IMPACT ASSESSMENT
OF SURFACE WATER MANAGEMENT
PROPOSED FOR THE
LAKE BRYDE RECOVERY CATCHMENT

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and Jonelle Black

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November 2002

Prepared for the Department of Conservation and Land Management (Katanning Office)

by

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REFERENCE DETAILS
The recommended reference details for this document is:

Viv Read and Associates (2002) Impact Assessment of Surface Water Management Proposed for the Lake Bryde Recovery Catchment. Report prepared for the WA Department of Conservation and Land Management.

PREFACE

The Lake Bryde Wetland Complex is recognised for high natural diversity values. These values are also recognised as being at risk due to changes in the water balance within the catchment due to extensive clearing of natural vegetation for agriculture during the past 50 years. This risk is recognised within the State Salinity Strategy (2000) in which the Lake Bryde Recovery Catchment is listed as a priority catchment for management of the risks to biodiversity values. The Department of Conservation and Land Management has responsibility for management of these threats to biodiversity that it undertakes in partnership with other agencies and the local community. Management for recovery processes within the catchment is coordinated from the Katanning District Office of Department of Conservation and Land Management.

The management approach adopted by Department of Conservation and Land Management has been to initially identify the key threatening processes. This has been by hydro-geological assessment, vegetation survey of Reserves in the catchment and by assessment of surface water flows in the valley floor.

The Department of Conservation and Land Management arranged with the Engineering Water Management Group of the Western Australian Department of Agriculture to undertake a surface water assessment and proposed a set of management strategies within the Lake Bryde Recovery Catchment. These strategies aim to and increase water retention in the catchment and improve surface water flow within the valley floor. Assessment of the potential impact of these proposals on nature conservation values is required. Assessment of the potential impacts of the proposals on social and recreational values of the Lake Bryde water body and its surrounding foreshore is also required.

This project provides an independent assessment of the surface water management proposals within the Lake Bryde Recovery Catchment. The project Brief requires that the method of assessment be based on that developed by Coleman and Meney (2000). The objectives of this project are to:

1. Assess the impact of the total surface water management proposal on nature conservation values of the Lake Bryde Wetlands System, and

2. Assess impact of the proposal on the social and recreational use of the Lake Bryde water body.

The assessment has been prepared by Viv Read & Associates in association with Syrinx Environmental Pty Ltd, Actis Environmental Services, J.D.A. Consulting Hydrologists Pty Ltd and Jonelle Black under contract arrangements with the Katanning District Office of Department of Conservation and Land Management.

Following commencement of the proposal assessment, Department of Conservation and Land Management recognised the opportunity to characterise the lakes within the Lake Bryde Recovery Catchment. This was undertaken by Syrinx Environmental Pty Ltd and Actis Environmental Services as an agreed contract service variation. The characterisation process is reported separately however information from it has been included during final revision of this proposal assessment.

ACKNOWLEDGEMENTS

The assessment or surface water management proposals on nature conservation, social and recreation values within the Lake Bryde Recovery Catchment was undertaken with supporting information and assistance from many people. Project management and support provided by Bruce Bone, Alan Kietzmann and Sandra Hohlich from the Katanning Office of the Department of Conservation and Land Management is recognised. Dr Darren Farmer from the WA Department of Agriculture provided a significant range of additional information and comments. Dr Neil Coles and David Stanton also provided useful comment on the draft version of this report.

Other information and support was provided by Dr Stuart Halse, Dr Neil Gibson and Jim Lane of Department of Conservation and Land Management and by Noel Scholtnecht (for soils information), David Stanton (for water harvesting information), Sally Phelan and Shahzad Ghauri (for groundwater monitoring) from WA Department of Agriculture. Dr Richard George (WA Department of Agriculture) provided useful review comments on regional hydrogeology and Peter Muirden (Water and Rivers Commission) provided comment on flood events in the Avon River Basin.

Access to private property within the catchment for assessment purposes was appreciated, particularly for Ron and Erica Russell's property. Useful comments were provided about regional issues by Kingsley Strevett. The time taken by landholders in response to the phone survey is appreciated.

Kevin Lyons (drainage contractor) and Earnie Graham (earthmoving contractor) provided costs estimates for the assessment.

EXECUTIVE SUMMARY

Threatened nature conservation values in the Lake Bryde Recovery Catchment are recognised in the State Salinity Strategy (2000). This catchment is within the Wheatbelt of Western Australia, approximately 350 km south-east of Perth. Clearing land for agriculture during the past 50 year period has cause surface water run-off to increase significantly and for land, water and vegetation to be at risk to salinity. The catchment support about 50 farming families. Lake Bryde is important for water skiing and other social and recreation activities. It also is the site of one of WA's Threatened Ecological Communities.

The management response by the Department of Conservation and Land Management has been to identify the range of nature conservation values (Ecoscape, 2001), establish the threatening processes (SKM, 200) and then to propose a range of management actions (Farmer et al., 2002). This assessment is to assess the impact of these proposals on nature conservation values and on the social and recreation opportunities at Lake Bryde.

A set of projects was proposed to manage surface water within the catchment in order to reduce inundation. The assessment recognises that the greater threat is from rising regional groundwater tables and the associated risks of salinity. The "Do Nothing" scenario is based on the potential impact from these threats if no action is taken. Surface water management to reduce inundation is recognised as addressing the more immediate processes of degradation and also in reducing the processes leading to the potential threat of salinity.

Some of the proposals are about surface water management and water harvesting on private land within the catchment. While these were assessed, they are more likely to add benefit than to impact on nature conservation values.

Conclusions from the assessment processes are:

1. The Lake Bryde Recovery Catchment is threatened significantly by high regional groundwater tables and the associated risk of salinity in the medium to longer term.. The potential threat is greatest for wetlands and the catchment valley floor. The extent and urgency of this threat will be better established by groundwater monitoring over the next 5 years. The proposed surface water management will reduce the threatening processes but will not remove the medium to longer term risk.

2. The proposed low-velocity waterway will be beneficial for nature conservation values in the Lake Bryde Nature Reserve and in the Ryan's Road area.

   The proposed waterway is intended to reduce inflow to Lake Bryde during low-flow events but not during medium to high flow events. It is likely that the medium to high flow events cause prolonged inundation in the lake and cause the salt load to increase substantially. Considering this, the proposed waterway is unlikely to have significant benefit in the recovery of the Threatened Ecological Community that occurs in the lake bed.

   The proposed waterway is expected to cause only minimal impact or provide minimal benefit to Lake Janet.

3. Wetlands in the Lakelands Nature Reserve have high conservation values that are currently degrading and are further threatened by inundation and salinity. Discharge of additional run-off and salt load from the catchment by enhanced waterway flow will result in accelerated degradation of these wetlands.

   The nature conservation values of the wetlands in the Lakelands Nature Reserve could be considered to be equal to if not greater than the nature conservation values in the Lake Bryde Nature Reserve.

4. The net benefit for nature conservation by relocation of Lake Bryde Road may not be positive. Improved conditions for vegetation regeneration can be achieved with the proposed waterway under 'Option 1'. This option will also improve road access for social and recreational opportunities at Lake Bryde by reduced periods of inundation.

5. The Yate Swamp should benefit from less inundation in the short term. The potential for there to be adequate environmental flow from road run-off and from run-off within the reserve for longer-term maintenance of a sustainable wetland ecosystem is not known

6. The 'Diversion Lake' is currently degraded and is unlikely to be further degraded in a significant way by discharging addition water to this wetland. The suggestion to provide an outlet for excess water from this lake to be discharged to wetlands in the Lakelands Nature Reserve would increase further the impact on those receiving wetlands.

7. Excess inundation of natural vegetation from eastern flows to Lake Bryde are at risk of in situ degradation however this risk is considered less that the additional risk to recovery of the conservation values within the lake if that water were to be released into the lake.

8. The nature conservation values of East Lake Bryde are high and the medium to longer-term threat from high regional groundwater tables is generally lower that for other wetlands within the Lake Bryde Recovery Catchment. The proposed surface water management is not expected to have negative impact on these values.

9. Lake Bryde is important for local social and recreational opportunities. The threats to the lake and its associated environment are well understood. While there is a general local view that the water skiing opportunity should not be diminished in favour of recovering the threatened plant community, especially as it is thought that it may not recover in the medium to long term, there is acceptance that management works are required for net social, recreation and conservation benefit. The proposed management should not significantly reduce the social or recreational opportunity.

10. The evaluation method initially required for the assessment was limited by the need for more specific information about the proposals. More appropriate use of this method for drainage proposals that intercept groundwater rather than for surface water management proposals.

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1. INTRODUCTION

1.1 Geographic Description

The Lake Bryde Recovery Catchment is located approximately 350km south-east of Perth in Western Australia. The catchment is south-east of Lake Grace and approximately equal distance (about 40km) from that town, Pingrup and Newdegate (Figure 1). It is within the Shires of Kent and Lake Grace.

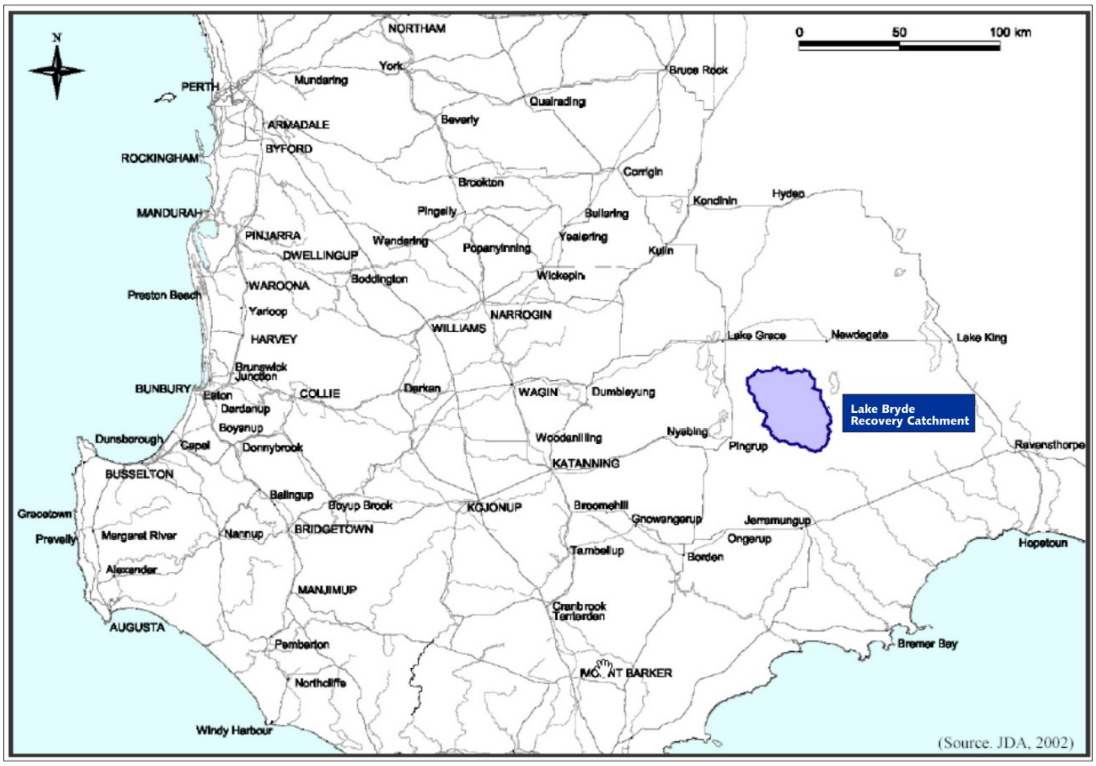


Figure 1 Location Map of the Lake Bryde Recovery Catchment

For the purposes of the assessment, the catchment is defined generally as the watershed area south of Mallee Hill Road. The Digital Elevation Model (Kevron, 2000) for the catchment has been used to identify 18 sub-catchments in this area including 7 within the valley floor (Figure 2). The total of this area is 117,592ha.

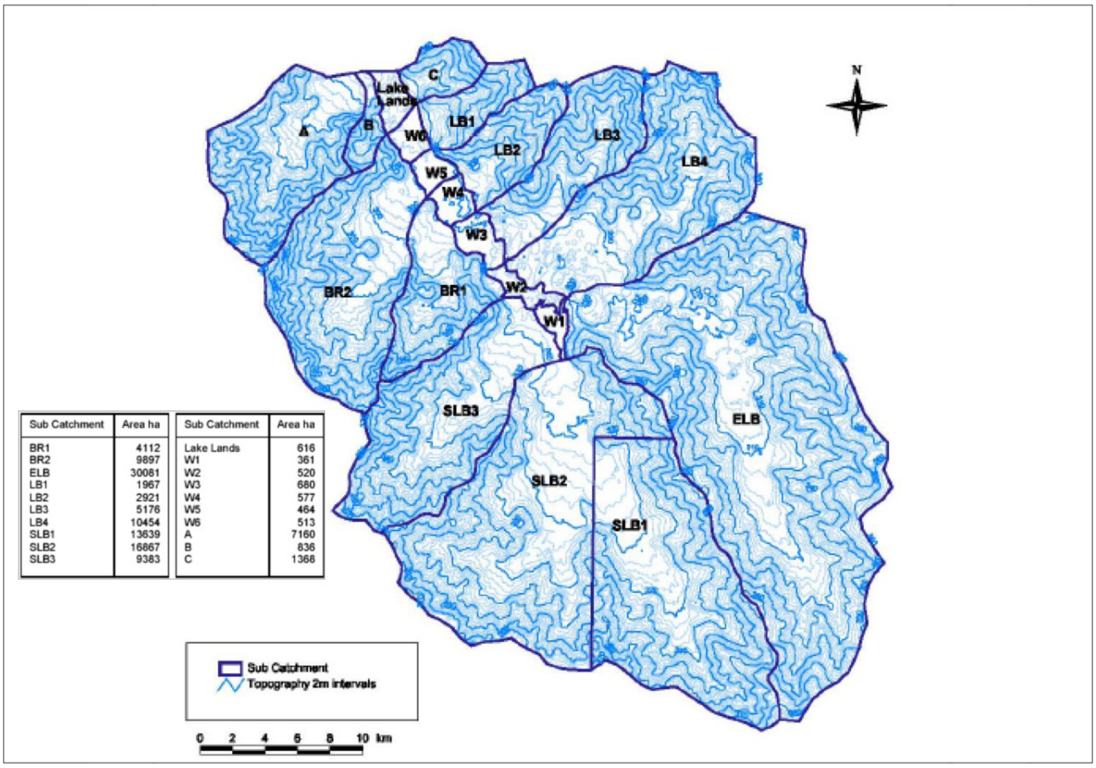


Figure 2 Sub-catchments derived from the Digital Terrain Model (DEM) for the Lake Bryde Recovery Catchment

Hydro-geological mapping for the region (Dodson, 1999) shows the catchment to be located between two major regional drainage systems (the Pingrup River containing Lake Grace (north and south) and Lake Chinocup, and the Lockhart River containing Lake Lockhart and Lake Magenta) as shown in Figure 3. These regional drainage systems are confluent approximately 40 km north of Lake Grace. With the Camm River, these form the dominant natural drainage system for the Lockhart Catchment of the Avon River Basin.

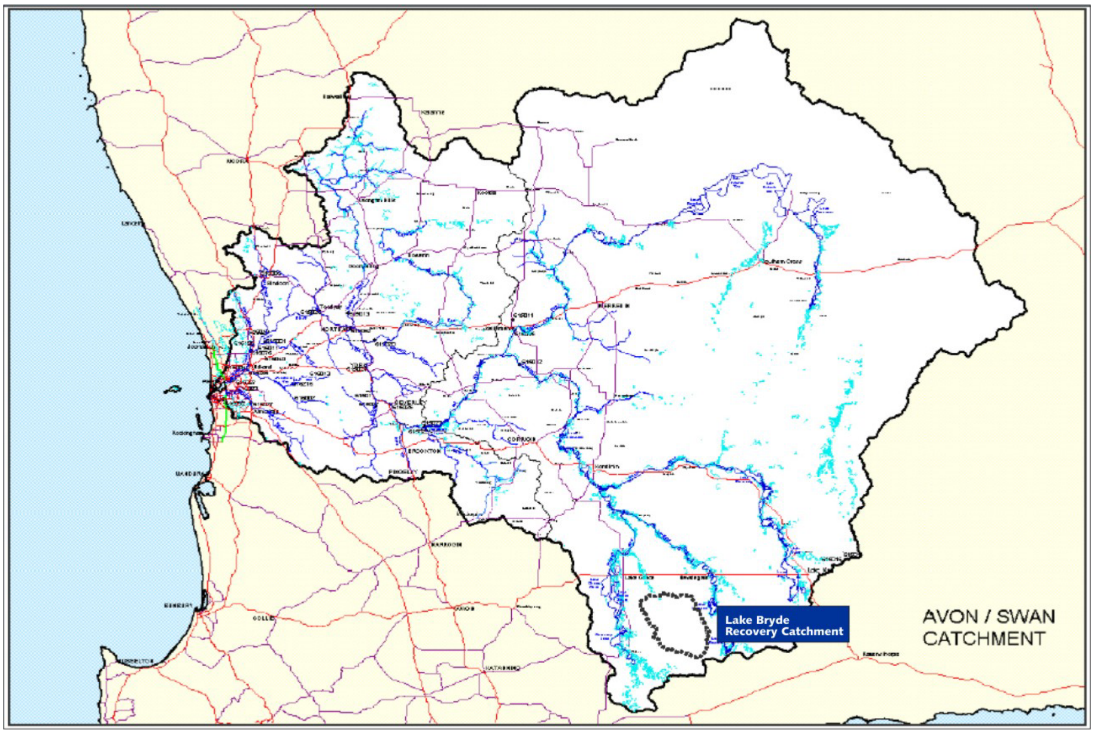


Figure 3 Regional Drainage Systems in the Avon River Basin

Based on long-term records for Pingrup, the average annual rainfall for the district is 361mm (Figure 3 in Report Five). The range is from under 200mm to over 700 mm annually. Evaporation is approximately 2100mm annually. It exceeds rainfall for 10 months of the year.

