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AUSTRALIA

Major Project Review

Toolibin Lake Recovery Plan

Project Number 350

**Report prepared by A Smith and K J Wallace on behalf of the
Toolibin Lake Recovery Team**

October 1998

Department of Conservation and Land Management

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Section 1: Introduction

1.1 The situation prior to funding the Recovery Plan

Toolibin Lake lies approximately 250 km south-east of Perth at the top of the Northern Arthur River Catchment. This catchment drains into the Blackwood River, a major south-west river for which a State Government sponsored Blackwood Basin Group has been established. The nature reserves including and adjoining Toolibin Lake are managed by the Department of Conservation and Land Management (CALM) on behalf of the National Parks and Nature Conservation Authority (NPNCA).

Toolibin Lake is the first in a series of nine lakes and it is the only major lake in the chain that has not become saline. It is one of the last inland lakes with good water quality and one that has retained a sheoak/melaleuca association across significant parts of the lake floor. Toolibin Lake and environs have important conservation significance as a breeding habitat for waterbirds. Twenty-four species of waterbirds have been recorded breeding at the Lake, and 41 species have been recorded using the lake.

Toolibin Lake is listed on the Register of the National Estate and is also registered as a "Wetland of International Importance" under the Ramsar Convention. It is the last significant representative of a once common wetland type of the inland south-west. Clearing of native perennial vegetation for agriculture has resulted in most inland wetlands becoming saline from rising saline groundwater and surface flows. This has killed emergent vegetation and aquatic species that cannot tolerate salinity. Airborne geophysics work has revealed that large dolerite dykes have been partly responsible for saving Toolibin Lake from this fate.

However, the vegetation at Toolibin Lake is in decline. Tree deaths were first noticed in the late 1970's, with extensive losses on the western side of the lake. These deaths appear to have been caused by increased soil salinity combined with increased waterlogging. To prevent further tree deaths from occurring across the lake floor, remedial action was required. The Northern Arthur River Wetlands Rehabilitation Committee (NARWRC) was established to investigate and develop recommendations for the conservation of Toolibin Lake. In 1987 the Committee produced a report *The Status and Future of Lake Toolibin as a Wildlife Reserve*. This report provided essential background information on the environment of Toolibin Lake, outlined previous studies completed and listed management recommendations for the lake. The recommendations included works such as revegetation of the western buffer zone, groundwater control via pumping, diversion of saline flow, and catchment regeneration. Many of the subsequent action items in the Toolibin Lake Recovery Plan are based on these recommendations.

The NARWRC Report listed the "hypotheses" for the Toolibin Lake project as:

1. Lake Toolibin is one of the few remaining freshwater lakes in the Western Australian Wheatbelt and is a vital breeding area for a wide range of birds, including some rare species such as the Freckled Duck.
2. A healthy and viable vegetation complex is vital to maintaining the effectiveness of the Lake Toolibin habitat for waterbirds.
3. Trends in health and structure of the lake vegetation communities will provide an index of the long term future of Lake Toolibin.
4. Increasing waterlogging and salinity threaten the Lake Toolibin habitat. An altered water balance following clearing for agriculture has increased the salt load of the surface inflow and raised regional and local groundwater levels. This is leading to vegetation death and the salinisation of Lake Toolibin.

Prior to the formation of the Recovery Team and writing of a Recovery Plan, efforts by State Government agencies included:

- the purchase and rehabilitation of 177 hectares of private land in the Toolibin Catchment which had been chained in 1977, but not burnt;
- the purchase, in 1979, of 40 hectares of land along the eastern side of Toolibin Lake to conserve bushland crucial to the protection of the lake;
- the purchase, in 1988, of 128 hectares of private land along the southern and western sides of the Lake and the subsequent fencing of this land;
- the raising and planting of approximately 35 000 tree seedlings into cleared land purchased in 1977 and 1988;
- various conservation management activities at the Lake and associated reserves including an experimental burn at one site, diversion of an interceptor bank and monitoring various environmental conditions;
- assessment, using consultants, of the environmental impacts of a proposed drainage system and preparation of a recovery plan for the Lake;
- work by Agriculture WA with Catchment landholders to encourage a wide range of land conservation activities.

Consultants completed the Recovery Plan for Toolibin Lake and surrounding nature reserves in November 1992. It was endorsed by the NPNCA in January 1993 and then reviewed and redrafted by the Recovery Team and Technical Advisory Group by September 1994. The Recovery Plan is being implemented by the appointed Recovery Team under the general guidance of CALM's Director of Nature Conservation.

1.2 The current situation

Since the launch of the Toolibin Lake Recovery Plan in October 1994 considerable works have been implemented both within the Lake's immediate environment and throughout Toolibin Catchment as a whole. The Toolibin Lake Recovery Team has been responsible for most of the recovery actions implemented at the Lake itself, such as the surface water diversion and the groundwater pumping program. This work has generally been funded by either the State Government or by Environment Australia through the Endangered Species Program.

However, the Lake Toolibin Catchment Group (LTCG) has also been crucial to the success of the Recovery Plan. The LTCG has been successful in attracting funding from a number of sources to instigate revegetation and protect remnants across the Catchment. This has included ongoing support from Alcoa of Australia, the Blackwood Basin Group and grants from the Remnant Vegetation Protection Scheme. Work funded by Greening Western Australia and various Federal grants, including funding under the National Landcare Program, has also been important. In addition, the land conservation works by many individuals at their own cost has, and continues to be, very important to the future of the lake.

The launch of the State Salinity Action Plan (SAP) in November 1996 provided significant funds for a range of recovery catchments including Recovery Catchments for Natural Diversity. Toolibin Lake is one of three such recovery catchments. Funding from SAP, Environment Australia and CALM have all been vital to the successful implementation of the Recovery Plan.

The implementation of the first round of emergency, short term recovery actions has been completed. Major drainage works within West Toolibin sub-catchment and the Lake's separator gate and diversion channel were completed in 1995, and were successfully used in 1996. These recovery actions prevent most highly saline surface runoff from entering the lake by diverting it along the western side of the lake into Taarblin Lake. Further surface drainage works are currently

being implemented in the North East Toolibin sub-catchment.

The groundwater pumping program has been in operation since March 1997, following the installation of six Airwell Pumps on the western side of the Lake in addition to the two existing trial pumps, and the completion of the transfer system to Taarblin Lake. Pumping is currently operating well, with works focusing on preventing silt and iron bacteria build-up.

Catchment revegetation has also been progressing with the Toolibin Alley Farming Trial implemented in 1996 and the Melaleuca Trial in 1997. Recent land purchases adjacent to Dulbinning Nature Reserve by CALM will create further revegetation opportunities in 1999, of both biodiversity plantings and revegetation trials using regional, productive species. Protection of remnant vegetation and revegetation on private property, funded from many sources including the landholders themselves, is significant.

Detailed discussion of these and other recovery actions are provided in Section 3: Actions. The progress of these actions in meeting the Recovery Plan objectives as measured against the criteria is discussed in Section 2. The current conservation status of Toolibin Lake and any improvements or deterioration in status since implementation of the Recovery Plan are discussed in Section 4. The technical and socio-economic lessons learnt from the "Toolibin Experience" are applicable to rural landscapes across southern Australia facing similar problems to Toolibin Catchment. The Toolibin project is an important case study of achieving conservation objectives on a catchment scale. To reverse the effects of rising water tables and increased salinity in the agricultural zone is a significant challenge. Section 5 of this report deals with this issue, outlining lessons learnt concerning both the management of Toolibin Lake as a threatened community and the management of the broader catchment. Publications that have resulted from this work are listed in Section 6.

It is emphasised that this report is produced with the aim of documenting works undertaken with funding under the Endangered Species Program and matching activity by State Government. Where appropriate, the work of other groups is detailed. However, it is not intended that this document provide a complete description of the work of these other groups. Also, recurrent expenditure by State agencies is not detailed in this document. Only special allocations for Toolibin are detailed.

Section 2 Objectives and Criteria

2.1 Objectives

The recovery objective of the Toolibin Lake Recovery Plan is stated within the report as:

'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 waterfowl'.

Although recovery of the Lake is the primary goal of the work of the Recovery Team, a set of wider responsibilities are also recognised. These are encapsulated in the following five principal goals of the Recovery Team:

- 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; and 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.

The success of the Toolibin Lake Recovery Team in meeting the recovery objective since Environment Australia funding for this project began in 1992 is discussed in detail below.

The Recovery Plan lists a number of biological and physical criteria against which the achievement of the recovery objective can be measured. Recovery of the lake will be achieved when these criteria are met.

2.2 Biological Criteria

a) No further deterioration is observed in the health of the vegetation of the lake or reserves.

Works to divert low volume, high salinity flows were completed in 1994/95. The positive impact of this work is immediate (see item (2) under 3.3). However, broader scale groundwater pumping did not begin until 1997, and the effects of this cannot be assessed for several years although there is already some visual evidence of beneficial effects near one pump. In the meantime, there has been further deterioration of both *Casuarina obesa* and *Melaleuca strobophylla* trees at some sites.

