALINE WATER TABLE
  - (iii) INCREASED SURFACE RUNOFF
  - (iv) INCREASED SALINITY OF SURFACE RUNOFF
  - (v) REDUCED DISCHARGE BY TRANSPIRATION

We only have evidence of (i), (ii) and (iii) for Lake Toolibin, but have no reason to doubt that (iv) and (v) also apply.

- LAKE INFLOW IS ANOMALOUSLY LOW IN SALINITY COMPARED WITH ALL OTHER GAUGED CATCHMENTS IN THE WHEATBELT.
- LAKE SALT LOAD IS APPROX. 4000 TONNES AND THERE IS NO EVIDENCE OF INCREASE OVER THE PERIOD OF DATA (1981-92).
- LAKE INFLOW SALINITY HAS NOT INCREASED OVER THE PERIOD OF DATA (1981-92).
- THERE IS NO EVIDENCE OF LAKE SALT LOAD INCREASING DUE TO GROUNDWATER DISCHARGE THROUGH THE LAKE BED.

The following statements were not agreed to:

- THERE HAS BEEN MINIMAL LEACHING OF SALT DOWNWARDS THROUGH THE LAKE BED OVER THE PERIOD OF DATA (1981-92).

Workshop Comments: Data are not available on which to base this statement.

- THE SALINE WATER TABLE IS NOW WITHIN 1 METRE OF THE LAKE BED (296 M AHD).

Workshop Comments: Data on water table elevation and piezometric head in monitor bores around the lake has not been collected continuously since 1990. Hence the current water table elevation is not known reliably. The casual measurement of saline shallow groundwater (0.3m below surface) in Dulbining Reserve along Brown Road in August 1992 needs to be confirmed by systematic monitoring of all available bores holes. Relatively fresh surface shallow sheet runoff subsequently occurred across Brown Road into the Reserve. During prolonged inundation, waterlogging of vegetation occurs. In addition, recharge occurs despite the high water table. Freshening of groundwater in other shallow bores over the winter period has been observed.

The apparent contradiction of downward heads and developing salinity in the measurements taken during the 1980's has still not been resolved.

Vegetation decline must not be seen only in terms of salinity, but in terms of waterlogging/salinity interaction and the broader issue of active management needs of Reserves.

- GROUNDWATER DISCHARGE INTO THE LAKE AND INCREASE IN SALT LOAD IS INEVITABLE IF THE EXISTING MANAGEMENT CONTINUES.

Workshop Comments: Although this prognosis may be correct, there is a possibility that the lake salt load may have stabilised.

### 3.0 BIOLOGICAL PROCESSES

#### 3.1 Description

Lake Toolibin is situated at the head of the Northern Arthur River Drainage System of the Upper Blackwood River catchment and is the first in a series of nine lakes, namely; Toolibin, Walbyring, Taarblin, Ibis, Billy, Bokan, Nomans, Lukin and White Lakes.

At present the lakes are surrounded by cleared agricultural land, with only small stands of natural vegetation remaining on the more gravelly ridges or in the wetter parts of the valleys. The NARWRC considers the most significant of these for the current survival of Lake Toolibin as a viable habitat for wildlife is the vegetation in and to the north-east of the lake (Dulbin Lake Reserve and Reserve 27286).

##### 3.1.1 Importance of Lake Toolibin

Of the 197 wetlands surveyed by the Royal Australasian Ornithological Union (RAOU) from 1981-1985, the only significant breeding areas are those wetlands with fresh to brackish water. Those with salinities less than 3.0 ppt TDS contain the greatest diversity of breeding species, while significant decline in breeding species occurs when salinities approach 10.0 ppt. (Jaensch *et al*, 1988).

As one of the few remaining freshwater inland lakes in Western Australia, Lake Toolibin is an important breeding area for a wide range of waterbirds, including some rare species such as the Freckled Duck and supports more breeding species than any other wetland in south-west Western Australia. (Jaensch *et al*, 1988). As such, it is classified as a wetland of international importance under the criteria of the Ramsar convention.

##### 3.1.2 Vegetation of Lake Toolibin

The vegetation in and around Lake Toolibin was reported to be healthy up until 1975. Reeds (possibly *Juncus pallidus*) were observed in the SE fringe of the lake, and in association with a light density of young *Casuarina* seedlings over the shallow marginal centre of the wetland (Munro 1975). Deterioration of the vegetation was first observed during the dry years of the late 1970's.