During the 1960's and 70's, approximately 60% of the catchment area was cleared for low-input dryland agriculture. There are approximately 50 farming properties within the Lake Bryde Recovery Catchment. The remaining area is natural vegetation in reserves or in remnant patches of bush on private land. The distribution of remaining natural vegetation is shown in Figure 4.

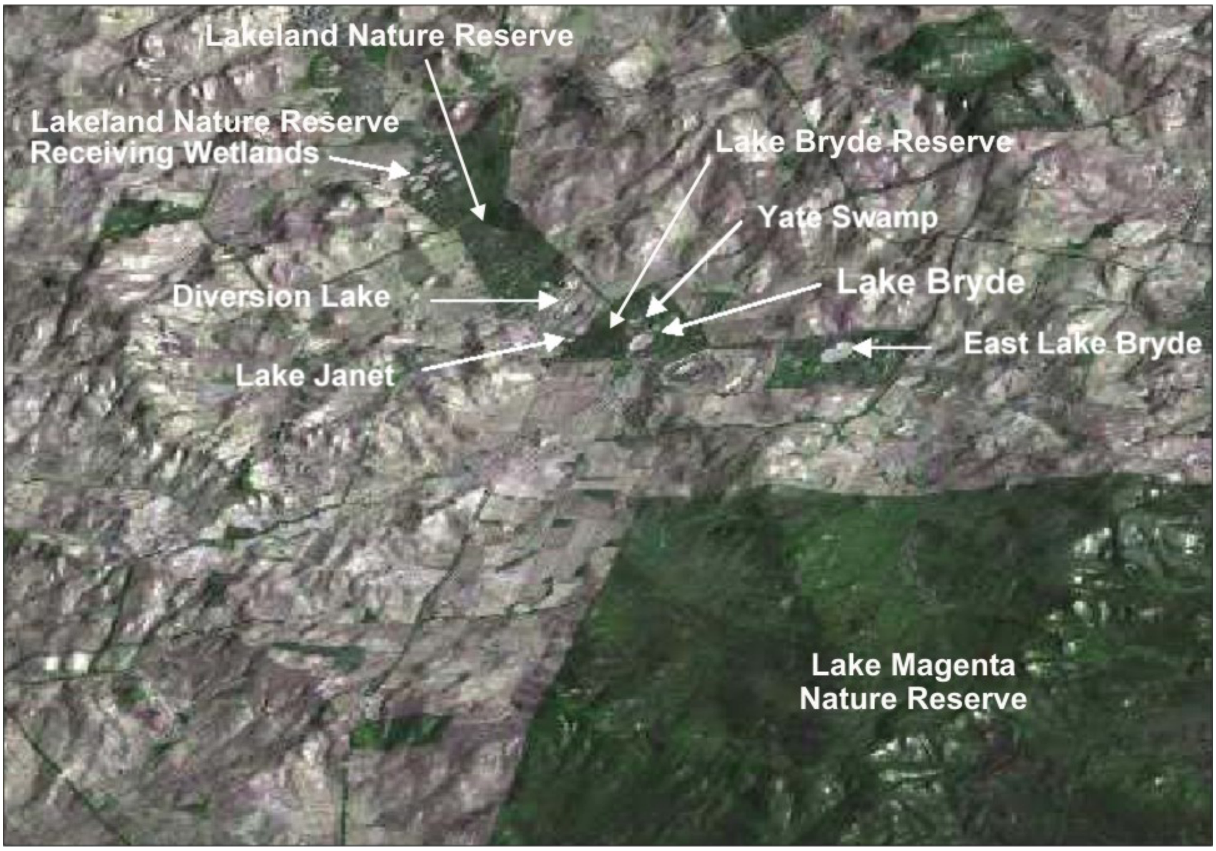


Figure 4 **Distribution of remaining natural vegetation and location of significant areas for nature conservation.**

Within the Recovery Catchment, there are 21 wetlands of significant size and numerous smaller lakes in the valley floor. Landforms within the Lakelands Nature Reserve are dominated by lake formations in a range of morphogenic stages. The larger lakes are characterised in a separate report (Coleman and Meney, 2002).

Although East Lake Bryde is larger, Lake Bryde is better known locally due in part to its use for water skiing and other social and recreational activities. It is also the site of a Threatened Ecological Community (TEC). The 50ha lake stores water at depths of up to 2 meters. The total water storage capacity of the lake is approximately 1x106 $m^{3.}$

1.2 Biodiversity Values and Threats

The Lake Bryde Recovery Catchment is recognised as a Priority Catchment in the State Salinity Strategy (2000) because of its high diversity values that are threatened by the processes of salinity. It is one of 10 recovery catchments for biodiversity values in Western Australia.

Within the catchment and immediately adjacent area, there are 18,200ha of natural vegetation in 16 Crown Reserves and 4,200ha in 19 Road Reserves (Ecoscape, 2001). These are listed in Tables 1 and 2 and shown in Figure 5. The linkage of reserves within the catchment adds significantly to the biodiversity value of each reserve. A significant feature is the extent of vegetation in the valley floor within the Lakelands Nature Reserve. The valley floors of Wheatbelt landscapes in WA were most often cleared first and completely. The significant width of road reserves is also important as it is unusual for the agricultural areas of this State. The largest reserve for nature conservation within the local region is the Lake Magenta Nature Reserve of which only 2.5% (2,650ha) is within the Lake Bryde Recovery Catchment.

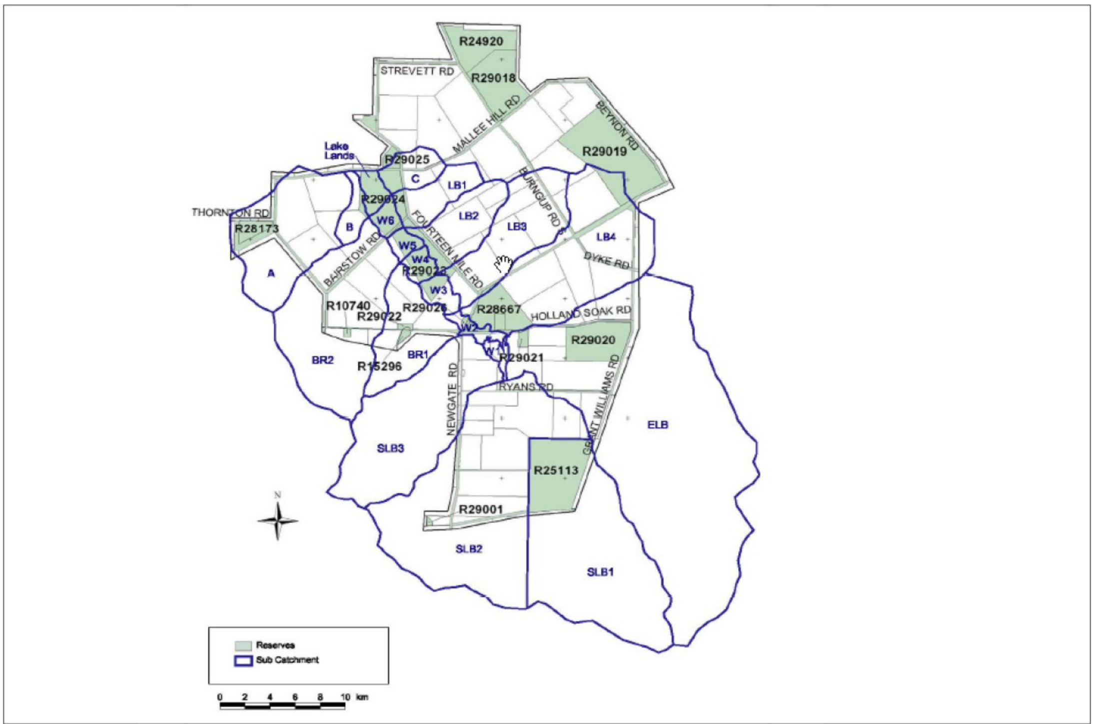


Figure 5 Crown and Road Reserves

Table 1 Crown Reserves Surveyed by Ecoscape (2001)

Reserve No.	Reserve Name	Area (ha)
24920	AgWest Experimental. Farm (Location 2566 only)	1 265
29018	Silver Wattle Nature Reserve	1 660
29019(part of)	Breakaway Ridge Nature Reserve	3 323
29020	Lake Bryde Nature Reserve	1 528
29021	Lake Bryde Nature Reserve	107
28667	Lake Bryde (Water, Picnic Ground, Conservation Flora & Fauna)	1 315
29026	Lake Janet Nature Reserve	32
29022	Holland's Rocks Nature Reserve	50
29023	Lakeland Nature Reserve	1 529
29024	Lakeland Nature Reserve	1 579
29025	Lakeland Nature Reserve	207
15296	Water Reserve	62
10740	Water Reserve	42
28173	Conservation of Flora & Fauna	331
29001	Water Reserve	26
25113	Part Lake Magenta Nature Reserve	~2 650

Note: Reserves within the recovery catchment are shaded.

Source: adapted from Ecoscape, 2001.

Table 2: Road Reserves Surveyed by Ecoscape (2001)

	Area (ha)	Road Name	Road Name
Mallee Hill Road	502	Featherstone Road	47
Burngup Road South	396	Ryan's Road	166
Strevett Road	99	Zwecks Road	253
Fourteen Mile Road	430	Holland's Soak Road	107
Beynon Road	171	Lake Bryde Road	203
Pelham Road	113	Dyke Road	103
Newdegate Road	560	Day Road	10
Bairstow Road	400	McDougalls Road	49
North Needilup Road	175	Grant-Williams Road	294
East Road	124		

Note: Reserves within the recovery catchment are shaded.

Source: adapted from Ecoscape, 2001.

A previous survey of flora in reserves within the catchment (Ecoscape, 2001) found 371 plant species (approximately 46% of the total plants expected for the local botanical region) in 22 plant communities. Of these, 10 communities are generally not well represented in reserves. Fifteen populations of 'Priority Flora' were identified.The distribution of plant communities is determined in part by edaphic factors - soil type, acidity and salinity relate reasonable well to plant distribution (Ecoscape, 2001).

A Threatened Ecological Community (TEC) dominated by *Muehlenbeckia horrida subsp. abdita* occurs within Lake Bryde. With one other similar living community in East Lake Bryde, it is endemic to the Lake Bryde Wetlands Complex. Plant communities can provide an indication of faunal community diversity. In a survey of reserves in the catchment (McKenzie, 1973), 7 species of mammal, 67 species of birds, 27 reptiles and 2 amphibians were found. The area is identified as of "outstanding ornithological importance" according to the Ramsar Convention.

These values are significantly threatened by increased surface water run-off from the catchment due to clearing for agriculture, and by salinity. These two threats are inter-related and are occurring at differing time-scales. The significance of these threats is recognised by nomination of the catchment for priority status under the State Salinity Strategy (2000).

1.3 Social/ Recreational Values and Threats

Lake Bryde and its surrounding environment are highly valued locally as identified by phone survey with 30 of the 50 families in the catchment for this assessment. Water skiing is the favourite activity however nature appreciation, picnicking and swimming are also important. While these activities occur mostly together, the lake is still used and valued when not suitable for water skiing.

Alternative sites for water skiing are a substantial distance away. It is understood that other communities within the region also enjoy visiting the lake. These groups provide valuable regional social and information links. Good access to the lake is wanted. Residents in the catchment are well aware of the threat of salinity to the lake and the surrounding environment. Some have undertaken considerable actions on their properties with the expectation that there would eventually be benefit to the lake. While water skiing is favoured as an activity, the health of the surrounding environment is considered important.

The local community is less well aware of the importance of the Muehlenbeckia TEC. Some would prefer to have 'dead trees and sticks' cleaned up from the lake to improve the water skiing opportunity. There are some logs and branches on the lake margin, but these comments refer primarily to the Muehlenbeckia plants in the lake which have a relatively uniform height of about 60cms. There is concern that the recreational and social opportunities at the lake may be diminished in favour of the lake-bed plants.

1.4 Requirements of the assessment

In response to the threats to biodiversity values of the Lake Bryde catchment, the Katanning District Office of Department of Conservation and Land Management has taken a range of steps through recovery catchment planning and management processes. These have been to arrange:

- A Recovery Team involving local communities and local government in processes to tackle the threats in ways that are integrated with other catchment and Shire management requirements.
- A hydro-geological description and salinity risk assessment (SKM, 2000)
- Detailed contour mapping of the wetland chain to identify areas of impedance to surface water flow (Kevron Aerial Surveys, 2000)
- Extensive groundwater and surface water flow monitoring (installation during 2002)
- Vegetation and associated soil survey of reserves in the catchment (Ecoscape, 2001)
- Surface water management recommendations (Farmer et al., 2002)
- Bathometric mapping of lake-beds (in progress during this study).

The sequence of these initiatives has been to establish the values and threats, then to identify a range of management options in response to these threats. The next stage is to undertake an assessment of the proposed management options (this study).

The objectives of the assessment are to:

1) Assess the impact of the total surface water management proposal on the nature conservation values of the Lake Bryde Wetlands System
2) Assess impacts of the proposal on the social and recreational use of the Lake Bryde water body.

These objectives reflect the importance of nature conservation values in the wetland system and recognise the importance to the local community of Lake Bryde for social and recreational use, including water skiing.

1.5 Approach to the Assessment

The approach adopted for assessment of potential impact on nature conservation, social and recreational values is based on two significant criteria:

1) That if no action is taken, the effects of waterlogging and salinity will increase and impact upon the nature conservation, social and recreational values as well as many other values in the catchment
2) That the individual proposals may have cumulative impacts if all are implemented

Considering these, the approach adopted for the assessment is to compare the potential impact of implementing the proposed management strategy with the likely impact on the same values if the strategy is not implemented. To assist in this assessment, a water and salt balance model for Lake Bryde has been developed.

The steps of the assessment process were to:

1) Review all available information
2) Undertake and on-site inception meeting (12th April, 2002)
3) Develop Key Assessment Questions
4) Undertake field survey to apply the Coleman-Meney (2000) approach to assessment, with noted amendments as required (23rd April – 3rd May, 2002)

5) Assessment of the direct impacts of the proposed road re-alignment by field survey, and of the costs associated with the proposed re-alignment
6) Undertake a survey of social and recreational values by phone interview (30 out of a total of 50 families contacted) from which impacts of the proposals were interpreted
7) Assessment of the impact of the proposed management strategies on valued sites (a cross-correlated matrix based on values and threats), including specific assessment of receiving water bodies and consideration of alternative discharge course alignment

Wetlands in the Lake Bryde Recovery Catchment were characterised based on ecological and hydrological criteria (separate report to the Department of Conservation and Land Management).

A salt and water balance model for Lake Bryde was developed to assist with understanding of the processes within the lake and the catchment (JDA, 2002, Appendix One). The model provides a systematic assessment of salt and water fluxes within the catchment based on hydraulic and salinity information measured monthly for a period of 22 years (1997 to 2000 inclusive) for Lake Bryde. The calibration of the modelled and observed data resulted in a very high correlation.

2. A CHANGING CATCHMENT WATER BALANCE – THE “DO NOTHING” SCENARIO

2.1 Surface water run-off from the catchment

During the past 50 years, approximately 60% of the Lake Bryde Recovery Catchment has been cleared for agriculture. The removal of natural vegetation cover and the subsequent reduction of water infiltration capacity of soils due to agricultural practice resulted in surface water run-off from the catchment to increasing by a factor of 2.5 (JDA, 2002, Appendix One). Local anecdotal information supports these changes by observations of significantly reduced run-off or significantly greater rainfall events required to generate run-off from those catchments with extensive areas of natural vegetation on water shedding slopes (eg areas N2 and N3 that include the Lake Magenta Nature Reserve as described in Farmer et al. 2002).

Proposals for surface water detention or harvesting on farms will reduce catchment water run-off although not to pre-clearing run-off levels. Higher than natural occurrence of surface water run-off is a long-term prospect.