Plant deterioration will be evaluated by vegetation monitoring during spring 1998. Until this work is complete, progress towards meeting this criterion cannot be quantified.

b) *Successful tree and shrub regeneration in the lake and reserves is established across all vegetation associations.*

To date there has been limited regeneration of the two species found on the lake floor. *Casuarina obesa* seedlings are present on the western side of the lake bed, however, they tend to be heavily grazed by kangaroos. On-going management includes fencing trials to protect seedlings until they are tall enough to survive inundation. Researchers from Edith Cowan University are also studying the interaction between regeneration and grazing. *Melaleuca strobophylla* also regenerated in two small, dense patches on the eastern side of the lake during 1996. This regeneration is very interesting as there are no previous records of such patch regeneration. If these patches survive, they will provide great confidence for further, artificial regeneration works on the lake floor.

Further research will continue to improve knowledge of regeneration requirements and contribute to the development of management techniques. It is anticipated that as effects of the groundwater pumping program become more apparent, regeneration on the western side of the lake will increase.

c) *Based upon available data, the lake supports sufficient species richness and numbers of invertebrates to assure waterbird food resources.*

Salinities of lakes within the Toolibin system vary from year to year as a result of differing rainfall patterns and the irregularity of the flushing of salt from the lakes. This makes it difficult to assess the success of the Recovery Plan at this stage. Irregular timing and methodology of invertebrate sampling has made measuring the success of this criterion particularly difficult. For example, Halse (unpublished data) surveyed Lake Walbyring in September 1985 and August 1986 when the salinities were 7.5 ppt and 3.6 ppt, finding a total of 27 taxa. Doupe and Horwitz (1995) surveyed Lake Walbyring almost a decade later when salinities were 1.0 ppt and 1.6 ppt. This survey found a total of 48 taxa present. These results show that it is premature to draw conclusions regarding this criterion, as numbers of invertebrates fluctuate according to climatic conditions. The current invertebrate monitoring program has been standardised to improve evaluation standards.

d) *The numbers and species of waterbird visitation (41 species) and breeding success (24 species) that currently occurs is maintained or improved.*

As for the aquatic invertebrates, interpreting waterbird data against this criterion is difficult due to a number of constraints. These include a great variation in the frequency, methodology and timing of surveys between 1970 and 1996, and variations in climatic conditions that resulted in changes to waterbird usage independent of salinity. However, since implementation of the Recovery Plan there has not been a significant decrease in the numbers and species of waterbirds visiting and/or breeding at Toolibin Lake. For example, in October 1981 Jaensch *et al.* (1988) recorded 18 species of waterbird at 1.45 m water depth, five of which were breeding. In March of 1990 J.D. Blyth (unpublished data) recorded 16 species of waterbirds, at a similar depth of 1.57 m. In September of the same year Halse (unpublished data) reported four species breeding, which is comparable to the survey by Jaensch in Spring a decade earlier. Birds were also monitored during 1996, a year of partial filling of the Lake. It was reported (S.A. Halse, personal communication) that there was a good range of species and numbers. Inference from current data is that there has been no significant change in water bird composition during the past 15 years.

2.3 Physical Criteria

a) *The minimum depth to the water table beneath Toolibin Lake and Toolibin flats in spring, when the lake is dry, should be 1.5m.*

Achievement of this criterion is to be met by the groundwater pumping program. Although pumping only began in March 1997, some results are already evident. In October 1997 groundwater levels at piezometers 5 and 6, which are close to Pump 10, the highest yielding pump, were 4.81 m and 2.9 m respectively below the soil surface. In October 1996 these piezometers were

measured at 3.06 m and 1.49 m respectively. Similarly, there was a drop in water table levels in the year groundwater pumping began for piezometers 11 and 12, which are located next to Pump 10. This lowering was from 7.97 m and 5.64 m in 1996 to 13.61 m and 10.16 m in 1997. These results are quite dramatic, due to the effectiveness of that particular pump.

In other areas there has been a more modest lowering of the water table such as for piezometers 15 and 16, which are located relatively close to Pump 9. In October 1996 the water table was measured at 0.46 m and 0.37 m respectively, well above the criterion stated above. By October 1997 the water table had been successfully lowered to 1.73 m and 1.68 m, which is meeting the desired criterion. Of the 21 piezometers on the western and central sections of the lake, 12 met the criterion of a water table depth of at least 1.5 m in Spring, compared to only five doing so in Spring of 1996. This excludes the six piezometers established in 1996 on the eastern side of the lake, which are not affected by groundwater pumping. There have been rising groundwater trends in the piezometers along the eastern part of the Lake, a matter of concern. Although the pumping program has not been in place long enough to determine definite trends, the results near the pumps are encouraging. The groundwater pumping program is critical to recovering the lake floor vegetation.

b) The maximum salinity of lake water when the lake is full should be 1 000 mg/l Total Dissolved Salts (TDS).

The most recent inflows to the lake occurred in 1996 when there was a partial filling during winter. A selection of water salinity data of equivalent seasons and water levels are:

1□Date	1□Water Depth (metres)	1□Salinity (mg/l)
1□September 1982	1.16	3780
2□September 1991	1.16	3350
3□September 1996	1.15	3400

Variation between seasons means that these data should be treated with caution, however, it appears that surface water salinities within the Lake are comparatively stable. The diversion separator was used in 1996 to by-pass water of poor quality around the lake (see (3) below), and this has helped achieve this positive result.

c) The maximum salinity of inflow to the lake measured at the Water Authority gauging station 609009 on the Northern Arthur River should be 1 000 mg/l during the winter months when the lake is full.

Since implementation of the Recovery Plan the only years that there has been inflow to Toolibin Lake was 1996. Data measured by the Water and Rivers Commission gauging station, which is located on the Toolibin inlet channel by Harrismith Road, was transferred to CALM to assist in management of the separator gate. Continuous data over 24 hours on 17.07.96 gave an average salinity of 1776 mS/m, or 976.9 mg/L, which is below the desired criterion. This remained fairly constant with the average salinity level over the period from 25 July to 8 August 1996 of 927 mg/L. However, the maximum salinity recorded at the station was 2 161 mS/m or 1 188 mg/l, and much higher salinities were recorded at the entrance to the Lake using a hand held salinity meter.

In the winter of 1998 flows reached the lake, but were not below 1 000 mg/l and were therefore by-passed around the lake. These high salinity flows, and those of 1996, emphasise the critical importance, and success, of the separator.

Based on the above data, the salinity levels for winter 1996 were just within the criterion stated above. The separator gate was used successfully in that year to ensure that high salinity flows were by-passed around the lake. In 1998, a comparatively dry winter, the flows have been above the criteria of 1 000 mg/l. It is expected that surface flow salinity will worsen for many years before catchment works stabilise surface salinisation. The separator has been designed to cope with this scenario.

d) The lake bed dries periodically by evaporation, on average once every three years.

A history of the lake bed filling and drying out has been documented by Jim Lane, who has been measuring surface water depths at least twice a year for a set of lakes including Toolibin Lake since 1978. For the period 1978 to 1996, the lake bed dried out nine times, or approximately once in every two years. Since implementation of the Recovery Plan began in 1992 the lake bed dried out in 1994, 1995, 1997 and 1998, or four out of seven years. Given the highly variable nature of filling and drying, current wetting and drying cycles are considered to be within the range expected to meet this criterion.

e) 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 are not to exceed 100 mg/l unless long term monitoring indicates that this criterion may be modified.

There is no formal monitoring of algae or other aquatic plants at Toolibin Lake because they rarely reach deleterious levels. High nutrient levels have not traditionally been a problem for Toolibin Lake, however, to ensure there are no changes in this status water samples are collected by CALM staff every six weeks and tested for nutrient levels when surface water is present. Total phosphorus levels have remained well below the criterion of 100 mg/L with all of the six samples taken between 1991 and 1996 analysed as less than 0.3 mg/L by the WA Chemistry Centre. There has been one botulism outbreak at Toolibin Lake, in March 1993, when 450 birds including 18 species were found dead. Nitrogen and phosphorous levels in 1993 were four times as high as those recorded in 1996. It is possible that the separator not only decreases the salt load entering the lake, but also decreases the nutrient load. More data would be required to demonstrate whether this is so.

Algae has, also on one occasion, been observed smothering *Casuarina obesa* seedlings.

Although the criterion for nutrient levels is generally met, monitoring will continue to ensure the current situation does not deteriorate.

Section 3 Actions

3.1 Appointing the Recovery Team

Implementation of the Toolibin Lake Recovery Plan involves a complex range of biological, physical and social issues. Implementation of the Recovery Plan must be flexible in order to respond adequately to changes in available information, environmental factors and resources. To ensure adequate consultation with stakeholders, the Plan is implemented by the Toolibin Lake Recovery Team which includes representatives of CALM, the Lake Toolibin Catchment Group, Environment Australia, Agriculture WA and the Water and Rivers Commission. The Recovery Team reports to CALM's Director of Nature Conservation.

The role of the Recovery Team includes:

- 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.

Due to the complexity of many of the technical issues related to Toolibin Lake, a Technical Advisory Group has also been established. Their functions include:

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

Both the Recovery Team and the Technical Advisory Group have been successfully established since September 1993. An initial joint meeting was held to discuss the roles of the two groups, the nature conservation values of the lake, resources, objectives and priorities for action. The two groups have held regular, independent meetings from that point.

Since 1993 the Recovery Team has successfully met the role allocated in the Recovery Plan. The relative importance and methodology of implementing action items in the Recovery Plan are discussed at Recovery Team meetings. The Recovery Team has also submitted the required Toolibin Lake Recovery Team Annual Reports to the Director of Nature Conservation. The Annual Reports are an important tool in allowing progress in the implementation of the Recovery Plan and justification of resource allocation to be accessible to interested parties.