Vegetation studies were initiated in 1977 with the aim to establish base-line data for the long-term monitoring of the structure and health of the vegetation. Preliminary assessment indicated that stressed, unhealthy or dead trees were clearly associated with saline soils, particularly on the western bank of the Lake (Mattiske, 1978). Further monitoring in 1982 and 1986 (Mattiske, 1982, 1986) showed evidence of a continual slow deterioration of the plant communities, particularly the *Casuarina obesa* - *Melaleuca spp* woodlands which dominate the low-lying areas of the Lake, due to saline conditions.

However, waterlogging due to increased runoff was also considered to be a possible factor in the deterioration of the vegetation. This is particularly so in light of the situation at Lake Taarblin, in which vegetation death occurred following inundation by high rainfalls in 1929.

Information on the waterlogging tolerances of Australian vegetation indicates the following:

- Only a small percentage of Australian trees can occur in areas subjected to prolonged waterlogging
- Species of *Melaleucas* and *Casuarinas* are among the few which can be grouped as occurring naturally on sites of extended waterlogging
- *E.rudis* occurs in periodically waterlogged areas
- Waterlogging tolerance can be severely reduced in the presence of saline soils.

A further study to relate the vigour of major tree species to soil salinity and waterlogging was conducted in 1987 (Froend *et al*, 1987). Conclusion from this study indicate that the main factor causing tree death to be topsoil salting due to groundwater capillary rise during dry periods which exposes shallow roots to high soil osmotic potentials, particularly when leaching and diluting of surface salts winter inflow does not occur, ie when the lake does not overflow. Deep rooting species exposed to increased soil salinity at depth would also be affected.

The specific results of the study indicate that;

- The cause of tree vigour and mortality varies with species.
- Vigour of *C. obesa*, *E. rudis*, *E. loxophleba* is deleteriously affected by increasing soil salinity

- *E. rudis*, *E. loxophleba*, *Acacia acuminata* and *Allocasuarina huegeliana* have a lower tolerance to saturation of the root zone than does *C. obesa*
- Increasing soil salinity at depth causing topsoil salting due to groundwater capillary rise was considered to be the main cause of tree death in species more adapted to waterlogging (*Melaleuca* and *Casuarina*).
- The antagonistic interaction of waterlogging and salinity was considered to be responsible for death of *E. rudis* - a species with a less tolerance to waterlogging.

Much of the healthy vegetation in the lake is located upon raised gilgai mounds which are a series of subtle undulations up to 1.5m high. These mounds provide an increased distance between the soil surface and the saline groundwater which reduces capillary rise and soil salting (R. Freund, pers. comm.). Casson (1988) notes their value as places where the phreatophytic trees (trees which are adapted to extracting water from the water table) can root above the saline water and where other vegetation is protected from inundation.

Germination of seedlings has been periodically observed. Monitoring in 1986 indicated that *Casuarina* was regenerating in the open woodlands of *Eucalyptus rudis* (Flooded Gum) in seasonally inundated areas of the lake.

### 3.1.3 Reserve vegetation

The results of monitoring have indicated that the deterioration of other plant communities on the periphery of Lake Toolibin, in Dulbining Nature Reserves 9617 and 27286, was not always associated with soil salinity. Lack of fire and/or other environmental factors have been suggested as contributing to the decline in the condition of the vegetation, which is described below:

- Low open forest of *Banksia attenuata* - *B. prionotes* - *Allocasuarina huegeliana* occur to the north-east of the lake, and into the Reserve 9617 above Dulbining Lake. This community is mainly composed of senescent trees of *Banksia spp.* and is stated by Mattiske (1986) as requiring managed burning for its continuing viability.
- The vegetation in Reserve 27286 is deteriorating due to the degraded state of the reserve. Unhealthy and dead trees, particularly *Melaleuca sp.* are evident along areas of saline seepage and drainage from Miller's Swamp at the north-east corner, although some seedling regeneration is occurring. Unhealthy vegetation is particularly obvious along an illegal drain running north-south from Miller's Swamp. Mattiske (1986) notes that areas of saline drainage do not support regeneration of *Acacia acuminata*. Large tracts of dead trees in the open *E. salmonophloia*, *E. salmonophloia* - *E. wandoo* woodland to the north-west of the reserve are due to extensive ring-barking practices which have occurred in the past, as well as a result of waterlogging through sheet flow from location 7349 (Casson, 1990). Areas of this association which support dense undergrowth and which are unburnt are deteriorating, while areas which were burnt in 1985 show vigorous growth of seedlings and saplings. Mattiske (1986) also notes that the closed scrub of *Melaleuca lateriflora* also requires managed burning.
- The lakes to the area north of Toolibin (Reserve 9617) contain the same perimeter and in-lake vegetation as Toolibin. The surrounding vegetation is on slightly higher ground and supports different communities. These communities are also deteriorating and are thought to require managed burning for their survival.