With low valley floor gradient, water accumulates causing extensive areas to be inundated for extended periods of time. Flow is further impeded by inadequately defined channel capacity for the increased run-off and by natural vegetation. Increased water inundation on the valley floor is directly affecting natural vegetation and will increase the effect of salinity on vegetation that occurs.

The extent of valley floor inundation varies depending upon the magnitude of the rainfall event and upon the soil/landscape water storage capacity at the time of the rainfall event. Wet conditions prior to a major rainfall event will cause very extensive areas on inundation to remain waterlogged sometimes for several weeks.

Excess surface inundation also increases the potential for groundwater recharge resulting in higher salinity risk.

2.2 Changing Hydrodynamics and Salt-load in Lake Bryde

Lake Bryde has a lake-bed area of 50 ha and a lake-full capacity (2 meters deep) of approximately 1x106 M3 (JDA (2002), Appendix One). Figure 6 shows that for the 22 year period (from 1979 to 2000 inclusive), the lake would have filled only once and would have half-filled on only two other occasions if the catchment were not cleared. It also shows that the lake would have received some water most years but that the period of detention was generally less than one year. Lake-bed inundation would have exceeded a one year period on only two occasions. This is the sequence of wetting and drying (hydroperiod) to which the Muehlenbeckia TEC would have adapted. It is likely that this sequence is required for natural regeneration of this community.

In contrast, Figure 6 shows that the lake has filled in 5 of the years and half-filled in 9 others. It also shows that the lake-bed has been inundated for periods of greater than one year on 4 occasions, the longest period was from 1998 to 1994. Local information suggests that the frequency of significant inundation of the lake (i.e. sufficient for water skiing – assumed to be more that 1 meter deep) is as being one year full in every 3-5 years. Figure 6 suggests this observed frequency to be correct although the observations do not reflect the periods for which the lake is dry.

It is clear that the hydroperiod of Lake Bryde has altered significantly and this change towards more frequent and longer periods of inundation of the lake-bed is likely to increase rather than decrease without management action.

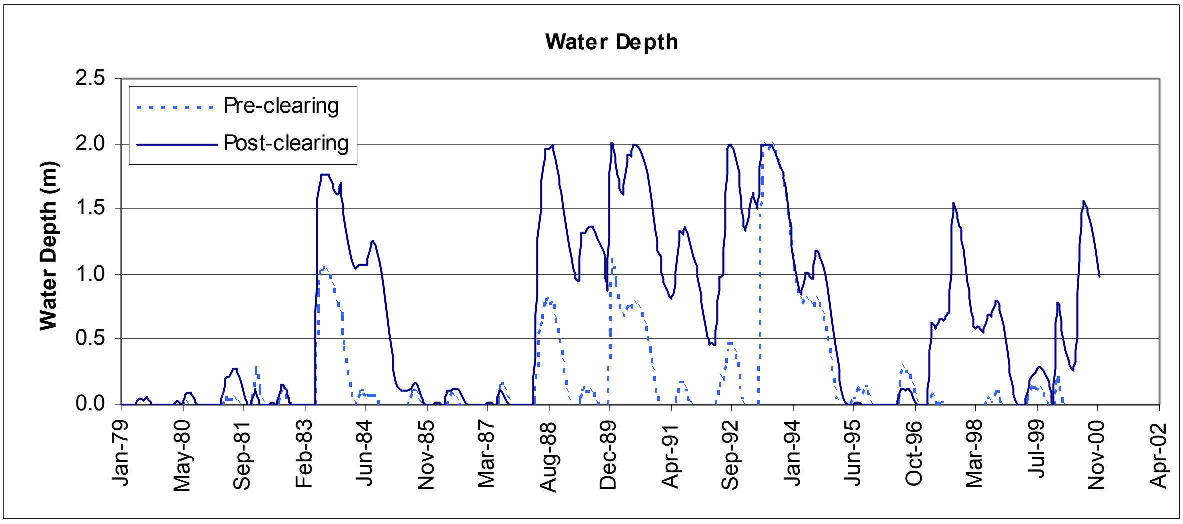


Figure 6 Modelled water depth in Lake Bryde (from JDA (2002), Appendix One)

Water quality monitoring shows that the salt mass in Lake Bryde was relatively low although increasing up to 400 tonnes by 1992. In that year, the salt load increased by 800 tonnes to a total mass of 1200 tonnes (Figure 7). The high salt load was verified by lake-bed soil sampling during this study.

Since 1992, there has been no clear trend in salt load change. The water and salt balance model suggests that it could be increasing although the monitored data could also be interpreted as having a declining trend. A small decline could occur by minor flushing or by seepage through the lakebed. Figure 7 suggests that there has been no significant flushing of salt from Lake Bryde.

The increased volume of water does not account for the substantial increase in salt mass during 1992. The 5 years prior to this were generally above average annual rainfall and 1992 was well above average (Figure 3 in JDA (2002), Appendix One). One explanation for the substantial increase in salt mass is that the wetter conditions of that period caused regional saline groundwater aquifers to rise resulting in higher salt discharge at the surface so that inflow to the lake in 1992 carried a high salt load.

A second explanation could be that saline groundwater directly intercepted the lake-bed. There are no groundwater monitoring records near Lake Bryde for that period, however the hydrograph for more recent monitoring suggests that groundwater may well have intercepted the lake-bed in 1992. Figure 8 shows the measured groundwater depth for LB19, a monitoring well located on the north-eastern side of the lake. Groundwater was at or less than 1.5 meters below the ground surface on three occasions between 1996 and 2001. More comprehensive monitoring by groundwater access wells installed at the time of this study will allow better assessment of this risk when data becomes available. In this study, it is assumed that both explanations contribute to the increased salt load in 1992.

A third explanation could be that discharge from the saline lake south-east of Lake Bryde contributed to the increased salt load. There is no evidence to support this although the possibility of this occurrence could be considered.

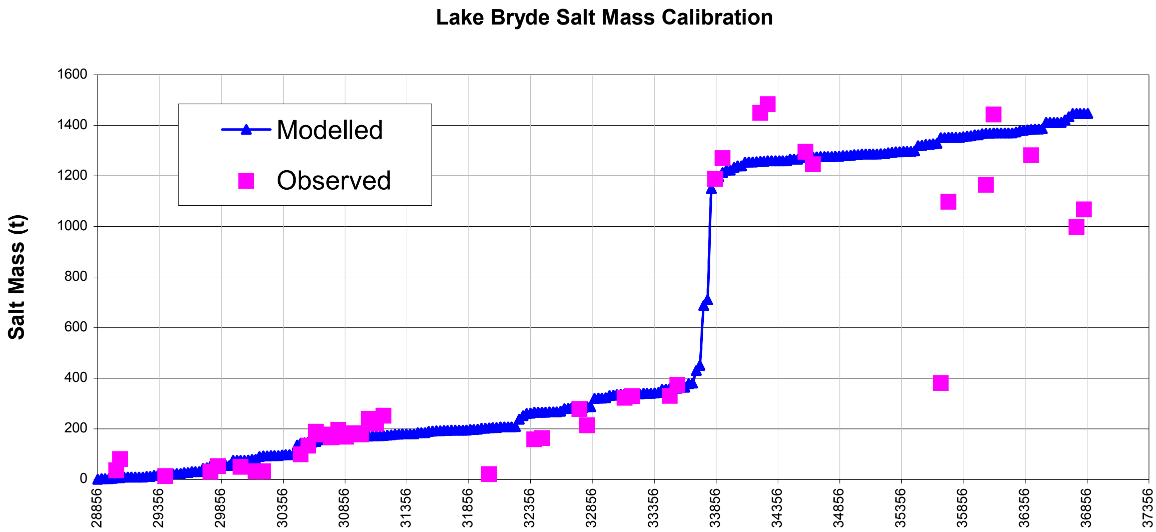


Figure 7 Salt load in Lake Bryde (from JDA (2002), Appendix One)

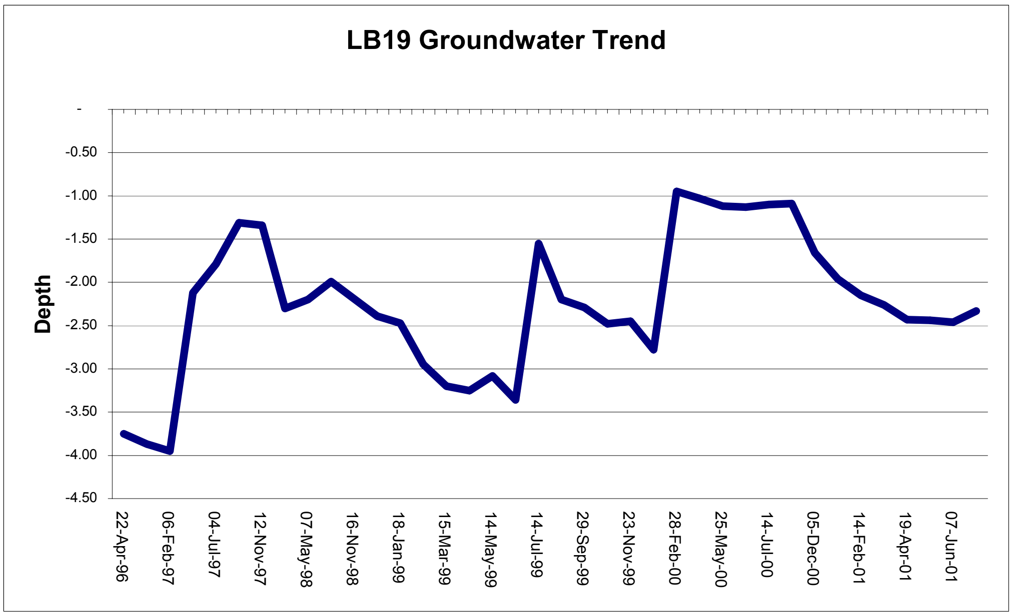


Figure 8 Groundwater depth adjacent to Lake Bryde (from WA Dept.Agric. data)

From the available information, it is clear that the salt load in Lake Bryde has increased substantially in the last 10 years and has not been flushed by subsequent lake infill events. It is expected that similar climatic and groundwater conditions will re-occur and that the lake salt load will continue to increase substantially under these conditions. As regional groundwater tables rise with time, the probability of this re-occurring will increase without there being management intervention.

2.3 Shallow Water tables in the Valley Floor

The hydro-geological study for the Lake Bryde Recovery Catchment (SKM, 2000) provides a clear description of groundwater aquifer processes based on modelling and available information. The general conclusion drawn from this study is that the areas with greatest risk to salinity by groundwater rise have a surface elevation of less than 300 meters (AHD). Figure 9 shows the area with this elevation or less. It also shows the location of reserves in the catchment. It is clear that the reserves located in the valley floor are at significant risk to salinity.

The extent of the area at risk and the time before the risk is fully realised remains uncertain. SKM (2000) project that 2-5% of the area shown as at risk (Figure 9) will have water tables at less than 1 meter below the surface and note that some areas are already affected by saline groundwater discharge on the western side of the valley floor. It is also projected that within 10 years, the areas with shallow water tables will be 30-40% of the area and within 20 years, more that 50% of the area. While these projections may be an over-estimate of the extent of shallow water tables (by perhaps 5%), they are considered to be reasonable (Richard George, pers. comm.).

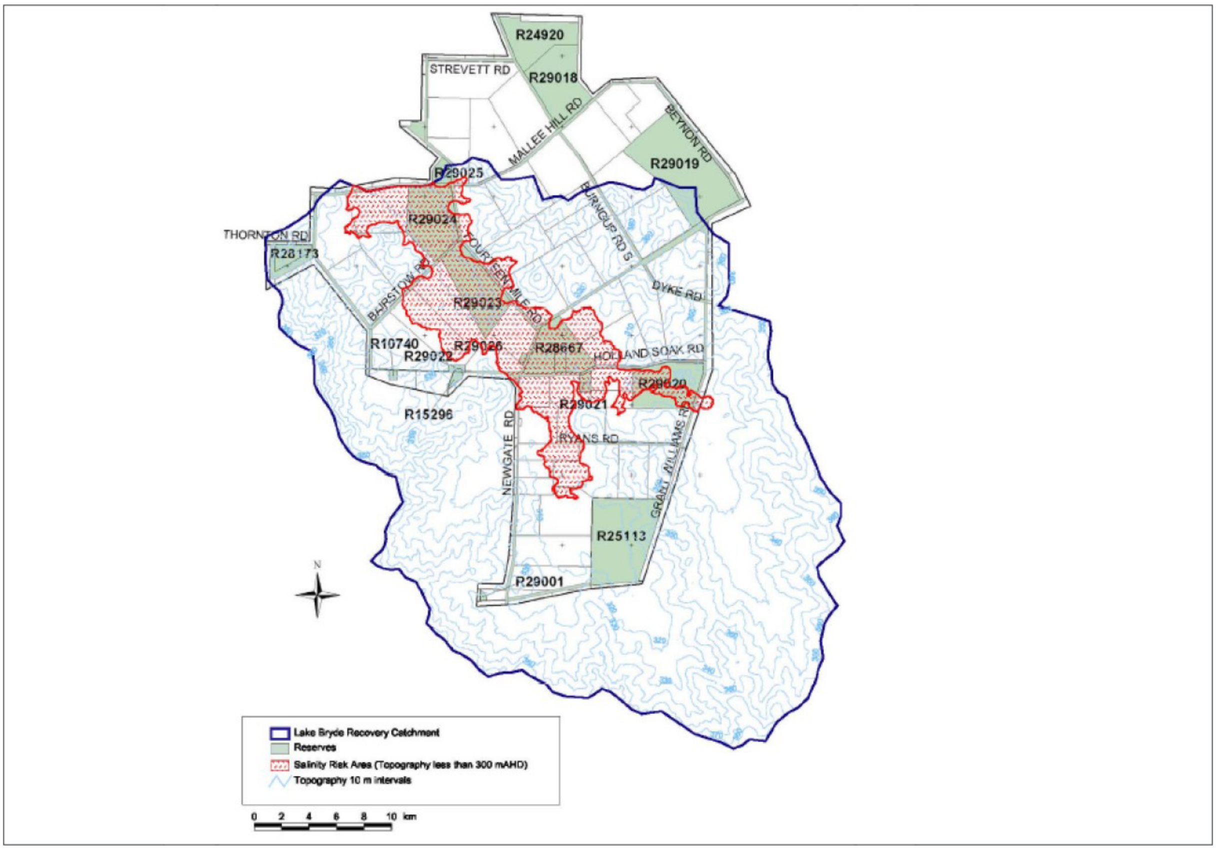


Figure 9 Potential extent of high water

The primary determinant of the area subject to salinity risk in the valley floor is micro-relief.   The landforms of the valley floor are described by Griffen et al. (2002). The 'hydro-aeolian' landforms contain soils derived by both fluvial and aeolian processes. Of these, the more elevated and transmissive aeolian sands are less likely to be salt-affected. The modelling adopted by SKM (2000) was not able to discriminate this finer level of landscape risk. The reports by SKM (2000) and Farmer et al. (2002) recognised the importance of surface water inundation in exacerbating salinity risk. Farmer et al. (2002) consider that the more immediate threat to biodiversity values is from the extensive inundation rather than by salinity due to groundwater rise. Natural drainage of inundated water is restricted by low valley floor gradient and loss of 'flow continuity' due to impedance from natural vegetation and culverts. Natural vegetation is considered to cause greatest impedance.

For this assessment, it is recognised that excess inundation is an immediate threatening process that will not be diminished without management intervention. However, this study also recognises and accepts the greater threatening process of rising regional groundwater tables within the catchment. The eventual extent of valley floor salinity in the Lake Bryde Recovery Catchment is difficult to estimate now, but with the recent installation of a network of 70 monitoring wells, the potential extent should be better established within the next 5 years.

The 'Do Nothing' scenario indicates that without intervention by management, natural vegetation will continue to degrade due to waterlogging and salinity, and that the salt load in Lake Bryde will increase.   The areas most immediately at risk are those where surface water accumulates (low flow impedance) as identified in the SKM (2000) report.

3. PROPOSED SURFACE WATER MANAGEMENT

The Department of Conservation and Land Management initiated a study to assess the threatening processes and to propose a range of management options for the Lake Bryde Recovery Catchment. The aims of this study (as outlined in Farmer et al., 2002) were to:

- conduct a preliminary assessment of soil hydrological properties, and in conjunction with the DEM and climatic data, provide an assessment of surface water movement, surface water impedance and recommendations for surface water management;
- develop a macro-scale, whole of catchment surface water management strategy;
- develop engineering design options to improve water flow at valley floor impedance points and to develop options for diversion of saline enriched surface water flows into essential water bodies; and
- to develop a strategy for managing recharge and discharge sites for the recovery catchment.

3.1 General Concepts and Assumptions

The report of the study (Farmer et al., 2002) provides a general description of catchment hydrodynamics and development of a conceptual approach to surface water management based on observations. While the report is primarily conceptual, some aspects are based on detailed graphical information and assessment (eg the proposals for works associated with Lake Bryde Road).