The Recovery Team has played an invaluable role in bringing the various stakeholders of Toolibin Lake and Catchment together. Input from members comes from both the local community and the appropriate government agencies, ensuring that there is full public awareness of progress in implementing the Recovery Plan. The Technical Advisory Group provides an important support role, by ensuring that the Recovery Team has access to expert technical advice when making decisions on action items in the Recovery Plan.

It is critical to the ongoing successful implementation of the Recovery Plan that the current framework of the Recovery Team, in liaison with the Technical Advisory Group, continues to be responsible for the supervision of implementing the Recovery Plan. This has been particularly effective due to cross membership with the Lake Toolibin Catchment Group.

3.2 Water table Drawdown by Groundwater Pumping

3.2.1 Groundwater Pumping Stage 1

The objective of Stage 1 of the Groundwater Pumping Program is to draw down 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, thereby preventing salinisation of the vegetation root zone. The priority of this was classed as essential, as it is the only short term emergency action that would prevent the lake bed vegetation from being killed by saline groundwater.

Groundwater is pumped to Taarblin Lake, a nearby nature reserve affected by salinity. Approval for the disposal of groundwater was obtained from the Commissioner for Soil and Land Conservation. The proposal was also submitted to the Department of Environmental Protection for their comment.

As part of this process, landowners adjacent to Taarblin Lake were consulted. Some farmers were unsure of the potential impacts of this on their properties and meetings were held to explain the pumping proposal and dissipate fears among farmers that pumping would result in saline water flooding onto their properties. Other groups notified included the Narrogin Land Conservation District Committee, Nomans Lake Catchment Group and the Blackwood Catchment Co-ordinating Group.

The Toolibin Lake Technical Advisory Group and the Toolibin Lake Recovery Team were also involved in designing the groundwater pumping and disposal schemes. The groups provided additional technical advice and ensured that Catchment Groups, Shires and individual landholders understood the proposed works. This has remained a priority with CALM throughout the implementation of the Recovery Plan.

It is difficult to accurately determine the success of Stage 1 of the Groundwater Pumping Program as it has not been in operation long enough for clear trends to emerge. At this stage, results from monthly monitoring of the piezometers indicate that while only seasonal fluctuations in the water table are evident on the eastern side of the lake, trends are beginning to emerge on the western side of the lake. This is due to two factors: the planting of a buffer zone of vegetation along the western edge of the lake approximately 12 years ago, and the impact of the pumping system. This trend is evident in piezometers 5 to 12, where the groundwater table has dropped in two stages which can be correlated to the impact of these two actions. For example the water table at TL 11 dropped 4 m between 1994 and 1997 and a further 5 m between 1997 and 1998. The piezometers where results such as this are evident are all located close to both the revegetation buffer zone and Pump 10, which has consistently been the highest yielding pump. Results of groundwater pumping to date have not been fully documented, please refer to a summary of monitoring results in Appendix 1.

Stage 1 of the Groundwater Pumping Program is an ongoing action item. Due to the nature of the work, it is a relatively long term recovery item which will require several years before the benefits can be clearly demonstrated. During the implementation of the pumping and transfer system on the western side of the lake, a great deal of technical knowledge has been accumulated. The requirements and setting of the project has been unique and it is hoped that the lessons learnt will be applicable to the wider community facing problems with salinity. Within the context of Toolibin Lake, it is essential that the pumping program (and funding of it) is ongoing to prevent the groundwater table from affecting the root zone of vegetation on the lake bed.

Table 1: Recovery actions implemented for groundwater control

Action	Financial Year	Cost	Funding Source	Outputs/Outcomes
Establishment of test pump on lake bed and running of electricity powerlines by the W A Geological Survey	1988/89	data unavailable	State Government	Report describing drilling and pumping trials to determine requirements for a groundwater pumping program to lower groundwater levels.
Airborne Magnetics Survey of Lake and reserves by Tesla 10 (W4/93)	1993/94	\$9 400	Environment Australia	Provided information on major geological structures to assist in locating groundwater pumps in areas of higher permeability.
Establishment of borefield by Flockart Drilling	1994/95	\$42 564	Environment Australia	Drilling of exploration bores on lake bed, to determine likely yields, airlift the test bores and case selected bores for groundwater pumping.
Establishment of a second trial submersible pump	1994/95	\$1 394	Environment Australia	To further trial the yields of groundwater pumping
GHD Engineering Consultancy for advice on the tender analysis process for pumping and transfer system contracts	1995/96	\$6 075	Environment Australia	Provided technical advice on the specifications and quotes by Airwell Pumps and Lachlan Consultancy, particularly the power supply and construction requirements.
Installation of 6 additional groundwater pumps by Airwell Pumps (W2/95)	1994/95	\$118 930	Environment Australia	To prevent the salinisation of lake bed vegetation by water table draw down
Installation of pipeline and transfer pumping system by Lachlan Consulting (W5/96)	1995/96	\$83 067	Environment Australia	To transfer saline effluent 6.5 km downstream to the degraded Taarblin Lake.
Superintendent from the Town of Narrogin	1995/96	\$3 600	Environment Australia	Overseeing the quality of work completed for the pumping program.
Groundwater pumping program maintenance	1997/98	Lachlan: \$33 299 Airwell Pump: \$22 612 Polyphaz: \$4 842 Champion: \$5 934	Salinity Action Plan* and Environment Australia	These companies provided an ongoing maintenance program for the groundwater pumps, transfer system, power conversion and compressed air supply. These fees also included remedial work investigating silt and iron bacteria build up.
Western Power	1997/98	\$24 402	Salinity Action Plan	Provision of power to the pumping station.

* A special allocation of WA Government funds.

3.2.2 Groundwater Pumping Stage 2

The objective of this recovery action item is to draw down the regional water table beneath salinised areas of the lake bed (additional to that along the western shoreline being dealt with under stage 1) to at least 1.5m below the soil surface in spring. At this stage only Stage 1 of the groundwater pumping program has been implemented. The project has been highly experimental and many technical difficulties have been overcome since the installation of the eight pumps along the western

edge of the lake. A team of hydrogeologists from Sinclair Knight Merz is currently working on a Groundwater Model for Toolibin Lake, including the effects of the current pumping system. The results of this modelling will give a clear indication of the impact of groundwater pumping and the number and location of additional pumps that will be required on the lake bed to achieve the objectives set in the Recovery Plan.

3.2.3 Groundwater Pumping under Reserves

The objective for this recovery item is to draw down the saline regional water table beneath Reserves 27168 and 9617 to at least 1.5 m below the soil surface in spring to ensure that vegetation in these reserves does not decline rapidly by salinisation of the root zone. This has been given a medium priority ranking in the Recovery Plan and has not been implemented at this stage. As with the action item above, works on this recovery action are dependent on the outcome of the groundwater modelling work scheduled for completion by October 1998.

3.3 Feasibility, Design and Implementation of Surface Water Control for Toolibin Catchment

3.3.1 Improved Farm Drainage for a Sub Catchment on the Toolibin Flats

The implementation of an effective drainage system was listed in the Toolibin Lake Recovery Plan as one of the short term emergency actions. Surface drainage on the Toolibin Flats, within private property and adjacent nature reserves, was proposed to alleviate water-logging of agricultural lands and prevent more saline run-off from entering Toolibin Lake. The work was given an urgent and essential priority and it became an Environment Australia Scope Item for 1994/95. The work was also to include the design of a monitoring system to evaluate the effectiveness of drainage works, which is discussed in Section 2.9.2.

A consultancy had been established in 1992 with GHD Pty Ltd to determine the feasibility of the various options that had been proposed for the Toolibin Flats Drainage. The report, 'Lake Toolibin Hydrological Studies', also included a draft document by T. Negus of the former WA Department of Agriculture, Narrogin, 'Toolibin Flats Surface Drainage Network Preliminary Design Proposals'. These reports provided CALM with sufficient technical information to submit 'Proposals to Divert Saline Flows within Toolibin Lake and a Surface Drainage Scheme' to the NPNCA. This report included two recommendations for the NPNCA, regarding endorsement of the sub-catchment drainage proposal and a separator proposal, which is discussed in the following section. Both recommendations were approved by the NPNCA.

West Toolibin was chosen as a trial sub-catchment, as it was one of the least saline areas and there was considerable landowner interest. This would test the efficiency of 'w' drains, grade banks and interceptor banks before applying them across the catchment.

A consultancy was established with hydrologists Jim Davies and Associates to design the drainage scheme for West Toolibin Catchment. Throughout the entire design process, there was regular interaction between the Consultants, AgWA, CALM and the other stakeholders in Toolibin Lake and Catchment regarding options, decisions and progress. The drainage meetings focused on the objectives of CALM and the farmers within West Toolibin Catchment and discussed the progress of design work by Jim Davies and Associates. This liaison was an important aspect of ensuring that works completed were meeting the objectives of all parties concerned.