### 3.1.4 Current state of the vegetation

The latest monitoring of the vegetation in 1992 (EM Mattiske pers. comm.) indicates the following changes in the condition of the vegetation associations:

1. Paperbark and Sheoak woodlands in low lying areas and Lake Toolibin
  - Maintenance of growth in lakebeds
  - Decline in localised lower lying sections of the reserve and near the south-west corner of Lake Toolibin.
  - Gradual decline in tree overstorey in the communities adjacent to the areas previously affected by salt.
  - Healthier trees restricted to the mounded areas on the lake surface of Lake Toolibin
  - Death of most young seedlings of *C. obesa* that were established on the lake surface in 1980's - coincident with extensive crusting of dead algae on the lake surface in the summer of 1991/92.
  - Herbivory observed but extent of problem not known.

2. *E. salmonophloia* woodlands
  - Continual slow decline
  - No regrowth of trees
  - Maintenance of *Melaleuca* shrublands
3. Mixed woodlands of *E. salmonophloia*, *E. wandoo* and *E. loxophleba* in Reserve 9617 which have been cleared and burnt
  - Significant regrowth of *Eucalyptus* and *Acacia* species
  - Majority of tree species have persisted and grown to 7-9 metres

### 3.2 Discussion

In subsequent discussion the following statements regarding the factors responsible for the deterioration of the vegetation of Lake Toolibin and its associated reserves were agreed to:

#### Lake Vegetation

- DETERIORATION OF THE VEGETATION IN LAKE TOOLIBIN IS PRIMARILY A CONSEQUENCE OF INCREASING SALINITY.
- THE INCREASED SALINITY IN THE LAKE IS PRIMARILY DUE TO RISING GROUNDWATER LEVELS.
- HEALTHIER VEGETATION IS FOUND ON THE GILGAI MOUNDS BECAUSE THEY EFFECTIVELY INCREASE THE DISTANCE BETWEEN THE ROOT ZONES AND THE GROUNDWATER.
- THE INCREASED SURFACE DRAINAGE FROM CATCHMENT CLEARING HAS RESULTED IN:
  - greater frequencies and higher water levels of inundation in the lake.
  - longer periods of inundation in the lake  
(IE THE LAKE IS WETTER FOR LONGER)

#### Reserve Vegetation

- THE HEALTH OF THE VEGETATION OF TOOLIBIN NATURE RESERVE, DULBINING NATURE RESERVE 9617 AND DULBINING NATURE RESERVE 27286 IS IMPORTANT FOR THE MANAGEMENT OF LAKE TOOLIBIN.
- FACTORS RESPONSIBLE FOR THE DETERIORATION OF THE VEGETATION OF TOOLIBIN NATURE RESERVE INCLUDE;
  - Lack of seedling recruitment due to an inappropriate fire regime. Herbivory is also considered to be a factor
  - Lack of sufficient information to allow for active management.
  - The small area of the reserve.
- FACTORS RESPONSIBLE FOR THE DETERIORATION OF THE VEGETATION OF DULBINING NATURE RESERVE INCLUDE;
  - Rising saline groundwater levels,
  - Surface drainage from above the catchment causing waterlogging
  - Lack of seedling recruitment. In some communities this may be due to due to inappropriate fire regime. Herbivory is also considered to be a factor
  - Lack of sufficient information to allow for active management.
  - Lack of rehabilitation of the cleared areas

The following comments were not agreed to:

- WATERLOGGING OF SOILS FOLLOWING SALINITY STRESS IS THE SECONDARY CAUSE OF TREE SENESCENCE IN SOME SPECIES (IE; CURRENT WATERLOGGING CONDITIONS WITHOUT SALINITY STRESS WILL NOT CAUSE TREE DEATHS).

Workshop Comments: It is known that waterlogging stress is exacerbated by salinity stress, however insufficient information is available on which to base this statement as waterlogging may be the primary cause of stress in some species.

- THE PRIMARY CAUSE OF LACK OF SEEDLING ESTABLISHMENT IN LAKE TOOLIBIN IS HERBIVORY.

Workshop Comments: Other factors such as inundation of the seedlings, and smothering by algae crusts which remain on the seedlings following inundation, were considered to also be factors in the lack of seedling establishment. It was agreed however, that herbivory would effectively stunt seedling growth, making them more susceptible to stress when inundated.