The report identifies that it is not a comprehensive catchment water strategy, but instead is dealing primarily with surface water as the perceived major cause of degrading processes. A more comprehensive catchment water strategy would including risk assessment, provide greater comparative analysis of water management options for recharge and discharge control, evaluate a range of disposal site options and consider environmental water requirements. It should be based on a catchment-scale water and salt balance model. This study (Farmer et al., 2002) deals primarily with one component of a comprehensive catchment water strategy – surface water management.

Some of the concepts and assumptions developed in the study are reviewed.

3.1.1 Landscape analysis

A soil-landscape assessment developed for the study (Griffin et al., 2002) provides a general distinction between 'shedding' and 'receiving' landscape units which effectively define the catchment valley floor but is not at a scale suitable for interpretation of micro-relief within the valley floor. Differentiation between the hydro-aeolian and the grey clay land units is important for broadly delineating areas of salinity risk. A useful description of landscape zones assists with understanding surface water flow processes. Broad descriptions are provided for differing flow characteristics within the landscape zones. A detailed analysis for the valley floor gradient is not included as part of the study.

3.1.2 Threatening process assessment

The study (Farmer et al., 2002) proposes that prolonged inundation is the dominant hydrological process driving degradation of the valley floor landscapes. It recognises salinity as a part of this process but attributes the cause to surface salt accumulation due to evaporation of ponded water more than being due to rising groundwater tables. The report does note the potential for regional groundwater tables as described by SKM (2000) but questions the importance of this as a threatening process based on local observations. The proposals are developed with the assumption that surface water inundation is the primary threatening process. Recent installation of 70 groundwater monitoring wells will assist in determining if this assumption is valid.

The nature conservation value assessment process (this report) recognises prolonged surface water inundation as an important degrading process but also recognises the potential for significant impact by saline groundwater table rise. Some areas are probably affected by rising groundwater at the surface currently.

3.1.3 Surface water run-off generation

The study (Farmer et al., 2002) recognises significantly increased surface water run-off as a result of clearing the catchment for agriculture. It develops a general assessment of run-off based primarily on observations of two rainfall events (for January 2000 and August 2001). While there is consideration of the likely run-off threshold capacity, the study does no provide a quantified estimate of the probable run-off volumes from sub-catchments under a range of Average Return Interval (ARI) rain events.

3.1.4 Inflow to Lake Bryde

Based on local observations, the study (Farmer et al., 2002) assumes that the increasing salt load in Lake Bryde is due to small events. It notes inflow periods during 1982, 1990, 1997 and 2000 but not the significant episodic inflow event of 1992 when the salt load in the lake doubled (Figure 7, this report). The assumption that it is low to medium flow events that are the major contributors to salt load in the lake cannot be substantiated.

The study also assumes that the January 2000 inflow event 'flushed' salt from the lake. From the water and salt monitoring, there is no convincing evidence that flushing of salt from the lake has occurred as a result of this event (Figure 7, this report).

The nature conservation value assessment process (this report) recognises some benefits in reducing inflows to Lake Bryde by diverting low to medium flow events but does not assume that these actions will result in significant recovery of the TEC in the lake. Empirical evidence shows that the larger events are causing prolonged periods of inundation and the significantly increased salt load in the lake and it is suggested that it is these events that are causing most harm.

3.1.5 Waterway functions

The study identifies that the major cause of prolonged inundation is poor continuity of flow. A low velocity waterway is proposed to reduce flow restrictions. The study also notes that ideally, the waterway should be discontinuous, presumably in recognition of the need to over-come specific constrictions. The general waterway concept developed however is for continuous flow with discharge at a terminal receival point.

The proposal is for this receival point to be located in the Lakeland Nature Reserve. The proposals do suggest partial and temporary detention in a constructed facility between Ryans Road and Lake Bryde and it does note the possible need for preparation of temporary detention points above the main lake chain of the Lakeland Nature Reserve, but it does not further consider partial or low to medium-flow detention options for waterway discharge between Lake Bryde and the Lakeland Nature Reserve.

3.1.6 Management Proposals

The proposed low-velocity waterway seems an appropriate concept for increasing flow continuity where surface water inundation problems occur. The proposals have been described but not designed or quantified. The concept is based on local observations of flow during significant surface water flow events. This is useful information and provides a reasonable basis for developing the concept but does not allow for a quantified assessment of potential impacts.

3.1.7 Disposal site assessment

The study (Farmer et al., 2002) has proposed the terminal receiving site to be water bodies within the Lakeland Nature Reserve with consideration of a constructed by-pass facility should the capacity of the receiving water bodies by exceeded. It notes that the lakes are showing few signs of saline degradation and that shoreline vegetation is in good condition although recognises degradation of same lakes on the western side of the reserve. The study also notes that the lakes were filled during the January 2000 run-off event but not during the event in August 2001. From this information, the study assumes that the wetlands in the Lakeland Nature Reserve have adequate capacity to receive addition flow from the proposed waterway.

The study does however note that the Lakeland Nature Reserves wetlands are in apparent good condition due to the current lack of upstream flow continuity and recognises the risk of adverse impact by increasing flow continuity.

3.2 Proposed Surface Water Management Projects

There are 14 separate projects proposed by Farmer et al. (2002) to address different parts of the Lake Bryde Recovery Catchment. The general concept for the projects is to manage surface water flows by reducing run-off from agricultural land within catchments and by increasing flow continuity within the valley floor. There is sufficient evidence to show the extent and period of surface water inundation that does occur within the catchment. Where prolonged inundation does occur, the risk of degradation due to water logging and secondary salinity is increased. Reducing inundation by the surface water management that is proposed will reduce these risks at the sites where inundation occurs and provide benefits for nature conservation. The potential for negative impacts to nature conservation is through construction of the proposed works and by potentially increased hydroperiod and salt load to receiving water bodies.

Table 3 lists the key management proposals for each of the projects. It also broadly identifies the potential for benefits and for negative impacts to nature conservation values.
From Table 3, the sites at risk of negative impacts to nature conservation values can be identified. It is these sites that are the major focus of this assessment process. The locations where benefits to nature conservation values are expected as a result of the surface water management proposals will be further considered as a part of the whole system net-benefit analysis.

Table 3 Proposed Lake Bryde Surface Water Management Projects

Project	Key Proposals	Potential Nature Conservation Benefit/Impact Areas
Lake Bryde Rd Valley	To improve flow and reduce inundation by construction of a waterway extending back to the Lake Bryde inlet. The waterway is also intended to reduce the potential for medium to low flows entering the lake. It is also proposed to relocate Lake Bryde road into the Lake Bryde Nature Reserve to provide more efficient waterway function.	• Benefit to vegetation currently affected or threatened by inundation • Potential benefit to Lake Bryde • Potential impact on Lake Bryde Nature Reserve by road relocation • Potential impact on receiving water body (Lakeland Nature Reserve).
Ryan's Rd	Upgrading the floodway on Ryans Road with low-flow culverts. Construction of a waterway and removal of sediment from the natural waterway and wetland. Diversion of low-flows from the lake Bryde inlet.	• Natural regeneration of vegetation between Ryan's road and Lake Bryde Road. • Reduced saline inflow to Lake Bryde. • Potential impact on receiving water body (Lakeland Nature Reserve).
Fourteen Mile Rd/Oliver's	Diversion of surface water run-off to an alternative disposal site (on Roe Location 2586 – temporarily called Diversion Lake) in association with planned road works. Allowance for some flow to yate Swamp. Proposal to direct excess flow from Diversion Lake to the Lakeland Nature Reserve by constructed waterway if required.	• Reduced groundwater recharge potential adjacent to the Yate Swamp • Potential reduced environmental flow to Yate Swamp • Potential impact on receiving lake (Roe Location 2586- temporarily called Diversion Lake). • Potential impact on receiving water body (Lakeland Nature Reserve).
Oliver's upper watershed	Surface water management and run-off reduction. Water harvesting opportunities.	• Reduced potential impact on receiving water body (Diversion Lake).
Lakeland Valley (Newdegate Rd – Bairstow Rd)	Construction of a low-velocity waterway through both Roe Loc. 2586 and Lakeland Nature Reserve. Waterway though some natural detention basins. Control of surface water flow in western boundary of Lakeland Nature Reserve.	• Potential damage to vegetation through Roe Loc 2586 during waterway construction although natural regeneration will occur. • Limited risk of soil erosion because of shallow clay sub-soils.

	Construct floodway on Bairstow Road.	• Reduced recharge and salinity risk on Roe Loc. 2586 by reducing inundation period, but also reduced natural flow detention capacity. • Potential damage to Lakeland Nature Conservation Reserve during construction of waterway. • Potential impact on receiving water body (Lakeland Nature Reserve).
Lakeland Valley (Bairstow Rd – Mallee Hill Rd)	Surface water management and flow interception on properties west of the reserve. Detention of discharge water from low-velocity waterway for evaporative depletion, including one of the larger lakes (with an option to bund this lake to prevent further discharge to other major lakes). Discharge lakes to overflow to the creek system by a constructed waterway west of the major lakes in the Lakeland Nature Reserve.	• Reduced inundation and salinity risk in the reserve by management proposals for farms west of the reserve. • Impact on Lakeland nature Reserve by waterway construction • Impact on selected discharge lakes by increased inundation period, salt load and sedimentation.
Days Creek/Needilup Rd	Water harvesting within the catchment to reduce surface water flow volume.	• Benefit by reduced inundation of vegetation on Lake Bryde road.
Lake Bryde Eastern inflow	Water harvesting within the catchment to reduce surface water flow volume. Removal of sill to increase inflow to Lake Bryde.	• Reduced inundation of vegetation in the Lake Bryde Reserve east of the lake • Increased inundation and potential increase of salt load into Lake Bryde.
East Lake Bryde	Reduction of inundation volumes in the lake and reduction of recharge in sandplain soils. Surface water management and water harvesting within the catchment.	• Reduced salinity and inundation risk for East Lake Bryde.
South Lake Bryde Flats	Surface water management to reduce inundation and recharge potential of flats. Diversion of water from areas shown to be of high salinity risk due to geological controls.	• Reduced salinity risk on water accumulating sites would allow increased natural regeneration of vegetation and a higher survival rate for revegetation. • Reduced potential impact on receiving water bodies.
Upper South Lake Bryde (East Road)	Surface water management and water harvesting.	• Reduced potential impact on receiving water bodies
Holland's Soak Rd Sub-catchment	Surface water management and water harvesting.	• Reduced potential impact on receiving water bodies (lakes in the Lakeland Nature Reserve).
Mallee Hill Rd South-West Sub-Catchment	Surface water management and water harvesting.	• Reduced potential impact on receiving water bodies (off-site).
Lakeland East Slopes	Surface water management and water harvesting.	• Reduced potential impact on receiving water bodies (lakes in the Lakeland Nature Reserve).

The locations where there are potential impacts to nature conservation values are listed in Table 4 and shown in Figure 4

Table 4 Potential nature conservation impact locations

Lake Bryde	Lake Janet
Lake Bryde Reserve (Proposed Road)	Lakeland Nature Reserve
Lake Bryde to Lake Janet Waterway	Receiving Lakes (Lakeland Nature Reserve)
Yate Swamp	North West Floodway Extension
Diversion Lake (Roe Loc. 2586)	East Lake Bryde

4. POTENTIAL IMPACT ASSESSMENT

4.1 Assessment process

Assessment the potential impact of nature conservation values by the surface water management proposals was undertaken through three separate but inter-related processes:

1. Ecological Assessment
   (undertaken by Syrinx Environmental PL and documented in the following section)

2. Assessment of Potential Impacts using the Coleman and Meney Evaluation Criteria
   (undertaken by Actis Environmental Services and included as Appendix Two).

3. Lake Characterisation
   (undertaken by Actis Environmental Services and Syrinx Environmental PL and reported separately).

The Brief for this project required the use of the assessment process developed by Coleman and Meney (2000) and sought an evaluation of it's suitability for application. As indicated in the Actis report (Appendix Two), the method was considered to be not directly applicable to assessment of surface water management proposals but the information collected provides a valuable supplement to the ecological assessment process.

Similarly, information from the Lake Characterisation study is used to supplement the ecological assessment process.

4.2 Ecological assessment

(Report component prepared by Syrinx Environmental Pty Ltd.)

4.2.1 Background

Surveys were undertaken within the Lake Bryde Catchment in April/May 2002 to assess current Nature Conservation Values of sites expected to be directly or indirectly impacted by surface water management proposals. The ephemeral chain of lakes comprising the Lake Bryde wetland system has been nominated as a Recovery Catchment under the State Salinity Strategy (2000) to be managed by Department of Conservation and Land Management. Lake Bryde is unusual in that it contains relatively fresh water in a landscape of increasing salinity, and therefore has regional significance. Lake Bryde (within Reserve 28667) and East Lake Bryde (within Reserve 29020) are unusual in that they are less saline than most other lakes in the associated salt lake chain (Watkins and McNee, 1987). Limited survey work undertaken by Department of Conservation and Land Management as part of a study for the State Salinity Strategy indicates Lake Bryde is an 'improving' wetland, which means remedial works are considered likely to improve quality (Halse and Cole, unpubl. update on results of wetland monitoring 1998-2000). Records undertaken in the mid 1990's indicated the salinity of Lake Bryde when full was approximately 200 mS/m, increasing to 2000 mS/m when almost empty (Mansell, 1995). The groundwater beneath Lake Bryde is hypersaline at 4000-6000 mS/m (Mansell, 1995). No studies have been made of salinity trends in other lakes in the Reserve.

The Lake Bryde Catchment lies within the Roe Botanical District and is part of the southern region of the Hyden Vegetation System on the Hyden Plateau, described generally by Beard (1981) as kwongan (scrub-heath and thicket) on sandplains, mallee on slopes over most of the system, mallee with patches of woodland on upper valley soils, woodland on lower valley soils and in saline areas a mosaic of woodland, shrubland and samphire. The vegetation characteristically forms a mosaic of vegetation types, with plant cover frequently varying in structure and composition every few metres due to the highly variable soil types, a situation which often complicates vegetation mapping (Beard, 1981). These edaphic factors (pH, conductivity, soil type) have been shown to correlate with vegetation (Ecoscape 2001). The study area also contains a Threatened Ecological Community (TEC) as one of the few remaining freshwater wetlands in the wheatbelt area.

In this study, assessments were made of the type and condition of major vegetation units intercepted by the proposed road re-alignment and low velocity waterway construction, as well as presence of priority or rare flora and/or vegetation communities. Assessment was also made of the regeneration potential of areas in terms of current impacts from waterlogging or salinity, and the potential impact from proposed surface water management strategies, as well as the extent of the current impact (i.e.. whether considered localised – i.e.. within a small part of a vegetation assemblage, or widespread – i.e.. throughout an assemblage).

The survey utilised information from previous vegetation surveys, as well as information on salinity and/or waterlogging changes where available. This survey should be viewed as a preliminary impact assessment, given that exact locations of the proposed waterway and Lake Bryde road diversion have not yet been determined. Furthermore, vegetation survey work was undertaken in reconnaissance fashion in autumn, so there may be priority flora in addition to that recorded in this survey.

4.2.2 Previous Vegetation Studies

Previous vegetation studies in the Lake Bryde Catchment include, most recently, a vegetation survey of the Crown Reserves and Road Reserves within the Lake Bryde Recovery Catchment as part of an inventory of the natural resources of the catchment by Ecoscape (Australia) Pty Ltd (January 2001). This covered approximately 18 200 ha of land on 16 crown reserves and 4 200 ha of vegetation along 19 road reserves (totalling approximately 22 400 ha) in a study area of approximately 165 000 ha. This survey was conducted over a three-week period in May 2000, using the methods of McDonald et al. (1998). Fifty sites consisting of nested quadrats of 100 m2 and 400 m2 were surveyed, as representatives of vegetation types in the catchment. Detailed information on the floristics, vertical structure and cover of the vegetation within each site was recorded, as well as information on soil and landform characteristics. The floristic and structural information obtained from the quadrats was combined with aerial photograph interpretation, field investigation and statistical analysis, in order to map the vegetation of the area, at a scale of 1:25 000 (Ecoscape, 2001).

In this study, three quadrats occurred immediately peripheral to Lake Bryde, one near the road entry to Lake Bryde, two peripheral to East Lake Bryde, four within the Reserve between the existing private land and Lakeland Nature Reserve, and six within the Lakeland Nature Reserve. Only one quadrat intercepted the proposed waterway route (start of waterway at Lake Bryde), and no surveys were undertaken within the lakes (i.e.. playa and lunette vegetation).

In the Ecoscape study, eight broad floristic associations were identified, which were further sub-divided into 22 floristic communities. The 22 floristic associations identified in this survey were compared with those described in Hopkins et al. (1996) to determine their conservation status.