Table 2: Recovery actions implemented for West Toolibin surface water control

Action	Financial Year	Cost	Funding Source	Outputs/Outcomes
Feasibility Study of surface water drainage for agricultural lands- Report by GHD	1992/93	\$19 500	Environment Australia	Determined the feasibility of the various options that had been proposed for the Toolibin Flats drainage.
Surveying of levels in West Toolibin Catchment by the Water Authority	1994/95	\$9 209	Environment Australia	Provided contour data necessary for the design and construction of drainage on agricultural lands & through nature reserve.
West Toolibin Surface Drainage Design by Jim Davies & Associates	1994/95	\$12 500	Environment Australia	Detailed assessment of flows & volumes, channel design, construction & operating checklists
Construction of drainage works in West Toolibin Catchment - nature reserve component	1994/95	\$5 230	Environment Australia	Provided drainage to alleviate waterlogging on the nature reserve section of the West Toolibin Catchment
Construction of drainage works on private property	1994/97	Not costed	Alcoa of Australia and local landholders	Provided drainage to alleviate waterlogging on the farmland section of the West Toolibin Catchment

Implementation of drainage works on the flats had been contentious for many years because landholders were suffering from water-logging, but agencies were concerned that drainage would place increased pressure on Toolibin Lake. Agreement to the drainage system included informal agreement by landholders to increase revegetation with perennial species and thus assist with groundwater control. Since the drainage scheme was implemented, significant areas have been revegetated.

There are still, throughout the catchment, on-going issues concerning the ability of landholders (including government) on the poorly drained flats to take speeded drainage from up-slope. The Toolibin West project demonstrated the importance of:

- proper engineering of surface drainage; and
- close interaction between technical experts with good communication skills and the land managers (government and private) affected by drainage.

3.3.2 Diversion of Saline Flows from Toolibin Lake

The Recovery Plan identified the need to control saline catchment run-off from entering Toolibin Lake. Initially this was envisaged as a drain that would by-pass highly saline flows around the Lake. However, this would be prohibitively expensive given the local topography. This issue was not resolved during the original planning process, and an officer from Water and Rivers Commission proposed that an effective drain to separate fresh and saline flows could be constructed on the floor of the Lake.

This approach was considered feasible by the Recovery Team and Technical Advisory Group, and in March 1995 Jim Davies and Associates produced a second report - 'Lake Toolibin Control Works' - which details a separator gate and diversion drain to prevent highly saline run-off from entering Toolibin Lake by diverting it around Toolibin and Lake Walbyring to Taarblin Lake.

Table 3: Recovery actions implemented for the diversion of saline flows into Toolibin Lake

Action	Financial Year	Cost	Funding Source	Outputs/Outcomes
Design for the diversion of saline catchment flows from entering Toolibin Lake-report by Jim Davies & Associates 'Lake Toolibin Control Works'	1994/95	\$10 564	Environment Australia	Detailed design of a drain and flow control point at the inlet channel of Toolibin Lake via a separator gate and diversion drain running along the western side of Toolibin Lake, past Lake Walbyring to Taarblin Lake.
Construction of separator gate and drains at Toolibin Lake by Archibalds & Co (W1/95)	1994/95	\$74 605	CALM	Allowed fresh surface water to flow into Toolibin Lake, while protecting the Lake from the more saline flows entering.
Cement revetment mattress	1994/95	\$33 586	CALM	Prevented erosion from occurring at the separator gate
Power and other materials	1994/95	\$14 160	CALM	Provision of power to the site, additional required materials and fencing of adjacent property during drainage construction.
Extension of drainage works to Taarblin Lake by Archibalds & Co	1994/95	\$80 000	CALM	Allowed for the disposal of saline effluent at Taarblin Lake, a degraded wetland 6.5 km downstream.

3.3.3 Further Surface Water Control Works: North East Toolibin Catchment

Following the successful completion of the separator gate at Toolibin Lake, transfer drain to Taarblin Lake and drainage works in West Toolibin Catchment, the next stage in the surface water control program for the Toolibin Flats was the implementation of drainage works for other sub-catchments.

Table 4: Recovery actions implemented for North East Toolibin surface water control

Action	Financial Year	Cost	Funding Source	Outputs/Outcomes
Surveying of levels in Dulbinning Nature Reserve and private property within North East Toolibin Catchment	1998/99	\$24 430	\$5 000 by Lake Toolibin Catchment Group, remainder paid by Salinity Action Plan*	Determine position of surface flows within an extremely flat site in order to design drainage. Construction of drains will improve drainage on North Toolibin Road, through Dulbinning Nature Reserve and assist in prevention of water-logging on private property.

* A special allocation of WA Government funds.

The North East Toolibin Project has been established as a joint effort between CALM, the Wickepin Shire and the Lake Toolibin Catchment Group. It has been an excellent example of different groups co-operating to achieve common objectives: improving road access, alleviating water-logging of agricultural land and potentially, water-logging of parts of the nature reserve. The Lake Toolibin Catchment Group has contributed \$5 000 to the surveying part of the project, due to the area of private property involved. Following discussions of the surveying results with the relevant parties, the next step to be implemented is the tendering out of the design for the drainage works. This will be followed by the drainage construction, which is anticipated to be in summer

1998/99. The Wickepin Shire will be contributing approximately \$11 000 to drainage works on North Toolibin Road. CALM will be responsible for any drainage works on Dulbinning Nature Reserve, using State Salinity Action Plan funding. Drainage works on the private property will be met by either the LTCG or the individual landholder.

3.4 Lake Outlet Control

3.4.1 Feasibility Study

The Recovery Plan identified the need for a feasibility study to determine the possibility of temporarily increasing outlet flows from Toolibin Lake, Walbyring Lake and Taarblin Lake by modification of the connecting channels. This increase of outlet flows from Toolibin Lake would allow more frequent flushing of accumulated salt in the lake, which would then reduce the salt load of the lake and limit the maximum salinity reached as the lake dries by evaporation. A lake water management study is required in order to design works options and operation rules for lake releases. This process will involve consultation with all interested parties, including local landholders.

A survey of the connecting channels was completed prior to commencement of the feasibility study and as part of the assessment of the separator and diversion channel. With the construction of the separator and diversion, and outlet control structure discharging into the diversion channel is now a comparatively simple task. Technical aspects of outlet control are currently being discussed by the Recovery Team and Technical Advisory Group.

The Recovery Plan Implementation Schedule stated that work on the Lake Outlet Control would be implemented in 1994. This did not occur, but funds have been set aside from the 1998/99 State Salinity Action Plan budget for this work to be completed. It is anticipated that additional surveying and the feasibility study will be completed by the end of 1998.

3.4.2 Lake Outlet Control Works

Following the completion of the feasibility study described above a tender will be prepared for the implementation of control works. This will involve a simple structure allowing drainage from the lake into the diversion channel connected with the separator. This work is scheduled for early in 1999, dependent on lake bed accessibility.

3.5 Enhancement of Lake and Reserve Vegetation

3.5.1 Protection from Grazing

Vegetation surveys have identified seedling recruitment of *Casuarina obesa* on the lake bed, however, the survival of these seedlings has tended to be poor due to grazing. CALM staff have erected fencing around a cluster of seedlings close to the bund and these seedlings have successfully grown to a height where they will now be able to withstand inundation.

There has been limited recruitment of *Melaleuca strobophylla* on the lake bed. Although only a small area, these seedlings have successfully survived without being fenced. CALM staff will continue to monitor the stands of seedlings.

Toolibin Lake Nature Reserve is included in the Narrogin District's 1080 baiting program to control rabbits. Measures will be implemented to control numbers of kangaroos if it is seen as necessary. Fencing will also be erected around any new groups of seedlings to protect them from grazing.

A student (G Ogden) from Edith Cowan University has completed a study of *Casuarina obesa* seedlings where exclosures were erected to ascertain the impact of grazing and seedling growth was monitored in detail. The results were then related to lake inundation regimes. CALM may

implement a similar study for *Melaleuca strobophylla*. Future seedling recruitment may be incorporated into the regular vegetation surveys at Toolibin Lake.

3.5.2 Construction and Planting of Artificial Gilgai Mounds

Most of the remaining healthy vegetation on the lake bed is located on raised gilgai mounds, which provide an increased distance between the root zone of the trees and the saline water table. The Recovery Plan recommends the construction of artificial mounds to be revegetated, as a trial at Dulbinning Lake and then at Toolibin Lake. CALM has delayed this work until the impacts of the groundwater pumping become clearly evident, in order to minimise potential damage to the lake bed. A recent salinity survey of the lake bed and the on going monitoring of the water table depth have given an early indication that the pumps are creating an impact on the water table within an immediate zone of each pump. If this trend continues, revegetation efforts can be concentrated in this zone around each pump.

3.5.3 Fire Management

The use of controlled burning to initiate regeneration within the nature reserves has been limited with one trial burn conducted at Toolibin to date. This work will be taken further however it remains a low priority at this stage. It is intended that future burning trials will be conducted in bush on the eastern side of Toolibin Nature Reserve, to test regeneration of jam (*Acacia acuminata*).

3.5.4 Revegetation of the Bund

In July 1998 a Tree Planting Day was organised for Toolibin Lake. The aim of the day was twofold, to revegetate areas on and surrounding the diversion channel, and to help create a community sense of contributing to the recovery of Toolibin Lake. School children from Wickopin, Yealering and Tincurrin Primary Schools spent a half day tree planting at the lake, along with CALM staff and members from the LTCG. Four thousand trees were planted by the community groups, all of which were grown from seed collected from the nature reserve. *Casuarina obesa* were planted on the actual bund of the diversion channel and *Eucalyptus loxophleba* and *Melaleuca acuminata* were planted as infill in the vegetation buffer zone along the western edge of the lake.