## 4.0 AGRICULTURAL SYSTEMS

### 4.1 Description

- The Lake Toolibin catchment contains six dominant Land Management Units derived from soils map (Valuer Generals Office).
- "Deep Sands" occupy 4.25% (2,000ha) of the catchment.
- "Toolibin Flats" occupy 35% (16,450ha) of the catchment.
- The land use consists of a mixed grazing and cereal cropping system.

### 4.2 Discussion

The following comments were agreed to:

- Groundwater recharge occurs in the 'uplands' (approximately 15% of total recharge may occur through the 'Deep Sands' L.M.U.).
- Surface water run-off from 'uplands' contributes to waterlogging, inundation and groundwater recharge beneath 'Toolibin Flats'.
- Groundwater discharge (seeps) and streamflow from the 'uplands' is generally fresh but may become more saline.
- Groundwater recharge beneath 'Toolibin Flats' is estimated to be 45mm/annum.
- 'Toolibin Flats' have the potential for a substantial increase in the area affected by soil salinity.
- Surface water inflow to Lake Toolibin will become more saline as the salinity increases on the 'Toolibin Flats'.



## 5.0 MANAGEMENT OPTIONS

### 5.1 Introduction

Following discussion of the natural processes at work in the catchment and lake, the Workshop divided into specialist groups to consider the following management options:

- GROUP 1 Groundwater Pumping
- GROUP 2 Surface Water Control
- GROUP 3 Natural Ecosystem Management
- GROUP 4 Agronomic Manipulation
- GROUP 5 Catchment Revegetation

The overlap and interdependence of the management options was noted prior to commencement of the group session.

Each group was asked to consider a number of statements and questions specific to their group and to appoint a reporter to respond to the Workshop.

The statements and questions together with group responses are presented in Sections 5.2 to 5.6 below.

### 5.2 Groundwater Pumping

#### 1. Is groundwater pumping required to recover Lake Toolbin ?

**RESPONSE:** We believe that groundwater pumping is a method which is guaranteed to be successful. It is simply an example of dewatering and there are mine sites throughout the State where the technology is being used.

#### 2. Did the previous perched lake leach salt through the bed to the deeper water table, and did this control the lake salt load ?

**RESPONSE:** We believe that it probably did have a significant effect.

#### 3. What need is there for geophysical survey to understand the hydrogeology of:

- (i) The lake
- (ii) Toolbin flats
- (iii) The catchment

before staged implementation of a borefield in the lake?

**RESPONSE:** We believe that geophysical surveys are not essential but possibly beneficial. There is argument about whether geophysics should be used to guide a drilling programme or whether drilling should commence on a large scale and then specific sites be guided by geophysics. Geophysical data for Lake Toolbin and catchment would be a useful tool but not absolutely essential.

#### 4. Will nine bores on the western lake side be adequate to prevent decline (of vegetation)?

**RESPONSE:** To the best of our present knowledge nine bores will suffice. This number was chosen on the basis of test pumping of the bores already completed. With test pumping of additional bores, the number may need to be revised up or down. It is doubtful if any bore will yield less than 20m<sup>3</sup>/d of the existing bore, but it is possible that some bores may produce up to 100+ m<sup>3</sup>/d, which would allow increased spacing between bores.

5. Will there be significant vertical transmission of surface water if groundwater levels beneath the lake are lowered?

**RESPONSE:** On the evidence of the gilgai mounds and the sodic nature of the clay we don't believe that there will be any significant change (less than 10%) in the period of inundation of the lake. This is deduced on the basis that the downward leakage of water through the clays will not exceed 10% of the evaporation rate from the lake, which is the major component of the water balance once overflow ceases. However, we do believe that there will be a very significant effect on the salinity of the lake bed surface soils.

6. Assess the off-site/downstream effects (environmental and social).

**RESPONSE:** These effects are believed to be negligible. This conclusion is based on the observations of the impact on Lake Taarblin of discharge from the existing bore and on previous experience of discharging saline water in other areas of Western Australia.

#### DISCUSSION

- (i) Pumping is costly in terms of bore installation and power requirements. Other measures need to be implemented to attempt to reduce to a minimum the volume of water to be pumped. It would be desirable to consider groundwater pumping to be a short term measure, however we are unsure how effective the other measures might be, whereas we are sure that groundwater pumping will work.
- (ii) Capital cost for the 9 bores (stage 1) was estimated in 1990 to be \$262,000. Stage 2 comprising an additional 16 bores to protect the entire lake was estimated to cost a similar amount. If groundwater pumping is considered to be the only guaranteed method of recovering Lake Toolibin then this cost has to be accepted.
- (iii) Whereas pumping of saline groundwater and disposal in downstream locations probably cannot be advocated for all situations, recovery of Lake Toolibin may be considered sufficiently important that this action is warranted.