Prior to the Ecoscape study, the following vegetation studies were undertaken (from Ecoscape 2001):

Beard (1976) mapped the major vegetation types of the study area as:

- Mixed woodland *of Eucalyptus salmonophloia* (salmon gum), *E. longicornis* (red morrel), *E. salubris* (gimlet) *and E. kondininensis* (Kondinin blackbutt);
- Woodland of *E. salmonophloia*;
- Mallee of *E. eremophila* (sand mallee) *and E. oleosa* (giant mallee) on lateritic soil;
- Paperbark scrub of *Melaleuca parviflora*;
- Scrub of *M. thyoides* (boree);
- Scrub heath of mixed *Proteacea*e and *Myrtaceae.*

Mattiske Consulting (1999) mapped 19 plant communities according to the Muir (1977) classification at 1:25 000 below the 300 m contour on the Lakeland, Lake Janet and Lake Bryde Nature Reserve. The communities consisted of 6 Woodland formations, 6 Mallee formations, 6 Shrubland formations and 1 Herbaceous formation. The majority of their study area was dominated by mallee formations of *Eucalyptus vergrandis, E. calycogona var. calycogona and E. occidentalis* over scrub on sand and mallee formations *of E. hypoclamydea subsp. ecdysiastes, E. phenax* and E. sporadica over low heath over low sedges in sand. Open woodland of *E. kondininensis* and thickets of *Melaleuca* species were prominent in areas surrounding lakes.

Ogden and Froend (1999) surveyed Lake Bryde's wetland vegetation as part of the Salinity Action Plan monitoring program. Four permanent transects were established at Lake Bryde to survey terrestrial vegetation to below the high water mark. Data on vegetation and physio-chemical parameters is being collected from these transects on a triennial basis.

4.2.3 Previous conservation value assessments

Both Lake Bryde and East Lake Bryde contain *Muehllenbeckia horrida ssp. abdita* across the lake-bed, which is a rare species and forms a Threatened Ecological Community (TEC) (Ogden and Froend, 1999).

Of the 11 vegetation associations identified in the Ecoscape survey, four could fall into the category of "not represented in conservation reserves" as described in Hopkins et al. (1996):

- Mosaic: Shrublands; mallee scrub; tall *E. eremophila* / Medium woodland; Gimlet (Si-11a/Mi-06o) - Ecoscape association type 3A;
- Medium woodland; mallet (Mi-04c) and Low forest; Moort (Lc-05b) – Ecoscape association type 3C; and
- Shrublands; *Allocasuarina campestris* scrub (Sc-04b) and Low woodland; *Allocasuarina huegeliana* (Li-11b) - Ecoscape association types 1C and 7B.

Six of the vegetation associations identified in the Ecoscape study could fall into the category of "poorly represented in conservation reserves". These correspond most closely with the following vegetation groups as described in Hopkins et al. (1996):

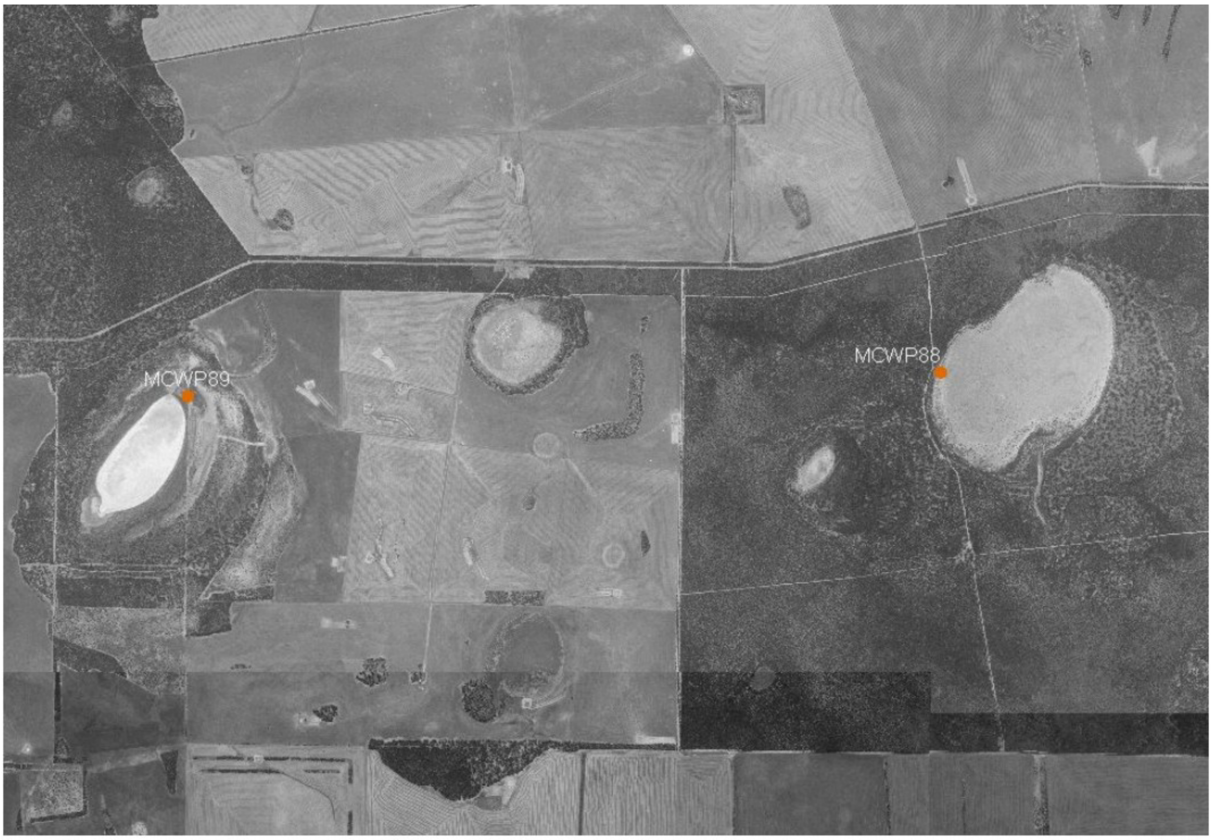
- Mosaic: Shrublands; mallee scrub; *tall E. eremophila* / Medium woodland; Salmon gum and Red mallee (Si-11a/Mi-06n) - Ecoscape association type 3A;
- Shrublands; *Allocasuarina campestris* thicket (Sc-04a) - Ecoscape associations type 1C and 7B;
- Succulent steppe; Tea-tree thicket over samphire (SC-02b) - Ecoscape association type 1A;
- Shrublands; Dryandra heath (Zc-02a) - Ecoscape association type 7C;
- Medium woodland; Salmon gum (Mi-05d) - Ecoscape association type 5.

Mattiske Consulting (1999) identified three Priority species. Nine species of priority flora were encountered during the Ecoscape study, in fifteen populations, as follows:
Leucopogon sp. Kau Rock (M.A. Burgman 1126) (P1), *Persoonia brevirhachis* (P2), *Rinzea affinis* (P2), *Dryandra epimicta* (P2), *Hakea brachyptera* (P3), *Stylidium neglectum* (P3), *Grevillea newbeyi* (P3), *Daviesia uncinata* (P3), *Grevillea prostrata* (P4).

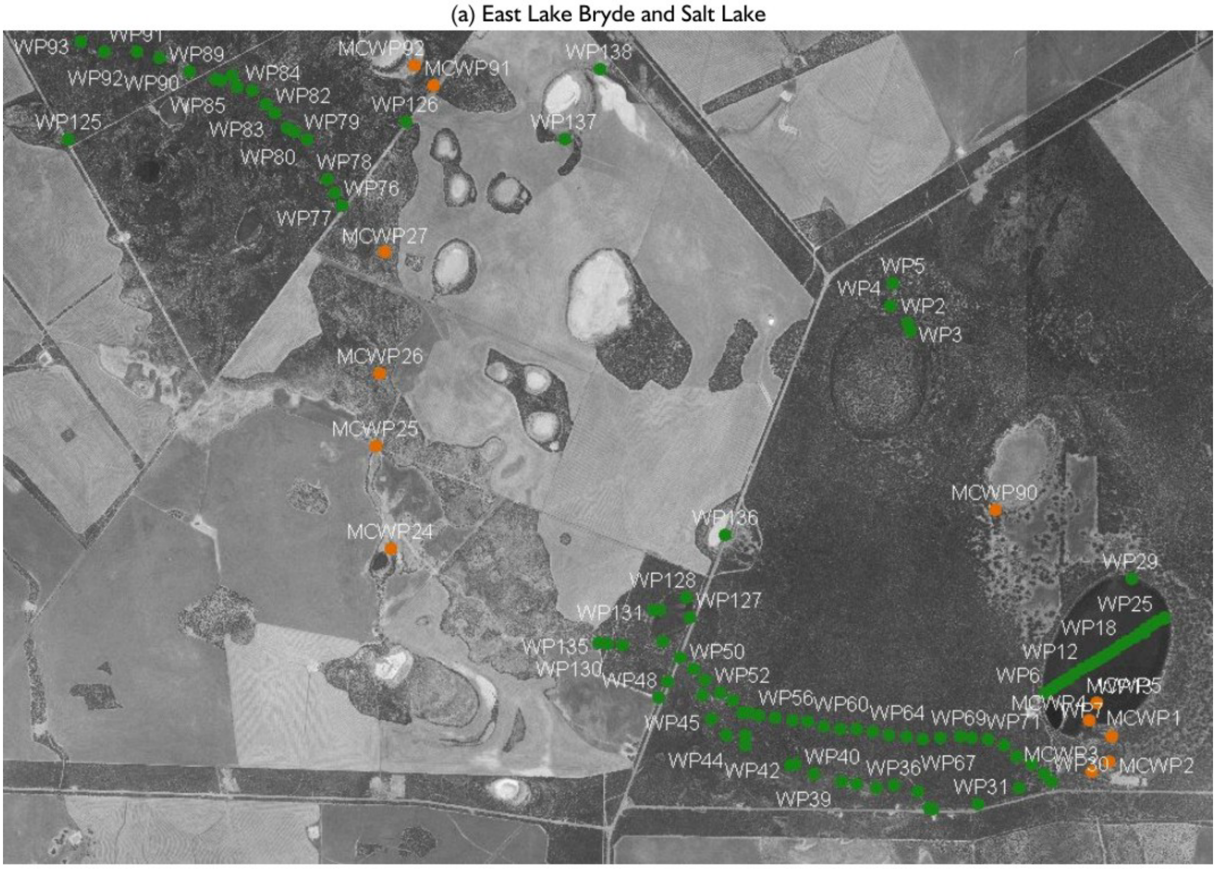
4.2.4 Methodology

Site Locations

Assessment of the conservation values of areas impacted by the proposed surface drainage strategies was undertaken by foot survey following GPS waypoints over a 6-day period in April/May 2002. Surveyed sites are shown in Figure 12 and the references are tabulated in Appendix Three.

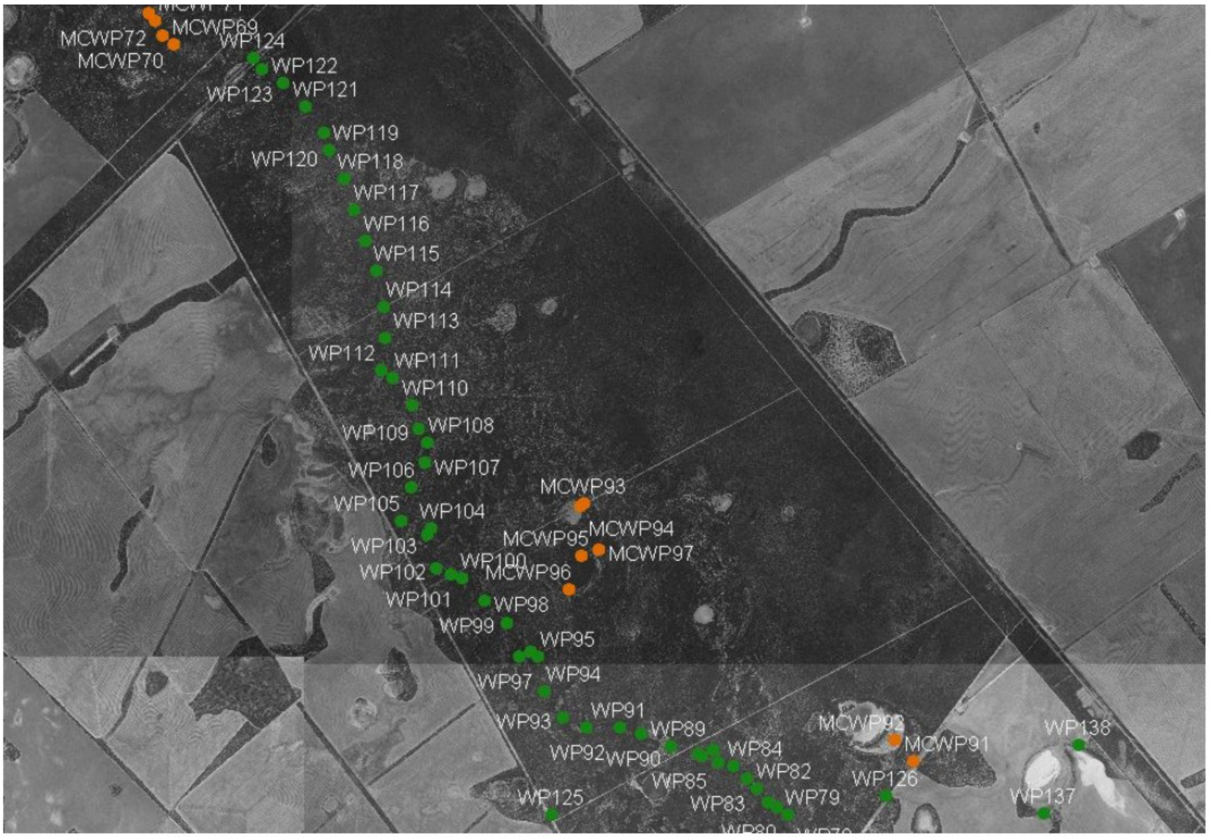


(a) East Lake Bryde and Salt Lake

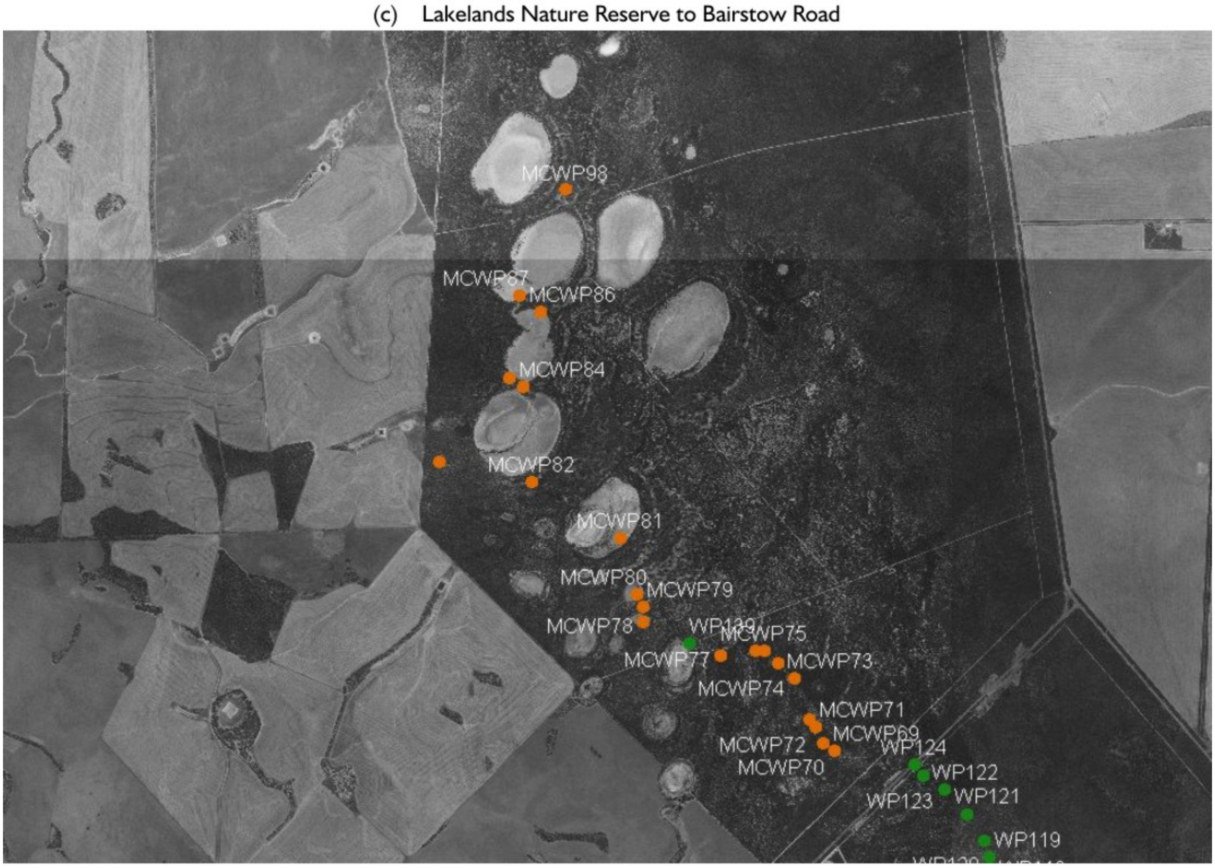


(b) Lake Bryde, Yate Swamp, Location 2586 and Lakelands Nature Reserve

Figure 12 Location of Survey Points



(c) Lakelands Nature Reserve to Bairstow Road



(d) Lakelands Nature Reserve (Receiving Wetlands)

Figure 12 Location of Survey Points

Survey approach

1. Lake Assessment
Vegetation surveys for the purpose of Lake assessment were carried out for the following lakes: Lake Bryde, Lake Janet, Fourteen Mile Road Lake, Diversion Lake (Private Land), Receiving Lakes (Lakelands Reserve), and East Lake Bryde

Lake vegetation was recorded within the lake bed, shoreline and surrounding vegetation. Lake shores were separated into distinct vegetation zones that usually reflected height above maximum water level, although relative levels were not recorded. This enabled thorough description of current lake condition and identification of successional change within these zones.