Table 5: Recovery actions implemented for Reserve revegetation

Action	Financial Year	Cost	Funding Source	Outputs/Outcomes
Revegetation of the Bund	1998/99	\$2 125	Salinity Action Plan*	Commencement of an ongoing program to revegetate the bund with local species to improve aesthetics and prevent erosion. Trees were planted by local school children and members of the LTCG which greatly contributed to a sense of community input and cooperation with government agencies.

* A special allocation of WA Government funds.

3.6 Revegetation of Catchment

3.6.1 Land Management Planning, Revegetation of Deep Sands and Revegetation of Salt Affected Land

The Recovery Plan identified the need for surface water drainage and groundwater pumping as the short term, emergency actions to prevent Toolibin Lake from becoming saline. However, it is acknowledged that the long term solution is to increase water use in the catchment to re-establish a

hydrological system that favours conservation of Toolibin Lake as a freshwater ecosystem. A major activity to achieve this is to strategically revegetate the catchment with perennial plants. This work is also important for the establishment of sustainable agriculture in the catchment.

This strategy is in the hands of the catchment land managers and the LTCG. Although most land managers are farmers, agencies control some land and both CALM and Agriculture WA are involved in revegetation works. Most of the landholders within the Catchment have a farm plan, drawn up with assistance from the Community Landcare Co-ordinator based in the Shire of Wickelipin.

Revegetation and remnant vegetation protection within the catchment has, over the past decade, been stimulated by:

- Alcoa of Australia who have supported a range of catchment works, including revegetation.;
- land managers planting with their own resources on their land;
- CALM, through trial programs, particularly the various Toolibin Alley Farming Trials;
- oil mallee plantings under a program that has been variously supported by CALM, Farm Forestry Program, and the Oil Mallee Association and Oil Mallee Company;
- State Remnant Vegetation Protection Scheme;
- funding through the Gordon Reid Foundation;
- Federal funding through programs such as the Farm Forestry Program and the National Landcare Program; and
- Greening WA through programs such as the One Billion Trees Program.

In April 1994 the West Toolibin Catchment Management Plan was formulated, with support from Alcoa, who will have funded up to \$230 000 in landcare activities in Toolibin Catchment over a five year period. A combination of revegetation and drainage works were used to pursue the following objectives:

- increase of plant water use within the Catchment;
- increase total productivity within the Catchment;
- decrease groundwater recharge and the rise of saline groundwater to the surface;
- decrease the volume of water leaving the Catchment in the long term.

The Lake Toolibin Catchment Group has been very successful in the past in attracting grants to implement revegetation, fencing and surface drainage. Between 1991 and 1994 the West Toolibin Catchment Group had revegetated 4.5 km of creek lines, planted 4.8 km of windbreaks, planted a 5 ha woodlot, revegetated 90 ha of salt land, fenced 80 km of remnant vegetation, planted 8 ha of tagasaste and constructed 4 km of interceptor banks. This work continued once Alcoa funding began in 1994.

Scriveners Soak Sub-catchment group have also been very active. Alcoa has funded plantings by this catchment group since 1993. In 1997 Alcoa funded works consisted of 9 km of fencing, 14 238 native seedlings and \$400 for weed control. 1996 saw the Western Power Greening Challenge commence, with 35 000 seedling plus fencing provided for Scriveners Soak by Western Power. Revegetation continues in 1998, with Tincurrin Primary School planting 1 000 seedlings along the Harrismith-Tincurrin Railway Reserve and the Catchment Group receiving a grant for the Blackwood Community Partnerships Project.

The following table summarises the funding the Lake Toolibin Catchment Group has been awarded for various landcare activities since 1990:

	1990-93	1994	1995	1996	1997	1998
Blackwood Basin Group Partnership				\$11 800		\$15 000
Remnant Vegetation Protection Scheme			\$630		\$2 520	
Western Power				\$16 694		
Gordon Reid Foundation			\$3 623	\$19 569		
Alcoa	\$45 379	\$59 023	\$24 100	\$20 539	\$19 840	\$19 596
National Landcare Program		\$18 000	\$8 530			
Natural Heritage Trust						\$25 484

This gives a total figure of \$310 327. Of particular note is that the Lake Toolibin Catchment Group received the inaugural Shirley Balla Wetland Award in 1995 for their contribution to managing the Toolibin wetlands.

CALM has also maintained an interest in Catchment revegetation, as outlined in Table 6.

Table 6: Recovery actions implemented for Catchment revegetation

Action	Financial Year	Cost	Funding Source	Outputs/Outcomes
Property purchase adjacent to existing nature reserve system	1998/99	\$95 250	Salinity Action Plan*	Biodiversity plantings will increase the area of nature conservation habitat in the Toolibin reserve system and revegetation trials are currently being designed to develop commercially productive species in configurations that will integrate sustainable agriculture with conservation of biodiversity.
Data entry for REX database	1997/98	\$1 000	Salinity Action Plan	The database will help government agencies and private landholders in choosing revegetation species and techniques.
Oil Mallee plantings of 44.6 km hedge (60 000) seedlings in Toolibin Catchment	Since 1992	#	State Government and landholders, and Farm Forestry Program	Has provided an example on a catchment scale the potential of revegetation by landholders which will provide a financial gain and increase water use within the property.

* A special allocation of WA Government funds.

Costs for Oil Mallee plantings are spread over a state wide project. No costs specific to Toolibin Catchment are available.

A database is currently being developed that will be released in the new REX computer data base. This will assist in determining revegetation species and techniques for both government agencies and private landholders. Other current work includes the proposed introduction of an oil mallee subsidy in 1999 to landholders within sections of the Toolibin Catchment that are a priority for

revegetation. This subsidy is being developed through close consultation between representatives of the Recovery Team, Technical Advisory Group and LTCG to ensure that funds are strategically applied and catalytic.

The production of a revegetation manual (Baxter and Bicknell 1996) for the catchment is an excellent example of a collaborative project that has produced an important reference source for Toolibin Catchment that is also very useful and relevant to other agricultural areas.

3.6.2 EM Surveying of Potential Salt Affected Land

Determining the electrical conductivity of potentially salt affected land within the Toolibin Catchment was identified as an action in the Recovery Plan. This work would provide information on the top 5m of the soil profile, done by either ground or aerial survey. The final product would be maps of high, medium and low soil profile salt storage. This would allow the selection of suitable tree species and location of tree planting in order to maximise productivity and water use.

Table 7: Recovery actions implemented for salinity surveying

Action	Financial Year	Cost	Funding Source	Outputs/Outcomes
Salinity survey of Toolibin Lake and immediate surrounds by Tesla 10	1997/98	\$5 800	Salinity Action Plan*	Produced a deep subsoil salinity map and a root zone salinity map. These will be important tools when planning lake bed revegetation and can be used as a benchmark to gauge progress of recovery actions.

* A special allocation of WA Government funds.

At a catchment scale, work with airborne geophysics and associated drilling is building a picture of the soils, geology, topography and salt storage that far exceeds anything contemplated during the writing of the Recovery Plan. This work is being funded under the National Dryland Salinity Program in conjunction with State agencies, and will be reported elsewhere. However, this work is making a major contribution to our understanding of catchment processes.

3.6.3 Alley Style Revegetation of Toolibin Flats

The Recovery Plan identifies CALM as the primary party responsible for the Alley style revegetation of Toolibin Flats. The objective of this strategy is to maintain groundwater levels at least 1.5 m below the ground surface of Toolibin Flats without loss of farm productivity. Alley style tree plantings have demonstrated that trees can maintain groundwater below 2.0 m, while still allowing cropping between the belts of trees or grazing after two years. The alternative is that large areas of the Toolibin Flats will become saline, resulting in decreased agricultural production and increased salinity of streamflow.

CALM has been successful in establishing alley trials in Toolibin Catchment according to the Implementation Schedule. In December 1994 a contract Revegetation Officer was employed to design and implement an alley style revegetation trial. Of the five sites originally researched, two sites on the Toolibin Flats were selected within private properties owned by the White and Davenport families. The work was designed according to a CALM Science and Information Division Science Project Plan. Technical input was provided by a Technical Advisory Group, consisting of members from CALM and Agriculture WA.

The general objective of the project was: 'to effectively integrate conservation of natural biodiversity and achievement of sustainable rural production' (Toolibin Alley Farming Trial, Year 1 Report). It was based upon the knowledge that woody plants can contribute to the mitigation of rising water tables, salinity and erosion. A specific aim was to determine the best combination of

belt width, alley width, revegetation density, and species to achieve this.

Three hypotheses are to be tested by the Toolibin Alley Farming Trial (TAFT) :

- crop and pasture production in the alleys will increase relative to untreated (control) areas;
- viable commercial products such as eucalyptus oil and farm timber will be harvested from the belts of revegetation;
- the total value of the commercial production from the new systems will be greater than the value of agronomic production from similar, untreated areas.

The experimental design involved four levels of revegetation, achieved by different combinations of belt widths and alley widths. The vegetation densities were planted at 0% (control), 15%, 30% and a 100% block planting. Four belt widths were compared: 32m, 18m, 11m and 4m. Species used were all regionally located and were suited for either timber, fodder or eucalyptus oil. The key species planted were *Eucalyptus vegrandis*, *E. occidentalis* and *Casuarina obesa*. Other minor species being tested are *Acacia acuminata*, *A. saligna*, *E. astringens*, *E. kondininensis* and *E. loxophleba*.