#### 5.3 Surface Water Control

1. Is waterlogging and surface water control in the "uplands" important for the recovery of Lake Toolibin ?

**RESPONSE:** The statement was agreed with although the term "management" would be preferred to "control". Any action which helps surface water control, particularly in terms of agricultural production, will be beneficial to Lake Toolibin.

2. Is waterlogging and surface water control on Toolibin Flats important for the recovery of Lake Toolibin?

**RESPONSE:** Yes, for the same reasons as given above.

3. Assuming that salinity of surface water run-off from the Toolibin Flats increases, should there be separate drainage and discharge systems for fresh and saline run-off ?

**RESPONSE:** Yes, but only if the surface run-off salinity does increase. The catchment is not yet in equilibrium and some runoff source areas presently fresh may subsequently become saline.

4. Will improved surface drainage of Toolibin Flats significantly affect groundwater beneath Lake Toolibin? (If so, how?)

**RESPONSE:** Yes, it will reduce the salinity of the run-off and will affect the amount of recharge which is occurring on the Toolibin Flats. However, given the low gradient of both the Flats and the associated water table, the significance of improved drainage is difficult to assess. The effect may be more significant in terms of the salinity of the surface runoff. The surface gradient is about 0.1% and given the highly transmissive sand, the hydraulic gradient towards the lake will not increase markedly.

5. If all catchment drainage is discharged into the lake, compare the resulting lake hydrological sequence with the former natural sequence. For example:
- frequency of inflow
  - frequency of lakefill
  - period of lake inundation

**RESPONSE:** If all catchment drainage is discharged into the lake it is believed that both the frequency of inflow and of lakefill will increase in comparison with the former natural sequence. In addition the period of lake inundation will increase.

6. Is Lake Toolibin outlet enhancement feasible?

**RESPONSE:** Yes, it is feasible and probably fairly inexpensive. The existing outlet is ill-defined and needs to be stabilised. The overflow level is believed to have risen by 0.3m between 1985 and 1990 for unknown reasons. The outlet at Toolibin, Walbyring and possibly Taarblin Lakes together with the driveway at Lachlan White's property need to be considered jointly. Outlet enhancement could be achieved economically and practically and could provide a management tool having a large effect on lake levels. However, we do not know what the appropriate settings would be for lake levels at different times of the year - this would require further research. Operation of any outlet structure would need to be part of a management plan and monitored appropriately.

7. Assess the downstream effects of improved surface water drainage from the catchment through Lake Toolibin with and without control of the lake outlet.

**RESPONSE:** Increased outlet from Lake Toolibin may cause inundation and increasing hydraulic head on downstream discharge areas, which may not be beneficial to Lake Toolibin. Any structure to control lake outlet will require a management strategy and the potential then exists for differences of opinion as to operation of the structure.

#### 5.4 Natural Ecosystem Management

1. Will groundwater drawdown by pumping prevent further deterioration of the vegetation of Lake Toolibin?

**RESPONSE:** Groundwater drawdown operating by itself would not prevent deterioration of the vegetation but would help. An important factor in the health of the vegetation will also be the quantity and quality of surface flows. Groundwater pumping also assist by providing greater option for management strategies of the surrounding reserve vegetation (eg: drawdown by transpiration of the perimeter vegetation will not be so important, allowing management for regeneration (eg burning) to occur).

2. If groundwater pumping occurs, what would be the effect of increased surface water drainage (ie increased water levels, frequency and duration of inundation) on the vegetation of Lake Toolibin?

**RESPONSE:** It is difficult to separate the groundwater issues from the surface water issues. The main factor affecting the vegetation will be the level of inflow. Water levels to current depths are considered to be satisfactory, however if inflow increases, there may be a need for an outflow control.

3. If groundwater pumping occurs, what would be the effect of increased surface water diversion away from the lake on the vegetation of Lake Toolibin?

**RESPONSE:** The degree to which the vegetation would be affected will depend upon the amount of water that is diverted away from the lake. Too little water in Lake Toolibin would be detrimental to vegetation and water fowl. In addition, the lake will require periodic flushing of surface salt, with the importance of flushing dependent upon the water quality of surface flow.

4. Would lake vegetation regenerate and survive if protection from herbivory was implemented.

**RESPONSE:** Herbivory is not the only cause of seedling deaths, however protection from herbivory would assist regeneration by allowing seedlings to reach sufficient height in which to withstand inundation.