2. Waterway/Road Diversion Transects
Nominal routes for proposed surface water management strategies were superimposed on an aerial photo of the Lake Bryde Catchment. GPS locations were determined from the aerial photo and used as navigation coordinates for all transects. GPS waypoints were taken approximately every 200m along each transect to record the exact route taken. The actual route taken is shown in Appendix Three.

Vegetation surveys along set transects were carried out using the point intercept method with plots located at points of significant changes in assemblage structure (change in key overstorey species, most abundant understorey species) or change in vegetation condition. Each plot was recorded on GPS. Key plant species within a minimum radius of 20m of the GPS location were recorded. This ensured detailed description of vegetation characteristics along all transects, and approximate plot size uniformity with the previous Ecoscape survey approach.

3. Vegetation Descriptions
For each site floristic assemblages were characterised according to key overstorey species and most abundant understorey species, evidence of plant stress and recruitment of plant species. Voucher specimens for all species were taken for later identification. It was not possible for all voucher specimens to be collected with fertile material, however all Eucalyptus species were able to be collected with either buds or fruit and all Melaleuca species were collected with fruit. All specimens were identified at the WA Herbarium, using current species lists, vegetation keys, the reference collection, and expert opinion as required.

Vegetation assemblages were assigned a floristic association that best correlated with the floristic associations identified by Ecoscape (2001). Using their data and that of Hopkins et al (1996), the nature conservation value of each floristic association was determined.

4.2.5 Floristic and Environmental Data

All recorded information for sites was broken down and recorded in Appendix Four:

- GPS location (AGD84, Northing and Easting);
- general site description;
- vegetation assemblage;
- dominant species
- associated perennial flora;
- correlated Ecoscape floristic association;
- percentage of live and dead dominant flora;
- occurrence and approximate age of vegetation recruitment;
- general condition and comments including: occurrence and type of vegetation stress including waterlogging and salt.

Data is interpreted on a site by site basis.

4.2.6 Assessment of potential impact locations

Results of the site survey are given in Appendix Four and summarised in terms of conservation status, extent of current impacts, likelihood of recovery through natural regeneration and successional replacement of degraded areas with no management action, likelihood of recovery through natural regeneration and successional replacement of degraded areas with the proposed management action, and impact assessment ranking.

The extent of current impacts are graded as follows:

1. **Major** – degraded showing possible loss of one or more associations, or with one or more associations showing loss of species not able to colonise upland areas;
2. **Minor** – degraded showing extension and contraction of one or more floristic associations, or successional loss and replacement of key species within floristic associations;
3. **None** – shows no current conservation threat.

Nature conservation impacts are graded as follows:

1. **Low** – proposed management strategy likely to have no or localised detrimental impact only; no priority flora or communities present.
2. **Medium** - proposed management strategy likely to have localised detrimental impact only; priority flora or communities present will require more detailed survey and possible re-routing of waterway/road structure.
3. **High** - proposed management strategy likely to have significant detrimental impact; priority flora or communities present or absent.

Floristic associations in this survey most closely matched the following Ecoscape Associations shown below. Associations 1A, 3A and 5 are considered poorly reserved according to Hopkins et al. (1996).
1A: Low-lying shrublands of *Melaleuca* species with or without forest of *Eucalyptus kondininensis* over salt-tolerant chenopod shrubland.

1B: Shrubland of *Melaleuca* species (commonly *M. lateriflora* subsp. *lateriflora*, *M. brophyi* ms, *M. uncinata*) with vines of *Cassytha melantha* over sedgeland of *Gahnia* sp.L (K.R. Newbey 7888).

2A: Open mallee forest of *Eucalyptus perangusta*, *E. phenax* and *E. suggrandis* subsp. *alipes* over shrubland of *Melaleuca depauperata* and *M. lateriflora* subsp. *lateriflora* over heathland of *Acacia viscifolia*, *Templetonia sulcata* and *Hibbertia gracilipes* over sedgeland of *Gahnia lanigera* and *Lepidosperma brunonianum*.

2B: Very tall open mallee forest or woodland of *Eucalyptus eremophila* and *E. flocktoniae* over shrubland of *Melaleuca uncinata* and *Santalum acuminatum* over heathland of *Melaleuca coronicarpa* and *Melaleuca societatis* ms over heath of *Boronia inornata* subsp. *leptophylla*, *Daviesia benthamii* subsp. *acanthoclona*, *Dodonaea bursariifolia*, *Grevillea huegelii, Grevillea oligantha*, *Melaleuca lateriflora* subsp. *lateriflora*, *Olearia ramosissima*, *Pultenaea conferta*, *Templetonia sulcata* and *Westringia rigida* over sparse sedgeland of *Gahnia lanigera* and *Lepidosperma brunonianum.*

3A: Mixed mallee forest, generally of *Eucalyptus eremophila* and open forest of *Eucalyptus urna* over shrubland of mixed *Melaleuca* species (*M. acuminata*, *M. lateriflora* subsp. *lateriflora, M. coronicarpa* and *M. adnata* over heathland of *Exocarpus aphyllus*, *Olearia muelleri* and *Templetonia sulcata*.
Includes mallet communities with similar understorey to mallee communities.

4A: Tall open forest of *Eucalyptus occidentalis* over shrubland of *Melaleuca acuminata*

4B: Tall closed forest of *Eucalyptus occidentalis* over low woodland of *Melaleuca strobophylla* over shrubland of *Olearia dampieri* subsp. *eremicola* over sedges, rushes and forbs.

5: Chenopod shrubland of *Atriplex paludosa* subsp. *baudinii*, *Rhagodia preissii* subsp. *preissii* and *Enchylaena tomentosa* over rushland of *Lomandra effusa* over forbland of *Vittadinia gracilis*.

6A: Tall shrubland of *Leptospermum erubescens* and *Melaleuca carrii* ms over heath of *Chamelaucium ciliatum* over rushland of *Lomandra effusa*, sedgeland *Gahnia lanigera* and *Lepidosperma brunonianum*, forbland of *Helichrysum leucosideum.*

6D: Mid-high open forest of *Eucalyptus suggrandis* subsp. *alipes* over mixed shrubland over chenopod shrubland of *Rhagodia drummondii*.

7A: Tall sparse shrubland of *Leptospermum erubescens* over heath of *Eremaea pauciflora*, *Hakea corymbosa* and *H. obliqua* subsp. *parviflora*, *H. brachyptera*, *Isopogon buxifolius*, *Lysinema ciliatum*, *Verticordia acerosa*, *Leucopogon constephioides* var 2, *Persoonia striata* and *Jacksonia racemosa* over forbland of *Stylidium repens* and grassland of *Neurachne alopecuroidea*.

8B: Tall mallee woodland of *Eucalyptus phaenophylla* subsp. *phaenophylla* and *E. scyphocalyx* over shrubland of *Callitris roei* and *Melaleuca uncinata* over heathland of *Exocarpus aphyllus*, *Melaleuca carrii* ms, *Melaleuca tuberculata* var *macrophylla*, *Hakea erecta*, *H. newbeyana*, *Isopogon buxifolius*, *Beyeria brevifolia* var *brevipes*, *Calytrix leschenaultii*, *Cryptandra minutifolia*, *Daviesia decurrens*, *Grevillea disjuncta*, *Lasiopetalum rosmarinifolium*, *Leucopogon constephioides* var 2, *L. minutifolius*, *Nemcia punctata* and *Hibbertia gracilipes* over sedgeland of *Loxocarya cinerea*, *Lepidosperma brunonianum* and *Gahnia lanigera*.

4.2.6.1 LAKE BRYDE

Lake Bryde is a depth gauged wetland monitored by Department of Conservation and Land Management more recently as part of the State Salinity Strategy study. Data indicate the volume of water entering the lake is approximately 2.5 times that of the pre-clearing scenario (JDA report, Appendix One), and that salinity has shown fluctuation over time, and a substantial salt mass increase during the 1992 peak event. From a vegetation perspective, the main stress impacts threatening the *Muehlenbeckia horrida* ssp. abdita TEC is the extended hydroperiod associated with larger water volumes entering the lake and inability of the existing outlet system to fully drain the lake for extended periods. This species requires fully drying for at least several months a year. This community is extensively degraded (>90% dead) in the less elevated south-eastern section of the lake where there is colonisation by samphires (Halosarcia spp). The northern sector is in good condition, with substantial and healthy populations of *Muehlenbeckia horrida* ssp. *abdita* and *Tecticornia verrucosa*, and extensive recruitment of *Melaleuca stropbophylla*. The Lake is of very high conservation value containing the rare species, *Muehlenbeckia horrida* ssp. *abdita* TEC, as well as poorly reserved floristic associations (1A, 5). Proposed drainage strategies relate to reduction of low flow events, and possible artificial maintenance of water levels.

Expected Impacts:	Reduction of low flow event surface water run-off entering lake Artificial maintenance of water levels through sill control on NE side.
Conservation Status:	Very High
Floristic Associations:	*Eucalyptus* Woodlands, *Melaleuca* Shrublands, *Muehlenbeckia horrida* ssp. *abdita* TEC ; Ecoscape Associations 1A & 5 (poorly reserved), 1B.
Priority Flora:	*Muehlenbeckia horrida* ssp. *abdita* endemic to Lake Bryde Wetland System.
Habitat Condition:	Good; poor on south-eastern side.
Current Impacts:	Lake bed = major; hydroperiod change and substantial salt load increase in the lake in 1992; peripheral vegetation = minor on south-eastern side to none elsewhere.
Regeneration potential with no action:	Recovery of *Muehlenbeckia horrida ssp. abdita* considered low without reduction in hydroperiod. Peripheral vegetation in the south-

	eastern section considered low without reduction in hydroperiod and possibly salinity.
Regeneration potential with drainage management:	High, assuming no major mobilisation of salts from surrounding catchment into lake bed through first major flush events or major inflow events (as occurred during 19920, and assuming no regional groundwater rise. This is considered likely (SKM 2000).
Impact Assessment (reduction of flows):	Low
Impact Assessment (with additional inflow from the north-east inlet):	High

4.2.6.2 LAKE BRYDE RESERVE (Proposed Road Relocation)

The proposed surface water management proposals include relocation of approximately 2kms of Lake Bryde Road between the Newdegate-Pingrup Road and the Lake Bryde inlet culvert; an area that has been identified as at risk (Farmer et al. 2002). This will require direct clearing of upland vegetation within the Lake Bryde Nature Reserve. Survey of the proposed route indicates it is of very high conservation value, and that impacts will be significant. The proposed road route passes through one poorly reserved floristic association (3A) at the Lake Bryde end, and a population of a Priority 4 species *(Grevillea prostrata)* in association 2B, occurring approximately halfway along the route. If this proposal is to proceed, it will require more extensive vegetation surveys to ensure protection of priority flora.

Expected Impacts:	Direct vegetation clearing through relocation of road (Project 1)
Conservation Status:	Very High
Floristic Associations:	*Eucalyptus* Woodland, Heathland, *Melaleuca* Shrubland, Mixed Shrubland; 3A (poorly reserved), 6A, 1B, 2B, 7A, 8B
Priority Flora:	*Grevillea prostrata* (P4)
Habitat Condition:	Very Good, locally degraded at western end.
Current Impacts:	Minor; localised waterlogging at western end; none elsewhere
Regeneration potential with no action:	Not applicable
Regeneration potential after clearing:	Road may result in degradation of immediate adjacent vegetation Athrough requirement for drainage culverts. In general, vegetation will have a good recovery potential in Woodland and Shrubland areas. Rehabilitation potential of the existing removed road is considered good because of the predominance of *Melaleuca* Shrubland.
Impact Assessment:	High

4.2.6.3 LAKE BRYDE TO LAKE JANET WATERWAY

The proposed waterway is to extend from the Lake Bryde inlet culvert, along the existing Lake Bryde Road, on either the northern side only (assuming relocation of the road), or on both northern and southern sides assuming retention of the road. This will require direct clearing of vegetation within the Lake Bryde Nature Reserve. Survey of the proposed route indicates that vegetation condition along the proposed northern route is generally poor, impacted by extensive waterlogging damage.

Conservation values are high since the site extends through *Melaleuca* Shrublands which are considered poorly reserved. This site can be considered degraded to severely degraded and will probably benefit from improved surface drainage.

Expected Impacts: Direct vegetation clearing from construction activities (Project 1).

Conservation Status: High

Floristic Associations: *Eucalyptus* Woodland, *Melaleuca* Shrubland, Mixed Shrubland; 3A & 1A (poorly reserved), 1B, 2A, 6A.

Priority Flora: None

Habitat Condition: Generally poor; localised good areas.

Current Impacts: Major; extensive waterlogging damage, loss of mallee associations, localised loss of species *(Gahnia sp., Eucalyptus suggrandis ssp. suggrandis),* and no evidence of mallee recruitment.

Regeneration potential with no action: Poor

Regeneration potential after clearing: High

Impact Assessment: Low

4.2.6.4 YATE SWAMP

Yate Swamp is considered of high conservation value due to the extent of healthy and associated shrubland, and the fact that it is a freshwater wetland which is a threatened ecosystem in the wheatbelt due to salinisation and waterlogging. Current impacts relate to high surface water flow events discharging to the wetland from upland agricultural clearing, which has resulted in mainly localised changes to vegetation assemblages. The amount of inflow to the swamp from non-agricultural land (ie from within the Reserve) is not known but is expected to occur only during significant rainfall events. It is not expected that the swamp will be inundated more than under natural conditions with the surface water management proposals.

Overall vegetation condition is very good. The main lake bed indicates minor impact from additional surface water flows, which mainly impact vegetation within and peripheral to the main drainage inlet. It appears that most of the additional run-off recharges the groundwater before entering the main lake bed. Recruitment of all major species is high, and has occurred over several events, with older juveniles probably emerging after a fire evidenced around the northern lake edge.

Expected Impacts: Reduction of surface water run-off entering lake (although the proposals suggest provision for diversion of some surface flow to the lake if required.)

Conservation Status: High, freshwater wetland which is unusual in the wheatbelt.

Floristic Associations: *Eucalyptus* Woodlands, *Melaleuca* shrublands; Ecoscape Associations 1B, 4A, 4B, 2B

Priority Flora: None

Habitat Condition: Good

Current Impacts: Minor; waterlogging localised.

Regeneration potential with no action: High through successional change, but will result in an extension of *Melaleuca* Shrubland and further localised loss of yates and Woodland species peripheral to the main inlet channel.

Regeneration potential with drainage diversion away form the wetland: High, but will result in contraction of successional *Melaleuca* High Shrubland that has colonised *Eucalyptus salmonophloia* Open High Woodland (Association 2B).

Impact Assessment (reduction of flows): Medium; will result in localised successional changes, mainly contraction of Melaleuca Shrubland.

4.2.6.5 CONNECTING WATERWAY AND DIVERSION LAKE (Roe Loc.2586)

Remnant vegetation in this area is generally degraded to severely degraded and contains several secondary salinised lakes. An existing drainage channel from Fourteen Mile Road is contributing to secondary salinisation of soils and recent degradation of vegetation. Good remnant vegetation pockets exist as margins to the lakes, or drainage line and include Eucalyptus eremophila Woodland (association 2B), and Melaleuca Shrubland (association 1A). The direct impact of the waterway through this land is considered low and the potential to reduce salinity is good.

Diversion Lake is degraded due to high salt load and additional inundation or salt load is unlikely to cause significant additional degradation. However, the potential impact of the proposal to divert excess discharge water beyond the main receiving lake (ie Diversion Lake) via a constructed waterway to the Lakeland Nature Reserve is considered extremely high. It is recommended that Diversion Lake is considered as a final receival point for a portion of flows.

Expected Impacts: Direct clearing of the connecting waterway; more frequent flushing of main 'Diversion Lake'.