The TAFT involved a number of dependent variables for measurement and analysis: water table level and salinity, soil salinity, productivity of the trees in the belts and pasture/crop productivity in the alleys. The trial aimed to identify how these dependent variables change along a transect A→B where A is the centre of a belt of trees and B is the centre of an alley. This will allow for the determination of the revegetation density and alley/belt width combination that will maximise long term benefits for both agriculture and land conservation.

From July 1996 water table level and salinity have been monitored by CALM staff every month for the first 12 months and then twice yearly for 71 piezometers at Davenport's and 41 piezometers at Whites'. At this stage it is premature to determine any trends in either salinity or water table depth other than seasonal fluctuations. All data is stored on the Combos database.

Table 8: Recovery actions implemented for Alley Style Revegetation

Action	Financial Year	Cost	Funding Source	Outputs/Outcomes
Toolibin Alley Farming Trial	1994/95 1995/96	\$ 35 053 \$26 660	CALM	Tested revegetation strategies to effectively integrate conservation of natural biodiversity with sustainable rural production.
Toolibin Melaleuca Trial	1996/97 1997/98	\$22 214 \$4 828	Salinity Action Plan*	For a specific soil type and landscape position within the Catchment, the trial will determine the best planting configurations and demonstrate the economic value of local melaleuca species

* A special allocation of WA Government funds.

Other analyses involved in this study are annual soil surveys using an EM-38, final grain yield using an experimental plot harvester, annual pasture production using a calibrated visual rating technique and tree growth and production. This last variable is to include measurement of survival rates, tree height, crown volume index, basal area, commercial productivity and parrot damage. However, it should be noted that it has not been practicable at this stage to establish any of the agronomic trial monitoring. This will be dependent on future resources. The result of this is a limited ability to achieve the project aims as described above, or to determine the accuracy of the project hypotheses.

Following the implementation of the TAFT the program of alley style revegetation of the Toolibin Flats was continued with a Melaleuca Trial in 1997. This trial consisted of two plantings, an alley farming trial of melaleuca species on Ron Miller's property and blocks of single species plus a direct seeding trial on Whites' (Nepowie).

The objectives of the Alley Farming Trial Site at Miller's were to:

- demonstrate that revegetation in belts will lower groundwater tables and be profitable for farmers when implemented in heavy clays in lower parts of wheatbelt catchments threatened by salinisation;
- determine the best combination of belt/alley width and revegetation density for the above soil type and landscape position;
- demonstrate the economic value of local melaleuca species;
- stimulate significant farmer driven revegetation within the Toolibin and other wheatbelt catchments.

Three species were used for the alley farming trial at Miller's: *Melaleuca acuminata*, *M. lateriflora* and *M. uncinata*. Four different density layouts were tested, as devised for the TAFT. Soil salinity, chemistry and water table depth and quality were measured prior to planting the site. A set of 22 piezometers were established at the site, which as for the TAFT were monitored for water table depth and salinity once a month for the first 12 months and then twice a year. As with the TAFT trends are not yet able to be determined.

Objectives for the seed production block planting and direct seeding demonstration at Whites' were to:

- increase the amount of perennial vegetation on the flats surrounding Toolibin and Walbyring Lakes;
- create a seed orchard for species native to the area;
- establish vegetation by direct seeding on heavy clay soils.

Species planted in the seed orchard were *Eucalyptus loxophleba*, *Casuarina obesa*, *Melaleuca acuminata*, *M. lateriflora*, *M. strobophylla* and *M. uncinata*. The direct seeding trial contained all of these species mixed together. This site also had an electromagnetic survey done using an EM-38. No piezometers were established at this site to measure groundwater depths.

Infill occurred at both sites in July 1998. Given the high levels of salinity and waterlogging at these sites and poor quality of seedlings, growth achieved has been very good. Germination within the direct seeding trial has been limited, however further germination may occur in 1998. Salinity and water table monitoring at Miller's by CALM staff will continue. This will allow progress towards project objectives to be assessed.

3.6.4 Break of Slope Revegetation

The objective of this action item is to establish a broad belt of trees around the margin of the Toolibin Flats. The break of slope between the uplands and the Toolibin Flats has a greater potential for groundwater discharge than adjacent areas. This work would involve establishing trees in co-ordinated belts or blocks throughout the break of slope. The species, location and priority of works could be determined by site specific EM-38 surveying. The Implementation Schedule of the Recovery Plan stated that break of slope revegetation could be implemented over consecutive years from 1994 to 2003. CALM has not yet implemented any of these plantings, but a significant amount of State Salinity Action Plan money has been set aside for catchment revegetation in 1998/99, a portion of which will be set aside for break of slope plantings. It has been estimated that approximately 500 ha of this type of plantings will be required, which would be implemented over a number of years. A register of tree plantings will be established for this work, as well as a set of

piezometers to monitor groundwater levels.

3.7 Agronomic Manipulation

3.7.1 Control of Waterlogging

The objective of this action item is to increase the use of soil water by crops and pastures, by improving soil drainage. Soils that are waterlogged have an increased potential for groundwater recharge. Waterlogging reduces crop and pasture productivity which also reduces the potential for water use. These works are the responsibility of the LTCC, catchment landholders and Agriculture WA. Works involve the construction of interception drainage to prevent inundation and waterlogging of the Toolibin Flats. In 1995 and 1994 extensive, co-ordinated drainage works were undertaken in the West Toolibin Flats, to the benefit of both local farms and the adjoining nature reserve system. Please refer to Section 3.3: Feasibility, Design and Implementation of Surface Water Control for Toolibin Flats for a detailed account of works implemented. Grade banks, contour farming, aspects of key-line farming and other works to control waterlogging have been variously implemented in the catchment. To date, these have not been documented.

3.7.2 Soil Structure Improvement on the Toolibin Flats

Agricultural methods such as minimum tillage, deep tillage, stubble retention, gypsum application, increased nitrogenous fertiliser applications and reducing stocking of saturated soils can all contribute to developing agricultural systems with improve soil structure and potential for increased water use. This work is under the jurisdiction of the LTCC, catchment landholders and Agriculture WA. No documentation of this work is currently available.

3.8 Development of a Decision Support System

The development of a computer based decision support system was recommended in the Recovery Plan to allow the Toolibin Lake Recovery Team to consider all available information during implementation and on-going management of the Recovery Plan. This would be of great assistance given the technical nature of many of the issues related to Toolibin Lake and the complexity of considering combinations of factors when making management decisions.

The Recovery Plan recommended the system include the following components:

- groundwater levels beneath Toolibin Lake;
- groundwater levels beneath Toolibin Flats;
- lake water levels in Toolibin Lake;
- lake inflow volumes;
- period of inundation.

The Implementation Schedule of the Recovery Plan named CALM as responsible for this project, to be completed in 1994. It was not completed in that year, however, a contract has been implemented in 1998, under Environment Australia funding, for a digital groundwater model. Sinclair Knight Merz has been contracted to construct and calibrate a groundwater model of the pumping system in operation at Toolibin Lake and to then use this model to predict the groundwater

response to pumping under different conditions. This model will allow managers of Toolibin Lake to make decisions regarding:

- installation of additional groundwater pumps, including volumes and locations;
- temporary or permanent cessation of groundwater pumping;
- effectiveness of steady state draw-down pattern under current operation compared to different operating conditions;
- optimal inflow and outflow conditions of Toolibin Lake.

Table 9: Recovery actions implemented for a decision support system

Action	Financial Year	Cost	Funding Source	Outputs/Outcomes
Digital Groundwater Model	1998/99	\$22 000	Environment Australia	Will assist managers of Toolibin Lake in decision making process regarding groundwater pumping requirements.

3.9 Monitoring and Reporting

It is crucial to the success of the Recovery Plan that a thorough and efficient monitoring program is implemented at Toolibin Lake and Catchment. A collection of baseline data is the first requirement, to give an understanding of the health and condition of the system. This can then be used as a comparison to gauge the effectiveness of the recovery actions implemented. Monitoring results also assist in making management decisions. All monitoring completed should be analysed and interpreted to allow for any changes that may be required to the implementation of the Recovery Plan.

3.9.1 Groundwater Monitoring

Monitoring of groundwater at Toolibin Lake and in the catchment allows for assessment of progress made towards achieving the recovery criteria. These criteria state that the maximum salinity of the lake water when full should be 1 000 mg/l Total Dissolved Salts. The minimum depth to the water table beneath Toolibin Lake and Toolibin flats in spring, when the lake is dry, should be 1.5m.

CALM have successfully monitored the existing bore network on a monthly basis. Water table depth is measured monthly at 27 bores at Toolibin Lake and at 7 bores at Taarblin Lake and adjacent private property. Water table depth and salinity has been measured every 12 months and then twice annually at the two Toolibin Alley Farming sites and the Melaleuca Trial site.

Within the catchment there are a large number of bores for which the LTCG have taken responsibility for monitoring. Data from these bores is stored in an Agriculture WA system.

Pumped volumes and water quality from production bores have not been monitored monthly by CALM staff, however, they have been regularly sampled by contract staff who are maintaining the pumping system. The Recovery Plan also required that a monthly report be prepared and submitted to the Recovery Team on a fixed date each month to assist decision making. To date, CALM has not been formally following this process as most of the routine monitoring and management decisions are completed within the Department. Reporting procedures will evolve as the pumping process becomes better established.