5. Will surface water control help prevent the decline of natural vegetation around Reserve 27286?  
6. Will surface water control help prevent the decline of natural vegetation around Reserve 9617?

**RESPONSE:** (To questions 5 and 6): Yes. Surface water control will assist in preventing the decline of natural vegetation in both reserves, however management of the drainage will need to address the impact on adjacent areas (eg farmland and Lake Toolbin). The impact on the vegetation will also depend on the method of surface water control, for example, if groundwater rise is identified as a major impact, then increasing surface water would be beneficial to the system. The ideal situation would be the greater use of water by improved transpiration upland and in the reserves.

7. Is fire required for some regeneration?

**RESPONSE:** Yes.

- *Banksia/Allocasuarina* association needs regular fire for germination to replace those seedlings eaten by herbivores.
- Salmon Gum community. Fire could be required but not recommended. Preferable more intense management techniques such as handplanting, and seeding of select ashbeds.
- York Gum community. Requires selective burning, hand planting and seeding.

Other factors considered necessary for regeneration include:

- herbivore control
- weed control
- the quantity of regeneration needs to be controlled, especially near the lake, until groundwater management is implemented.

#### SUPPLEMENTARY QUESTIONS

8. What would be the effect of groundwater drawdown on the biology of Lake Taarblin, and further downstream?  
9. What would be the biological effect of increased surface drainage into Lake Taarblin and further downstream, as a consequence of increased surface drainage into Lake Toolbin, and discharge from groundwater pumping?

**RESPONSE:** Biologically, Lake Toolbin has priority over Lake Taarblin. Concerns include:

- Impacts of waterlogging and salinity on downstream landholders
- Approvals will be required under the provision of the Soil and Land Conservation Act.
- Referral will be required to the EPA, for advice and determination of the level of assessment.

10. Other

**RESPONSE:**

In addition to the established programmes, monitoring of the following is considered to be essential:

- Water quality (salinity)
- Water quality (nutrients)
- Lake water levels
- Invertebrate levels (which may affect waterbird populations)
- Veldt grass and other weed control

#### 5.5 Agronomic Manipulation

1. Can a new hydrological equilibrium be achieved by agronomic methods that are currently economically available to agricultural land managers? (i.e. in the absence of other lake management). (Note: Include tree-planting for agricultural benefit as an agronomic method).

**RESPONSE:** Control of waterlogging on duplex soils may increase average wheat yields from 1.84T/ha to 2.4T/ha which may utilize an additional 30mm of water. Growing tagasaste on the 2000ha of 'Deep Sands' may significantly reduce groundwater recharge. Improved soil structure by management (gypsum applications, fertilizer adjustments, tillage) with waterlogging control will substantially increase crop and pasture production so reducing groundwater recharge.

2. If a new hydrological equilibrium were established by agronomic manipulation, will this eventually be suitable for sustained ecosystem at Lake Toolibin?

**RESPONSE:** Economic methods of agronomic manipulation in the catchment (without other lake management) will not prevent the immediate risk of lake salinisation.

3. Is high water use agriculture more significant (to the recovery of Lake Toolibin) in the south-east sub-catchment than in other parts of the catchment?

**RESPONSE:** The south-east sub-catchment is very fresh at present so may not contribute significantly to surface salinity. The influence on groundwater from this sub-catchment is unknown.

4. If, for example, Tagasaste were planted in all areas most suitable for Tagasaste, will the farming system have also changed adequately to ensure optimum management in perpetuity?

**RESPONSE:** Landholders within the Lake Toolibin catchment who have established significant areas of tagasaste have adjusted their farming systems to include the fodder shrub. The advantages suggest that tagasaste will continue to be managed optimally.

## 5.6 Catchment Revegetation

1. Will commercial revegetation of 'the uplands' be eventually beneficial to the recovery of Lake Toolibin?

**RESPONSE:** As Tagasaste currently has limited use, and probably will not exceed 2,000ha other products (e.g. eucalyptus oils, timber products) need to be developed so as to provide an economic alternative to agriculture. Revegetation in the 'uplands' needs to be substantially complemented by revegetation on the 'Toolibin Flats' to benefit Lake Toolibin.

2. If revegetating Toolibin Flats for commercial and environmental gain, which strategy is best?

- treebelts along soil-type boundaries, or a break-in-slope
- low density alley-style treebelts in areas of low soil salinity
- high density plantations in areas of higher soil salinity
- tree blocks or belts associated with geophysical features (dykes, bedrock highs, paleo-drainage lines etc).