Erosion Risk: The proposed waterway is unlikely to cause significant erosion. The overall gradient is 0.007% and for most of the proposed course, the substrate soils are of clay texture and would resist erosion. An existing 'W-drain' in one section of the proposed watercourse shows little erosion.

Conservation Status: Low

Floristic Associations: Samphire, Eucalyptus Woodlands, Melaleuca Shrubland; (poorly reserved), 2B.

Priority Flora: None

Habitat Condition: Generally poor; localised good areas.

Current Impacts: Major; localised waterlogging damage, salt damage, agricultural clearing.

Regeneration potential with no action: Poor

Regeneration potential with drainage management: Poor

Impact Assessment: Low

4.2.6.6 LAKE JANET

The proposed surface water management strategy to increase flow continuity by construction of the waterway upstream from Lake Janet will result in a reduction of surface flows through the southern lake inlet. This lake is considered of high conservation value, with the lake bed and lake edge vegetation showing localised waterlogging damage due to higher water volumes and extended hydroperiod. The lake bed is dominated by samphires (including Tecticornia verrucosa), and maximum water heights appear to be 0.5m higher than expected in pre-clearing conditions.

Lake Janet contains poorly reserved Melaleuca Shrubland communities with Eucalyptus kondininensis on the outer eastern lunette, and the lake itself is part of the chain of threatened ecological freshwater wetland communities in the Lake Bryde Wetland Catchment.

Expected Impacts:	Reduction in surface water volumes
Conservation Status:	High
Floristic Associations:	Samphire, Eucalyptus Woodland, Melaleuca Shrubland, Mixed Shrubland; 1A (poorly reserved), 1B, 6A.
Priority Flora:	None
Habitat Condition:	Generally poor; localised good areas.
Current Impacts:	Minor; localised waterlogging damage.
Regeneration potential with no action:	Poor without reduction of hydroperiod.
Regeneration potential with drainage management:	High
Impact Assessment:	Low

4.2.6.7 LAKELANDS NATURE RESERVE (Roe Loc. 2586 to Bairstow Road)

This area lies within the major valley system, but traverses a mosaic of vegetation types ranging from Shrublands to Mallee Woodlands and is dominated by Association type 1A (Melaleuca Shrublands) which are poorly reserved. The condition of vegetation is excellent in the southern sector, extends through pockets of localised waterlogging damage further north where the main channel abuts farmland to the east, to widespread waterlogging impacts where surrounding farmland drainage channels converge on the western side. Samphires are absent south of this connecting farmland channel, indicating increased salt loads and waterlogging impacts in the central and northern areas directly due to these flows. Direct clearing impacts will therefore range from high to low, depending on location within this reserve. The impact of diverting high volumes of water and higher salt loads through this area is considered very high.

Expected Impacts:	Direct clearing; receipt of saline waters and higher water volumes from upstream waterway and suggested overflow from 'Diversion Lake'.
Conservation Status:	High
Floristic Associations:	*Eucalyptus* Woodlands, *Melaleuca* Shrubland, Mixed Shrublands; 1A (poorly reserved), 1B, 2A, 6A, 6D.
Priority Flora:	None
Habitat Condition:	Generally good; localised poor areas.

Current Impacts: Minor; localised waterlogging damage, salt damage.

Regeneration potential with no action: Average, will result in extension of samphires and replacement of mallees with Melaleuca Shrublands, assuming no increase in salt loads.

Regeneration potential with drainage management: Poor; unlikely waterway will be a fully sealed system (expect higher salt loads and water volumes and increased frequency of inundation).

Impact Assessment: High

4.2.6.8 LAKELAND RESERVE

This area is the northern extension of the waterway from the start of the Lakelands Reserve to the first receiving lake. Vegetation is dominated by Association type 1A (Melaleuca Shrublands) which are poorly reserved, with pockets of mallee or Eucalyptus kondininensis Woodlands. The condition of vegetation within the main channel is degraded, showing evidence of localised to widespread waterlogging and salt damage. This is considered to be due to run-off from agricultural land on the western side and from connection with the drainage channel further south. Samphires are present within Melaleuca Shrubland communities, indicating increased salt loads and waterlogging impacts. Direct clearing impacts are considered low. The impact of diverting higher volumes of water and higher salt loads through this area is considered very high.

Expected Impacts: Direct clearing; receipt of saline waters and higher water volumes from upstream waterway, excess discharge water from the 'Diversion Lake' and saline drainage from the western agricultural land.

Conservation Status: High

Floristic Associations: *Eucalyptus* Woodlands, *Melaleuca* Shrubland; 1A (poorly reserved), 1B.

Priority Flora: None

Habitat Condition: Average to poor; localised good areas.

Current Impacts: Major; waterlogging damage, salt damage.

Regeneration potential with no action: Poor, will result in extension of samphires and replacement of mallees with Melaleuca Shrublands, assuming no increase in salt loads.

Regeneration potential with drainage management: Poor; unlikely that waterway will be a fully sealed system, expect higher salt loads and length of inundation.

Impact Assessment: Medium

4.2.6.9 RECEIVING LAKES (Lakeland Nature Reserve)

The proposed management strategies will require a nominated disposal point for diverted water and salt loads. This has been nominated as the first six or so lakes within the Lakeland Nature Reserve north of Bairstow Road. These lakes at present have little evidence of receiving flows from the upper catchment except on irregular events (JDA, Appendix One), and are all ephemeral. Vegetation is diverse, dominated by Association type 1A (Melaleuca Shrublands) which are poorly reserved, Eucalyptus kondininensis Woodlands over chenopod shrublands (association type 5, also poorly reserved), yate woodlands and mixed mallee woodlands. Two of the upstream lakes previously supported Muehlenbeckia horrida ssp. abdita, which is still present as dead remnants across the lake bed. Lake characteristics are variable, with some saline, others evaporative gypsum-based lakes, showing a high diversity of origin and therefore conservation significance (Meney and Coleman, 2002).

The condition of vegetation in the lakes is variable. It is generally degraded in the lake bed along the southwest, adjacent to farmland, and is generally showing localised to widespread waterlogging and salt damage. Samphires are present within Melaleuca Shrubland communities, indicating increased salt loads and waterlogging impacts. Lakes in the north and north-east are in good to very good condition. This variability in lake condition over small areas, with most degraded lakes adjacent to agricultural areas to the west, suggests groundwater rise may not be the key issue at this stage.

The proposal is to discharge water from the low velocity waterway into lakes within the Lakeland Nature Reserve. The capacity of these lakes is approximately 1.3x106 M3 (about 30% greater than the capacity of Lake Bryde) which is adequate to contain the discharge flows in all but exceptionally high flow events (JDA, Appendix One). It is likely that in most years, only a small proportion of that capacity would be filled however the more frequent inflow will alter the hydro-period of the lakes.

The impact of diverting higher volumes of water and higher salt loads through this area during medium to large flow events is considered very high. The impact of larger run-off events (which will overflow the proposed low-velocity waterway) is due to accumulation of residual salts. This is potentially damaging to peripheral vegetation (currently in excellent condition).

Expected Impacts:	Direct clearing; receipt of saline waters and higher water volumes from upstream waterway, excess discharge water from the 'Diversion Lake' and saline drainage from the western agricultural land.
Conservation Status:	High
Floristic Associations:	Eucalyptus Woodlands over chenopod shrublands (5, poorly reserved), Melaleuca Shrubland 1A (poorly reserved), 1B, 2A, 6A.
Priority Flora:	None; Muehlenbeckia horrida ssp. abdita dead in two lakes; seed bank reserve unknown.
Habitat Condition:	Average to very good.
Current Impacts:	Major to none; waterlogging damage, salt damage.
Regeneration potential with no action	Poor to average, will result in extension of samphires, loss of Melaleuca shrublands, and replacement of mallees with Melaleuca Shrublands further upslope, assuming no increase in salt loads.
Regeneration potential with proposed drainage management:	Poor, expect higher salt loads and water volumes in major events.
Impact Assessment:	High

4.2.6.10 EAST LAKE BRYDE

East Lake Bryde is predominantly fed by the fully vegetated Lake Magenta Catchment, and is a freshwater lake of high conservation value, in excellent condition. The lake contains the only living population of Muehlenbeckia horrida ssp. abdita other than Lake Bryde. This species showed variable recruitment ages of this species, with the most recent seedlings approximately one-year old. Freshwater conditions are evidenced by fresh crustaceae exoskeletons. Peripheral vegetation is also in excellent condition, dominated by Yate (Eucalyptus occidentalis) Woodland over Melaleuca Shrubland. Mixed mallee Woodland occurs in the surrounds. At this stage East Lake Bryde indicates no threat from surface water changes, and is considered at most threat from long-term changes to groundwater levels.

Expected Impacts:	Uncertain, at this stage undefined 'limited engineering intervention' to modify surface water inflows; possible groundwater management strategies.
Conservation Status:	High, freshwater wetland = TEC
Floristic Associations:	*Muehlenbeckia horrida ssp.* abdita with *Tecticoria verrucosa* = TEC, *Eucalyptus* Woodlands, Melaleuca shrublands; Ecoscape Associations 1A, 4B, 6A
Priority Flora:	*Muehlenbeckia horrida* ssp. *abdita* Rare; endemic to Lake Bryde Wetland System.
Habitat Condition:	Excellent
Current Impacts:	None (there is relatively recent decline *of Melaleuca sp*. associated with the inlet (opposite the road access). This is probably related to increased salinity of minor flows to the lake that evaporate and concentrate in the vicinity of the inlet.
Regeneration potential with no action:	High; major risk is groundwater rise.
Regeneration potential with: minimal drainage management:	High

5. LAKE BRYDE ROAD WATER MANAGEMENT AND ROAD RE-ALIGNMENT

5.1 Current situation

Lake Bryde Road, from the Newdegate-Pingrup Road to the road entrance to Lake Bryde, a distance of approximately 2.5km, is located in the valley floor. Figure 10 shows the area of inundation that may occur during a large flow event in relation to this road (Farmer et al. 2002). The effect is that Lake Bryde Road is frequently inundated even with small rainfall events and may remain affected for up to 3 weeks.

The source of water that accumulates in this area is from South Lake Bryde catchment, which has a high salt load, and from Days Creek and smaller local waterways which are relatively fresh. The surface water flow pattern has been mapped (EWM, 2001 Figure 4). Stream flow from Days Creek has previously been diverted towards the South Lake Bryde tributary because of localised flooding problems on agricultural land although the same volume continues to inundate the valley floor.

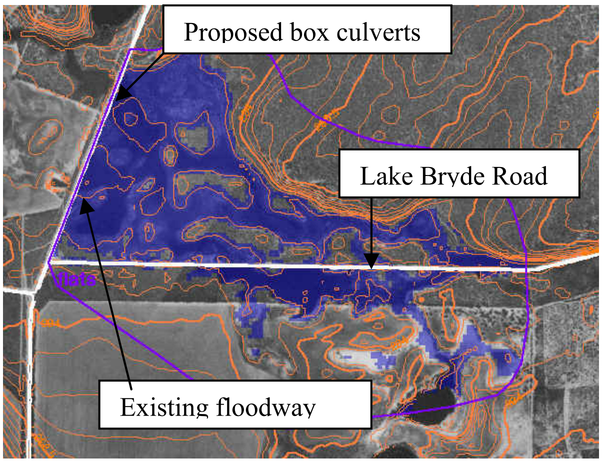


Figure 11 Potential extent of inundation in relation to Lake Bryde Road
(Source: Farmer et al., 2002)

The causes of surface water accumulating in this area are:

- restrictions caused by the Newdegate/Pingrup Road,
- restrictions caused by the Lake Bryde Road,
- low landscape gradient
- impedance by vegetation

Inundation of this location is causing significant degradation to vegetation. It is an area of recognised high salinity risk (SKM, 2000 and Farmer et al., 2002). Excess periods of inundation will add to this risk. It is also a traffic hazard and increases the cost of road maintenance.

5.2 Proposed Management

Initially, it should be noted that an important proposal made by Farmer et al., (2002) is to reduce impedance to flow for surface water that is currently detained near Ryan's Road (Project 2: Ryan's Road-Lake Bryde Road). This will clearly be of benefit to that area and will enable vegetation there to regenerate. Although artificial detention is proposed as a part of the improved flow, there will still be addition flow to the valley floor near Lake Bryde Road that will add to inundation there without in situ management action. Flow from Ryan's Road has a relatively high salt load. As noted by Farmer et al., (2002), continuity of surface water flow in the Lake Bryde Road areas is required before the Ryans Road project should proceed.

Existing pipe culverts on the Newdegate/Pingrup Road are inefficient due to their limited capacity and because of inadequate hydraulic pressure difference across the road (EWM, 2001). Installation of a set of substantial culverts and retention of the existing floodway (Figure 10) are recommended by EWM (2001) to increase the culvert discharge capacity.

It is also proposed that a low velocity waterway be constructed to provide continuity of flow to the new culverts on the Newdegate/Pingrup Road and away from these culverts on the western side connecting to the proposed waterway into private land (Russell) and eventually to Lakelands Nature Reserve. It is expected that the waterway built in conjunction with the proposed box culverts will significantly reduce waterlogging and enable natural vegetation at the site to regenerate.

There are two options for location of the waterway (EWM, 2002).

Option 1: construct the waterway with crossings over the existing location of the Lake Bryde Road (Figure 11a),

Option 2: re-locate the Lake Bryde road away from the valley floor in order to better locate the proposed waterway and to avoid road-water crossings and road inundation (Figure 11b).

For the assessment process, it is understood that both waterway location options will reduce inundation although Option 1 may result in some delayed detention due to impedance cause by the road. The differences are in their potential impacts on nature conservation, the costs and social benefits.

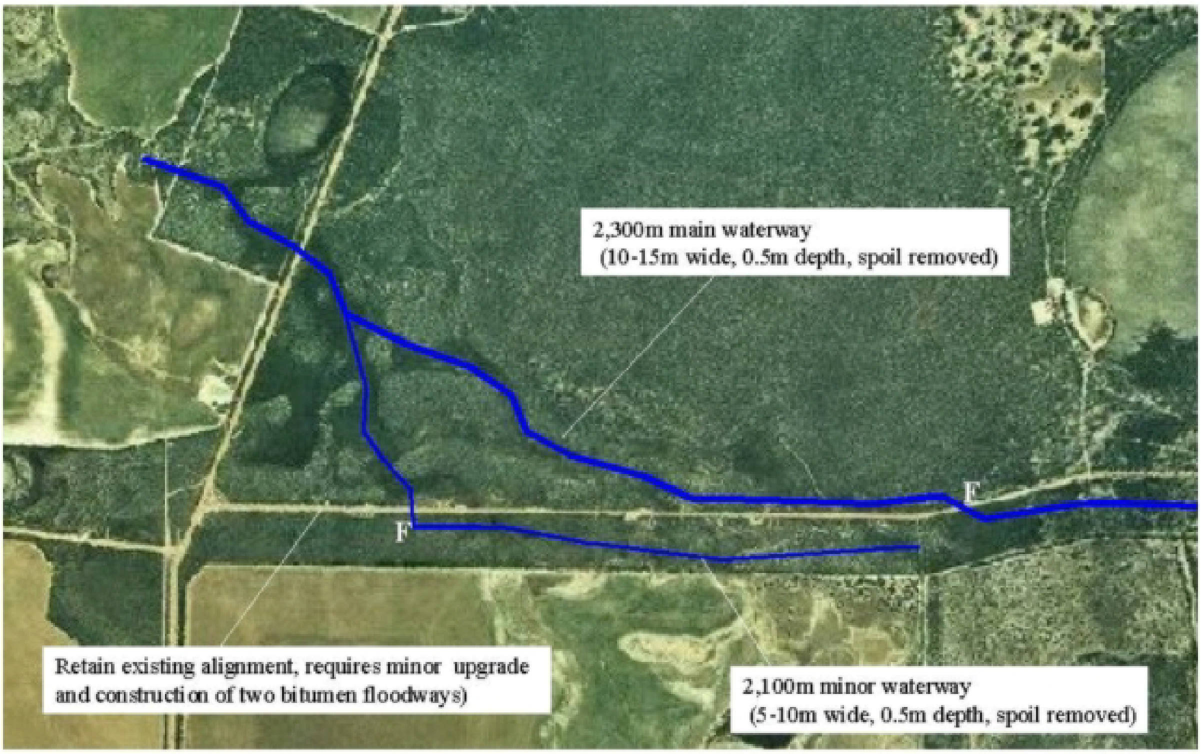


Figure 10 Option 1 for alignment of the proposed waterway and Lake Bryde Road
(Source: EWM, 2002).