3.9.2 Surface Water Monitoring

Regular and accurate monitoring of surface water is also crucial to the implementation and adaptation of the Recovery Plan. The Water and Rivers Commission have provided support for the continued operation of the Northern Arthur River gauging station 610090, which is located at the

Toolibin Lake inflow channel, by Harrismith Road. This gauging station contains a continuous data logger, measuring flow rates and salinity. CALM staff may access this data when deciding whether to open or close the separator gate at Toolibin Lake. During this time CALM staff make daily salinity readings of the surface water at the gate to determine when water is fresh enough to close the gate and allow it to enter Toolibin Lake.

The Recovery Plan requires monthly monitoring of all existing and constructed drains at Toolibin Lake and associated reserves. This is currently done by Agriculture WA, who have monitoring stations on Oval and Canal Roads, slightly north east of Toolibin Lake.

Whenever surface water is present at Toolibin Lake CALM staff conduct salinity and nutrient sampling at six sites across the lake every six weeks. Data is stored at CALM and copies sent to appropriate staff within CALM, WRC and Agriculture WA. Salinity measurements are useful to assess the progress of recovery actions and nutrient levels are monitored to ensure CALM staff are aware of potential botulism outbreaks. As with groundwater monitoring, CALM does not, given the seasonality of the lake, prepare and submit monthly reports of results to the Recovery Team as described in the Recovery Plan.

In March 1998 the TAG conducted a monitoring review meeting, to discuss current monitoring and determine further requirements. The surface water monitoring program required various additions or upgrades for optimal data collection. These included the upgrade of Agriculture WA monitoring of the drainage network described above, an upgrade to the WRC monitoring station 610090 to improve measurement of flow, rainfall, temperature and conductivity, and the re-activation of the WRC multi port tower in the central east section of the lake bed to provide continuous electrical conductivity readings. Of these three tasks only the first has been completed. Other additions to surface water monitoring determined at the meeting were the installation of a monitoring station at the separator gate to measure flow, temperature and conductivity, and monitoring stations at the natural and proposed artificial outflow channels to measure flow, temperature and conductivity. CALM will liaise with WRC and Agriculture WA during 1998/99 to implement this additional monitoring.

Table 10: Recovery actions implemented for surface water monitoring

Action	Financial Year	Cost	Funding Source	Outputs/Outcomes
Funding to Agriculture WA for surface water monitoring in Toolibin Catchment	1997/98	\$4 100	Salinity Action Plan*	Allowed for an upgrade of surface water monitoring facilities, which assess the impact of surface water drainage works completed in West Toolibin Catchment.

* A special allocation of WA Government funds.

3.9.3 Vegetation Monitoring

The objective of the vegetation monitoring program is to monitor the condition of vegetation at Toolibin Lake and the associated reserves. This will assist in determining the extent to which the Recovery Plan is working and help in making management decisions. Specific areas that this monitoring will help assess are:

- vegetation health, including further deterioration or improvements;
- impacts of groundwater pumping;
- impacts of surface water diversion;
- assessment of grazing management;
- assessment of natural regeneration trials;
- regeneration from fire management trials.

A baseline flora and vegetation survey was conducted in 1977 for the Northern Arthur River Wetlands Rehabilitation Committee by Mattiske Consulting, who have regularly surveyed the terrestrial and lake vegetation at Toolibin since that time. This work involved establishing 22 vegetation monitoring plots and mapping plant communities and their status and condition. Four additional plots were established in 1980 in the reserve to the north of the lake, to record the impact of clearing and burning activities. Eleven of the 26 plots are located on the actual lake bed with the remainder found on the reserves to the north east of the lake. Reassessment of the plots was conducted in 1980, 1982, 1986 (including seedling sub-plots), and 1992.

Dr Ray Froend, of Edith Cowan University, has also surveyed vegetation at Toolibin Lake in order to investigate the causes of lake bed tree mortality. A one-off intensive study of the lake bed vegetation was conducted in 1983, when five lake bed transects and four study plots were established. These plots were re-measured in 1988. Four plots at Toolibin Lake are also monitored as part of the Salinity Action Plan Wetland Monitoring. The plots previously established by Froend and Mattiske will now be monitored to both SAP standards and to the standard set by previous consultants.

Table 11: Recovery actions implemented for vegetation monitoring

Action	Financial Year	Cost	Funding Source	Outputs/Outcomes
Surveying of vegetation plots at Toolibin	1980, 1982, 1986 & 1993	\$15 120	CALM	Provides continued data set from vegetation surveying originally completed by Mattiske Consulting for the Northern Arthur River Wetlands Rehabilitation Committee.
Surveying of vegetation plots at Toolibin	1998/99	\$13 021	Salinity Action Plan*	Continues data set to specifications of previous consultant and the State Salinity Action Plan methodology. Vegetation surveying will also provide an important method of assessing the impact of recovery actions.

* A special allocation of WA Government funds.

This surveying has focused primarily on monitoring of the overall vegetation condition at Toolibin. However the survey plots will also be indicative of regeneration success and grazing impacts. The effect of the groundwater pumping and surface water diversion on vegetation has to date been difficult to assess accurately. Future surveying should be able to determine any improvements of lake bed vegetation, which will be indicative of the success of recovery actions. To date limited fire management trials have been implemented at Toolibin. This will be part of future works, as will monitoring of the lake bed revegetation program that is to be implemented.

CALM also has a commitment to vegetation monitoring within a wider context than Toolibin Lake. Toolibin Catchment is the focus of a variety of monitoring and research programs. The TAG monitoring review identified a need for all remnant vegetation within the Catchment to be assessed for biological risk in relation to salinity, interaction with bore data and a general monitoring strategy. Agriculture WA has compiled a draft list of nature reserves within the Catchment that may be at risk of salinisation. Once the biological components of each reserve has been listed a monitoring program can be implemented. This would be the responsibility of CALM for all nature reserves within the Catchment and any remnant vegetation on crown land, and the responsibility of the Wickepin Community Landcare Co-ordinator for any remnants on private property.

3.9.4 Aquatic Invertebrate Monitoring

Regular monitoring of the invertebrate species diversity and numbers at Toolibin Lake and associated wetlands is necessary in order to assess the quality of food resource available to breeding waterfowl. Invertebrates are often sensitive indicators of water quality change and can be used as another indicator as to whether recovery criteria are being met.

Invertebrate monitoring at Toolibin, Walbyring and Dulbinning Lakes has been sporadic and of limited use in assessing temporal changes in community structure due to changes in water quality. This has been due to minimal sampling over a short time frame, no standard methodology and a lack of standard levels of taxonomic resolution being employed. Studies have previously been completed by Halse of CALM and by Doupe and Horwitz of Edith Cowan University.

The TAG monitoring Review determined that monitoring of macroinvertebrate and microinvertebrate fauna, including Ostracoda, is to occur every second year as part of the SAP monitoring program. If monitoring is required out of sequence years, it is to be completed and paid out of Toolibin Recovery Funds. Methodology for this monitoring is to follow the Monitoring Review and is to occur at two sites within Toolibin Lake.

Table 12: Recovery actions implemented for invertebrate monitoring

Action	Financial Year	Cost	Funding Source	Outputs/Outcomes
Funding to Edith Cowan University for studies at Toolibin Lake and surrounding farm dams	1997/98	\$1 048	Salinity Action Plan*	Data on invertebrates, an important food resource to water fowl. May be an indicator of water quality change and provide a tool to measure whether recovery criteria are being met.

* A special allocation of WA Government funds.

3.9.5 Waterbird Monitoring

One of the primary reasons a Recovery Plan was established for Toolibin Lake was the important role the lake played as a habitat and breeding area for waterbirds. This factor and the unique vegetation association found across the lake bed are the major reasons the lake is listed as a RAMSAR Wetland.

To ensure that the current habitat values of the lake continue to be met, an on-going waterbird monitoring program must be implemented to establish the numbers, species diversity and breeding success of waterbirds visiting the lake. CALM conducts waterbird monitoring at Toolibin Lake every second year if water is present, as part of the SAP wetland monitoring program. If Toolibin Lake holds water on a non SAP monitoring year, waterbird monitoring will still occur, using Toolibin Recovery funds.

3.9.6 Toolibin Data Review and Analysis

Due to the wide range of complex factors that have been monitored at Toolibin Lake, often with no continuity or cohesion with other monitoring programs, the Recovery Plan pointed out the need for a detailed report on all monitoring that had previously been completed at Toolibin and any requirements for additional monitoring. This work was done by Froend and Storey (1996). The report 'Monitoring Design and Data Analysis Toolibin Lake and Catchment, produced in December 1996, consisted of two documents. Part 1: Review and Analysis of Monitoring Data and Part 2: Monitoring Design. The two reports have been of great benefit in locating previous monitoring data and deciding on future monitoring requirements.

Table 13: Recovery action implemented on monitoring data reporting

Action	Financial Year	Cost	Funding Source	Outputs/Outcomes
Toolibin Data Review and Analysis by R. Froend and A. Storey	1996/97	\$30 000	CALM	Provided a detailed review of all monitoring that had been completed for Toolibin and assessed requirements for additional monitoring.

3.10 Salt Harvesting and Aquaculture

It may be possible to make use of the saline water available throughout the agricultural region by the promotion of industries such as salt harvesting or aquaculture. Inland aquaculture and small scale salt harvesting are both areas where very little research or works have been completed, although the two have been successfully combined in a Victorian venture. CALM intends testing the prospects of these industries in a co-ordinated project applied to the Toolibin system.