**RESPONSE:** Revegetation of the break-in-slope landscape position is most useful. Saline areas of the 'Toolibin Flats' will be limiting for commercial and water use potential. The aim should be to establish trees where there is access to groundwater. Multiple benefits of treeplanting on the Toolibin Flats should be evaluated. Cost-sharing could be further considered. Current revegetation of drainage lines should be continued. The groundwater response to alley-style revegetation of the Toolibin Flats may differ to that measured for the Boundain trial. Groundwater information from similar plantings within the catchment should be evaluated.

3. What prevents the rapid adoption of alley-style treebelts?

**RESPONSE:** A full-scale demonstration with an evaluation of all benefits and costs is required.

4. What prevents the rapid adoption of commercial woodlots?

**RESPONSE:** Lack of suitable commercial products, or industry and market development. Potential for private investment. The added possibilities of tourism by increased scenic value should be considered.

## 6.0 SUMMARY COMMENTS (DR. D.J. MCFARLANE)

The uplands are furthest from the lake and probably have the greatest agricultural potential, although there are problems of waterlogging of duplex soils, which could be improved by drainage. There are also areas of deep sands, some of which are of poor quality. The influence of the uplands on Lake Toolibin is probably greatest through their contribution of runoff to the Flats. This runoff could be controlled by contour working, and there are research results from the eastern wheatbelt to show that contour working can lead to increased cereal yields. This implies extra water use and higher farm productivity. This in turn should lead to dryer soils and a lower rate of surface runoff should result from the higher soil moisture deficit prior to rainfall.

Uplands also contribute groundwater recharge feeding the seepages which are forming at the break of slopes between uplands and flats. Field data shows that the break of slope has the lowest elevation in the landscape, approximately 0.50m below surrounding land, and is where salinity tends to develop. A groundwater mound was observed under the uplands feeding these seeps. Increased production on the upland areas feeding these seeps is a win/win situation for farmers/lake. In fact many of these seepages have been fenced off and replanted in the last few years, and beneficial effects should be observed within 5 to 8 years. The planting of trees near salt affected drainage lines or near the lake itself will provide short term benefits. Away from these areas, tree planting may have medium to long term effect on the lake because of low gradients and low hydraulic conductivities.

On the Flats the most important problem is the poor soil structure, which results in low infiltration rates. Minimal tillage could improve the poor seed bed conditions and low crop production. There is probably more opportunity for gypsum response trials, and the University of Western Australia should be asked to advise on suitable test procedures. The saline area is undoubtedly spreading laterally even if there is no appreciable rise in water table, and more salt will be carried into the lake.

The contribution of in-situ recharge versus upland contribution has not been investigated, and this should be done using water balance techniques. One positive aspect which has yet to be fully exploited is the ease with which surface water flows can be diverted on the Flats, for example between drainage lines with small structures. Active management of water is required in the same way that active management of Reserves is being proposed.

The lake surrounds are the area where management options will most readily be seen. Groundwater pumping should be considered as an insurance. Pumping need not be continuous, but if vegetation and lake quality declined, pumping could commence. The value of the lake and surrounding Reserves is so high, and our understanding of physical processes incomplete, that the borefield should be in place, so that it could be used at short notice. In terms of chaos theory, the present state of quasi-stability could quickly change to a state of rapid decline.

The processes are sufficiently complex that it is difficult to anticipate the effect of any change to the existing system. A computer process model should be developed to explore the implications of a change in any particular attribute. In addition there is a need for a separate management model, for example to model the effect of lake outflow control.

We may not be able to wait until all the answers are available, before recommendations are made on suitable management. We need to pursue those management options which have a short term outcome and for which we have some confidence in what the outcome will be.

Longer term management options should be delayed until process modelling reveals more about their outcomes. Monitoring of data has not been complete in recent years and should be upgraded.

## 7.0 SUMMARY COMMENTS (DR. E.M.MATTISKE)

The recovery of Lake Toolibin requires the management of three major areas, namely the Lake itself, the associated reserves, and the whole catchment.

In summary, the specific issues relating to Lake Toolibin are:

- Salinity
- Water-logging
- Inundation
- Grazing
- Hydrological Processes

Specific issues relating to the adjacent reserves are similar, however require additional management practices (eg fire management) and the necessary understanding of the ecology of the system to decide appropriate active management procedures.

These issues are reflected in the whole catchment, as follows:

- An understanding of the processes
- A revegetation programme- this needs to be commercial, social and achieve aims of reducing run-off and controlling groundwater and increasing transpiration.
- Diversification of land management
- Integration with the management of the reserves.

There are many positive things about the current situation at Lake Toolibin

- Lake Toolibin still exists in relatively good condition
- There has been significant documentation on some aspects of the lake
- The number of people interested in the problem
- International listing and therefore awareness
- Appears to be several answers that are relatively inexpensive to undertake ie pumping, drainage and planting trees

However, the negative aspects of the current situation are many. These are:

- Lake Toolibin may collapse
- Don't know interactions of biological and hydrological processes
- Don't know many of processes which influence interaction
- Weaknesses in research - needs planning and interaction
- Need resources - funding!!

In summary, the overall recovery of Lake Toolibin requires the following:

1. Need for overall management and recovery plans
  - Lake Toolibin
  - Lake Toolibin and Reserve
  - Catchment
2. Need for integrated monitoring
  - Water quality, quantity, time of water availability, nutrients and salinity
  - Biological
  - Whatever is done needs to be based on research and monitoring
3. Need for active management for:
  - Lake Toolibin
  - Lake Toolibin and Reserve
  - Catchment

4. Need basic resources - money, person power, long-term commitment
5. Importance of integration of systems. Need understanding and information on critical relationships between : landuse, agronomics, catchment management, geology, geophysical, surface and groundwater hydrology, habitat, vegetation, fauna, understanding or inter-relations
6. Need to prioritise research needs eg. as part of on-going Management Plan and Recovery Plan - need for a Technical Advisory Group to overview monitoring results and implement on-going management decisions. This group will be a part of, and report to the Recovery Team.



## 8.0 CONCLUDING COMMENTS

The concluding session consisted mainly of an open forum addressing aspects of the workshop. The following suggestions, recommendations and comments were received:

- It is unlikely that Lake Toolibin will remain in a stable state for much longer.
- The need to commence action of Lake Toolibin is urgent, and groundwater pumping is recommended to commence as soon as possible.
- Flushing of the lake may be improved <sup>by</sup> lowering the outlet of Toolibin, and possibly other Lakes downstream.
- The construction of artificial gilgai mounds is considered to be an option for vegetation regeneration. It was recommended that trial gilgai mounds be constructed at Lake Walbyring. The mounds should be constructed by infill, rather than excavation.
- An option suggested by Tim Negus of the Narrogin Agricultural Department for surface drainage, which considered using Miller's Swamp as a retention basin was not considered by the workshop. Several opinions were arrived at, namely that this option should still be considered feasible and that salt harvesting is essential to this scheme. However, it was raised that salt harvesting at such a small scale would not be economically feasible. In addition, the proposal would require the consent of the owner, which may be difficult.
- A geophysical survey of the flats was not considered to be strictly necessary to the management of the catchment. It was suggested that other items might be more economically preferable.
- The priority site for revegetation was suggested to be where a break in slope occurs .
- The revegetation of the catchment of Lake Toolibin is considered to be essential for the long-term recovery of the lake. This will require the purchase of considerable tracts of land, or alternatively, will require incentives to be provided to landholders to undertake tree planting. This must eventually take the place of the groundwater pumping scheme, which economically, must be seen as a short-term option.
- The uncertainty and risks associated with the recovery of Lake Toolibin, may mean that funds are difficult to come by. The combination of the Water Resources Council, the National Parks and Nature Conservation Authority (NPNCA) and the Soils and Land Conservation Council in supporting the recovery and management plan is seen to be essential.

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LAKE TOOLIBIN RECOVERY PLAN WORKSHOP

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# LAKE TOOLIBIN RECOVERY PLAN

## TECHNICAL WORKSHOP PROGRAMME

<u>TIME</u>		
9.30	Registration	
	<u>Processes</u>	
10.00	Introduction	Viv Read "Rural Planning"
10.15	Hydrological Processes	Jim Davies "Jim Davies and Associates"
10.30	Biological Processes	Bev Walker "Bowman, Bishaw and Gorham"
10.45	Agricultural Systems	Michael Elliott, W. A. Dept. Agriculture, Narrogin
11.00	"Processes" discussion	
12.00	Towards Consensus	
12.15	Lunch	
	<u>Management Options</u>	
13.00	Introduction	Viv Read
13.15	Option Analysis	(Groups)
13.45	Group Presentations	
14.15	Integration	
15.00	Towards Consensus	
15.30	Afternoon Tea	
	<u>Summary</u>	
16.00	Summary Comments (Don McFarlane, Dept. Agric., Albany )	
16.15	Summary Comments (Libby Mattiske ,E.M. Mattiske & Associates )	
16.30	Consensus	
17.00	Close	