Table 14: Recovery actions implemented for salt harvesting development

Action	Financial Year	Cost	Funding Source	Outputs/Outcomes
Consultancy with Aries Pty Ltd to determine the feasibility of establishing a salt harvesting operation near Toolibin Lake (W10/96)	1996/97	\$7 000	CALM	Provided economic analysis that a salt harvesting venture at Toolibin may not be economically viable. The report provided a base for continued investigation into salt harvesting and aquaculture.

Little progress on salt harvesting or aquaculture was made for 18 months following this report. In mid 1998 a proposal was formulated by CALM for the Commercial Use of Saline Water at Toolibin Lake. It is hoped to develop an inter-agency project between CALM, Agriculture WA and Fisheries WA where a Steering Group would be responsible for:

- the formulation of a project plan;
- provision of advice to CALM on the development of a consultancy to conduct a detailed feasibility analysis of salt harvesting and primary production projects using saline water at Toolibin Lake;
- provision of advice on the development and implementation of aquaculture projects.

The objectives of the salt harvesting and aquaculture project at Toolibin Lake are:

- to develop and test techniques for disposing of saline effluent in a cost effective and environmentally safe manner, which at worst should be cost neutral;
- to develop new industries that are environmentally benign and contribute to the achievement of sustainable land use; and
- to extend results to the Australian community so that knowledge from Toolibin provides a firm basis for future developments.

Although it is not dealt with in the Recovery Plan, CALM sees this work as an important Recovery Action, as it provides an opportunity to test and develop new methods of dealing with salinity. CALM have allocated a considerable amount of 1998/99 SAP funds to the implementation of this work.

3.11 Communication and Interpretation

Work at Toolibin is not only perceived as important for the Lake and its catchment, it is a vital component of building the technical capacity to combat salinity in southern Australia. To achieve this goal, it is essential that the lessons learnt at Toolibin are communicated to others. Due to the technical and complex nature of many of the issues involved, a great deal has been learnt since implementation of the Recovery Plan that will be very relevant to others. Rising groundwater and salinity are major issues to the farming community and rural towns. It is hoped that the knowledge accumulated throughout the drainage, groundwater pumping and revegetation program will be used by those groups. The Recovery Team will make this information accessible by producing a set of Toolibin Technical Bulletins for used by groups such as town and shire councils, other government agencies, landholders, catchment groups and Land Conservation District Committees. These notes will range from those that are descriptive to others that are highly technical so that groups planning works similar to those at Toolibin have comprehensive information on which to build.

In addition to this, CALM is currently working on a Communication and Interpretation Concept Plan for Toolibin Lake and Catchment. This is being completed by the CALM Parks, Recreation, Planning and Tourism Division.

The Concept Plan will be aimed at interest groups such as catchment groups, schools, and nature enthusiasts. The Plan will include an information shelter at the lake, outlining the importance of Toolibin Lake and the Recovery Plan. There will be interpretative sites throughout the Lake and Catchment detailing points of interest and recovery actions such as drainage, groundwater pumping and revegetation. Also planned are walk trails, board walks, a waterbird observation hide, and access control measures.

Table 15: Recovery action implemented to develop a Communication Plan

Action	Financial Year	Cost	Funding Source	Outputs/Outcomes
Toolibin Communication and Interpretation Plan	1997/98	\$10 000	Salinity Action Plan*	Provides a tool for communicating to the general community the lessons learnt from the 'Toolibin Experience'. The Design Plan will allow for the construction of interpretation works at the Lake and Catchment.

* A special allocation of WA Government funds.

The Lake Toolibin Catchment Group are keen to become involved, particularly with Catchment issues. A set of information brochures will be produced on topics such as: RAMSAR Sites, Toolibin Lake waterbirds and vegetation, threats to Toolibin Lake, the Toolibin Lake Recovery Plan, Groundwater Pumping, the TAFT, the Lake Toolibin Catchment Group and Toolibin Catchment revegetation. CALM and the LTCCG will liaise over the production of these brochures, which will emphasise the need for co-operation between government agencies and private landholders when implementing such projects.

Section 4: Conservation Status

4.1 Assessment of Status

Toolibin Lake is unique in that it is funded by Environment Australia as a threatened ecological community rather than an individual threatened species. CALM is currently assessing other threatened ecological communities within the Western Australian Wheatbelt. However, until 1998, Toolibin Lake was the only community funded by Environment Australia for management, rather than for land acquisition.

CALM has developed a classification process for threatened ecological communities equivalent to that applied to the IUCN Red List Categories for Species. This classification process has been applied to the community of Toolibin Lake, resulting in an assessment by the Threatened Communities Advisory Panel of Critically Endangered. The Report "Identifying and Conserving Threatened Ecological Communities (TECs) in the South West Botanical Province" (English & Blyth, 1997) defines the category Critically Endangered as 'An ecological community which has been adequately surveyed and found to have been subject to a major contraction in area and/or which was originally of limited distribution and is facing severe modification or destruction throughout its range in the immediate future, or is already severely degraded throughout its range but capable of being substantially restored or rehabilitated.'

Toolibin Lake was assessed as fitting this category as it matched each of the three criteria outlined in the report:

- A) The estimated geographic range, and/or total area occupied, and/or number of discrete occurrences since European settlement have reduced by at least 90% and are continuing to decline such that total destruction of the community is imminent (within approximately 5 years).
- B) Current distribution is limited and there are very few occurrences, each of which is small and/or isolated and extremely vulnerable to known threatening processes.
- C) The ecological community exists only as highly modified occurrences which may be capable of being rehabilitated if such work begins in the immediate future (within approximately 5 years).

The Specific Recommendation for Toolibin Lake as a Critically Endangered Threatened Community was for the continued support by CALM staff of the recovery process as managed by the Recovery Team for Toolibin Lake wetland reserves 24556, 9617 and 14398. This has been achieved to date, however, the continuation of the recovery process will be dependent on ongoing funding by Environment Australia and the State Salinity Action Plan.

4.2 Changes in Status

Definition of Status

There are no IUCN categories of threatened status for communities. However, as discussed above, English and Blyth (1997) have defined and reported on threatened ecological communities in the South West Botanical Province. In their report, English and Blyth categorised Toolibin Lake as Critically Endangered. There has been no change in the condition of Toolibin Lake since that time that warrants a re-examination of the status of the lake.

Biophysical Status of the Lake

Over the short period of recovery plan implementation, the surface water quality of the lake and its use by waterbirds has been maintained. The quality of surface water entering the lake has been maintained or improved. However, during the same period there has been a decline of lake floor vegetation at a number of sites. Whether this decline continues or is arrested in the short to medium term will depend on the success of groundwater pumping. In the medium to longer term significant reductions in catchment recharge will also be critical for recovery of the lake.

The emergency measures listed in the recovery plan have, with the exception of the second and third phases of groundwater pumping, been implemented. Before further expansion of groundwater pumping is contemplated, it is essential that the effectiveness of the current bore field is better understood. The necessary knowledge should be available within two years.

In the meantime, it is vital that works in the catchment, particularly strategic revegetation, are significantly expanded. To achieve this will require on-going support from State and Federal funding sources.

Section 5: Knowledge/Understanding of the Community

The knowledge and experience gained by CALM and the community since implementation of the Toolibin Lake Recovery Plan in 1993 has been vast and varied. These changes need to be viewed in the context of synergistic interactions between the Toolibin Catchment Group and the Recovery Team, as well as the range of State, Federal and industry funding sources. All these players have been critical to the successes achieved and knowledge gained. Concentration of work has inevitably attracted other work, such as current geophysical and modelling research. Significant areas in which knowledge advances are being made include:

- interactions of groundwater and groundwater pumping;
- modelling of groundwater characteristics;
- technical development of groundwater pumping in situations like Toolibin (note, in particular, that knowledge should be transferable to recovery catchments under the rural towns rescue program);
- alley farming and interaction with groundwater (trials have recently begun, and are being further developed). This program is contributing to the development of sustainable, high water use production systems;
- development of commercially prospective species. Work at Toolibin is contributing to the development of prospective eucalyptus and melaleuca oil industries;
- relationships between invertebrates, waterbirds and salinity; and
- improved understanding of managing the socio-cultural aspects of catchment management.

It is very important to emphasise that the lessons learnt from Toolibin are applicable to rural landscapes across southern Australia, rather than exclusively within Toolibin Catchment. Such areas, in the long term, are facing very similar problems with salinity and will continue to do so unless effective recovery actions are implemented.

Furthermore, Toolibin Catchment is an important case study of what can be achieved on a catchment scale. It is proof that when government agencies, private enterprise and catchment groups work together towards a common goal, complex, on-ground management of natural systems can be delivered. To date there are no examples of landscape scale recovery in rural Australia. A major role of the work at Toolibin is to demonstrate that landscape scale management of salinity is practicable. If this can be shown, then rural Australia can take heart from the knowledge that difficult and complex long term goals can be achieved.

However, it will take some years for salinity to be controlled and then reversed at a catchment scale. A major challenge facing Toolibin, and all those who wish to manage salinity at a landscape scale, is to maintain and increase management works over the next decade even although, during the same period, salinity will worsen. Success will require considerable resolve and commitment of resources. The prize will be integration of sustainable land use and conservation of a significant element of the nation's natural diversity.

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