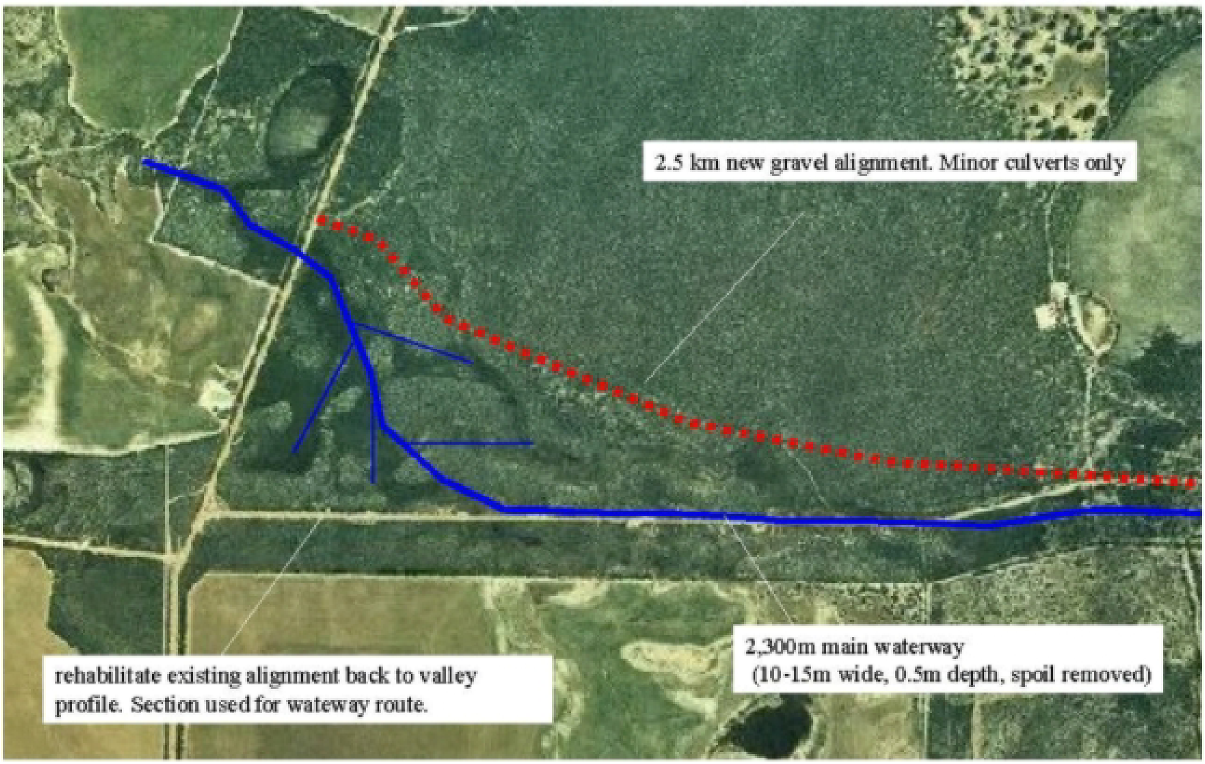


Figure 11 Option 2 for alignment of the proposed waterway and Lake Bryde Road
(Source: EWM, 2002).

5.3 Impacts on nature conservation

Assessment of the proposed course of the waterway for either option shows although there will be impacts by construction of the waterway, the potential for regeneration of both the disturbed area as well as adjacent areas currently degraded by inundation is high. The net effect is that the eventual impact will be low (Section 4.2.6).

Assessment of the proposed route for re-alignment of Lake Bryde Road shown in Figure 11(b) is through very high conservation status woodland within the Lake Bryde Nature Reserve that is currently not extensively degraded. Although the proposed disturbed areas would recover, the proposal has a high impact assessment (Section 4.2.6). The potential for impact on nature conservation values of alternative routes for road re-alignment were not assessed.

Construction of the proposed waterway includes removal of excavated spoil in order to increased the hydraulic efficiency of the waterways, to reduce in situ impacts by spreading the spoil and to reduce the potential for sedimentation of the channel or adjacent areas within the Reserve by erosion of spoil deposits. The estimate for spoil excavation for Option 1 is approximately 22,000 M3 and for Option 2, it is approximately 14,000 M3. The proposal is for spoil for either option to be re-located to private property (Roe Loc. No 2586) where there would be some potential for degradation due to sedimentation. There is little difference between the two options in relation to the potential impact due to spoil deposition with appropriate site management.

5.3 Cost and Social Benefit Analysis

Construction Costs

The proposals for waterway construction and road relocation are based on developed concepts rather than being based on detailed design. Accordingly, costs estimates are indicative only based on preliminary estimates of the works required.

Preliminary cost estimates for construction of the waterway are:

Item	Method	Estimated unit cost
Excavation of the waterway channel, load, removal of spoil (1-2km to deposition site).	Excavator, loader and truck.	$4/M3
Spoil spreading and site rehabilitation	Erosion control, vegetation/pasture establishment.	$2,500/ha
Site rehabilitation within the Lake Bryde Nature Reserve	Site preparation, direct seeding or revegetation.	$2000/ha
Road construction	Gravel road formation.	$15,000/km
Floodway construction	Bitumen seal	$17,000/floodway

For Option 1, the preliminary cost estimate of construction could be:

Excavation and relocation of 22,000M3 of spoil (for 4.4km of waterway)	$88,000
Management of 11ha of spoil site	$27,000
Rehabilitation of 6ha of disturbed land	$12,000
Construction of two floodways	$34,000
TOTAL	**$161,000**

For Option 2, the preliminary cost estimate of construction could be:

Excavation and relocation of 14,000M3 of spoil (for 2.4km of waterway)	$56,000
Management of 7.2ha of spoil site	$18,000
Construction of 2.6km of new gravel road	$39,000
Rehabilitation of 8ha of disturbed land	$16,000
New road disturbance rehabilitation costs	$10,000
TOTAL	**$139,000**

Maintenance Cost of Proposed Waterways

Maintenance costs for the proposed waterways will be incurred due to inevitable sediment deposition. The waterways are located in the catchment valley floor in a position near to change in catchment gradient (i.e. from 'shedding' to 'receiving' landform units). Reducing stream flow velocity will result in deposition of sediment within the vicinity of the waterways. These sediments will be progressively mobilised into the low-gradient waterways. Based on available information, there is no reason to expect difference in the maintenance costs of the waterways for the two options.

While the frequency of maintenance will vary considerable depending upon flow events, a reasonable estimate would be for sediment removal from the waterways at an interval of 5 years. The maintenance costs of roads, in addition to normal gravel road maintenance, will be greater for Option 1 and will increase for this option as the potential for high water tables and salinity beneath the road increases.

Expected Benefits

Reduced inundation will enable natural vegetation to regenerate and will reduce the risk of high water tables and salinity in the area. Both options will achieve these benefits.

While both options will improve access on Lake Bryde Road, Option 2 will clearly provide better access as there is no requirement for water to cross the proposed new road location. Improved access will benefit those who live locally and who visit Lake Bryde.

5.5 Comparison of Options

From the information available, Option 2 will be less expensive to implement than Option 1, have lower long-term maintenance costs and provide better and safer road access although these differences are not substantial. Both options provide significant benefit by enabling rehabilitation of natural vegetation.

Option 2 has a 'High Impact' rating and is in a 'Very High' conservation status area located within the Lake Bryde Nature Reserve. Option 1 will cause short-term disturbance although the potential for regeneration is good so there should be a longer-term net benefit for nature conservation.

6. ASSESSMENT OF SOCIAL AND RECREATIONAL VALUES

(Report component prepared by Jonelle and Genevieve Black)

6.1 Background

Historically, Lake Bryde has been an important social venue for local communities and visitors to participate in water-based recreation, picnics, bushwalks, horse riding and camping.

Over the past decade, the natural appearance of the Lake Bryde area has been affected by inundation and the onset of salinity. In July 1999, Lake Bryde was officially declared a 'recovery catchment for natural diversity' and is listed a priority catchment in the State Salinity Strategy (2000). At the time, Environment Minister Cheryl Edwards said:

The aim of this study is to evaluate how landholders in the catchment perceive Lake Bryde in terms of its current use and values. A synthesis of local attitudes on this topic will inform resource managers of the potential impact of any proposed actions on social and recreational values.

This study was instigated as part of an assessment of the potential impacts of proposed surface water management strategies of nature conservation, social and recreational values within the Lake Bryde Recovery Catchment (Farmer et al. 2002). This particular component of the assessment was required to provide a baseline of community values from which to compare the "do-nothing" scenario with the various options for surface water management.

6.2 Method

Natural resource managers have generally adopted a participatory approach to decision making. However, obtaining landholder opinions has usually relied on information generated from community meetings. Despite the meetings being open to everyone, often only a small section of the community attends. Research has indicated that those people inclined to attend a meeting do not necessarily represent the views of the broader community. In landcare circles, this observation has been described as "preaching to the converted". To avoid this sort of bias, it was decided to conduct a random survey of landholders in the recovery catchment.

In order to achieve a high response rate in the targeted population, a telephone survey was selected as the appropriate method. The interviews were conducted at various times of the day and early evening from the 27 April to the 1 May 2002. A total of 30 people were interviewed, representing over half of the households in the recovery catchment.

The questions were a mixture of closed and open-ended questions in order to generate quantitative and qualitative results.

6.3 Results and discussion

How did people respond to the interview?

Most people were enthusiastic about answering questions regarding the use and management of Lake Bryde, although a number of people expressed their concerns that there were too many studies and not enough outcomes on the ground. From the total sample of households, only one person refused outright to participate in the interview. Another family could not participate as they were new to the district.

Who was interviewed?

The majority of households sampled were a husband and wife partnership. To assist with obtaining a mixture of males and females in the survey, households were phoned at different times of the day and early evening. Just over one third of the respondents were female (37% female; 63% male).

Despite the survey being conducted in the school holidays, only one son of a landholder participated in the survey. Another two children declined due to their limited knowledge of the Lake.

How does Lake Bryde contribute to a sense of place in the district?

At a community meeting held on the 19 September 2001 it was suggested that Lake Bryde was the "jewel of the community". This term of reference was meant to capture the natural and social values associated with the lake. To determine how widely the term was accepted in the community, the survey respondents were asked to state how strongly they agreed or disagreed with it.

A majority of the respondents supported the term of reference (27% strongly agreed; 43% agreed). A number of respondents that refuted the term said that although the Lake was an important focal point for the community, it was not the "jewel" because there were other attractive places in the district. One respondent said that while the Lake was in government hands, and not owned by the community, it could not be their "jewel".

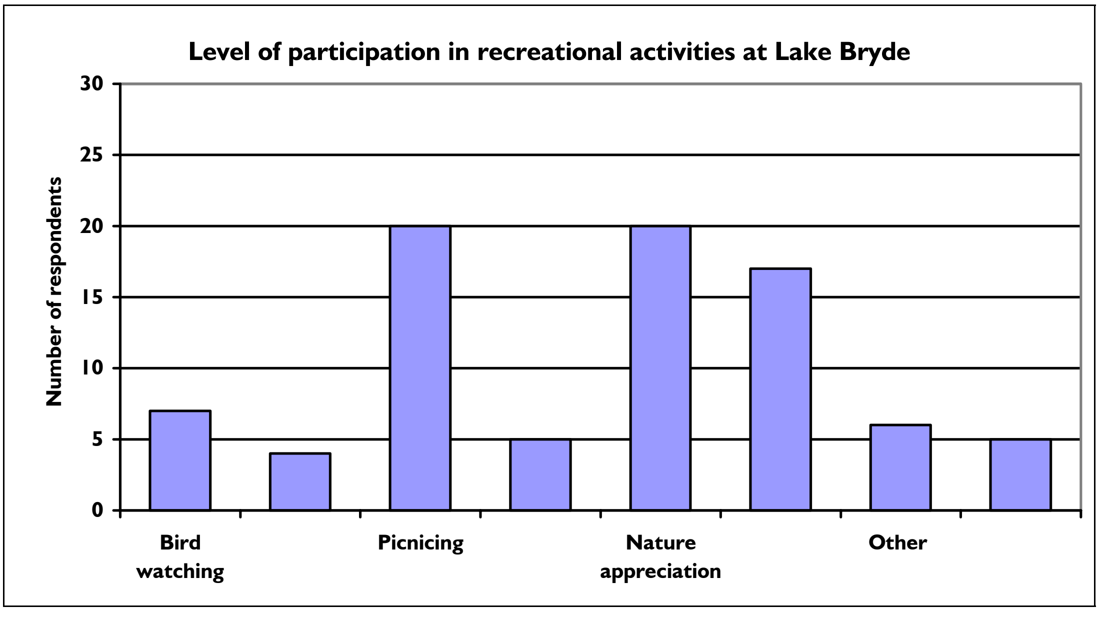
A number of features in the region were seen to complement Lake Bryde, and Holland's Tank was by far the most commonly mentioned. Other complementary features included: the Nature Reserves, natural vegetation such as the Salmon Gums, Holland's Track, wildlife (especially birdlife), wildflowers, breakaways and the history of the district.

What recreational activities do people pursue at Lake Bryde?

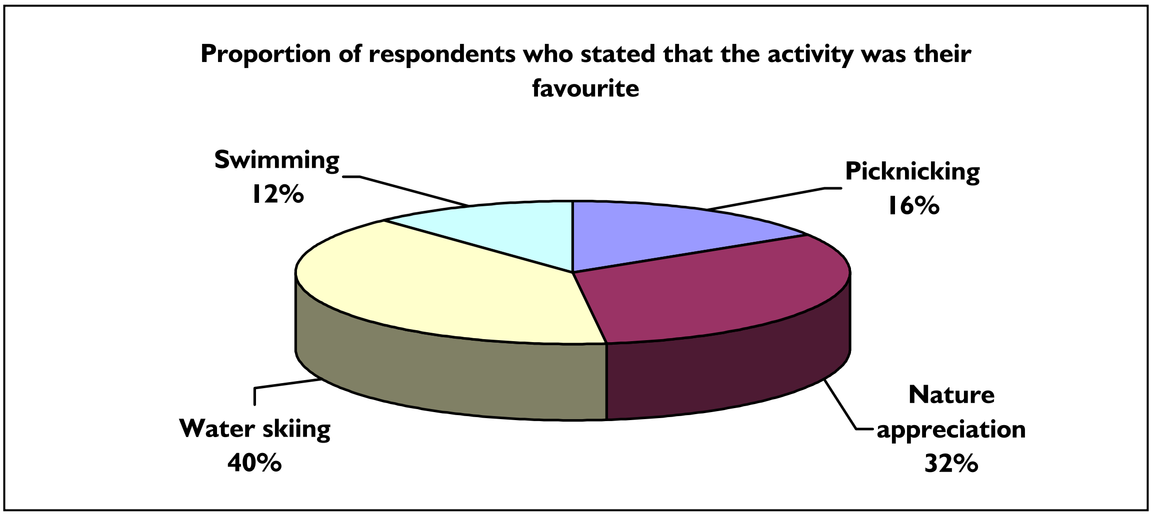
Out of the 30 respondents, only five did not recreate at the Lake. The most common activity was tied between picnicking and nature/landscape appreciation (67% of respondents). This was closely followed by water skiing (57% of respondents). Less than 25 per cent of the respondents participated in bird watching, camping and horse riding.

Trail biking was an option stated in the survey, however nobody reported to having participated in this activity. Perhaps, this would be higher if more children were interviewed in the survey. Other activities not stated in the survey, but noted by participants, included swimming, jet skiing and windsurfing.

It is also interesting to note how many activities people nominated: only four respondents nominated one activity, three respondents nominated two activities, 10 respondents nominated three activities, four respondents nominated four activities and four respondents nominated more than four activities. A strong correlation exists between picnicking, nature appreciation and water skiing.



What are people's favourite activities at Lake Bryde?
Whilst the previous analysis established the level of participation in a range of activities, it is important to determine the most popular or highly valued activities.



Respondents were asked to pick their favourite activity (minus the five that did not participate in any activities). Results show four activities that make the short-list. Water skiing is at the top of the list, followed by nature appreciation, picnicking and swimming.

The following analysis applies to the short-listed recreational activities, although the results could probably be applied more generally to other uses.

Timing

- Water skiing is restricted to the summer months, mostly on a weekly basis. For the last couple of years there has been insufficient water in the lake to ski.
- Nature and landscape appreciation can be an all year activity for some, usually on a monthly basis. Others prefer certain times of the year, such as the wildflower season or after the rains which bring the frogs out. Other people like to take visitors to the Lake to enjoy the scenery.
- Picnicking is favoured on special occasions, such as Mother's Day. Summer and spring were also popular times, usually on a fortnightly to monthly basis.
- Like water skiing, swimming is restricted to the summer months and by water levels in the Lake. The frequency that respondents participate in this activity is variable.

Social networks

- Water skiing is an activity undertaken predominantly with family and friends.
- A small proportion of respondents liked to appreciate nature and the landscape alone.
- Picnics and swimming were taken with the family or with family and friends.

Conflicting recreational uses

- No other recreational uses were seen to conflict with water skiing and swimming.
- Rubbish from picnickers was raised as a conflicting issue with nature and landscape appreciation. Trail biking was seen as a potential problem.
- A source of conflict for some picnickers was the loud noise emanating from powered water craft.

Site satisfaction

The overall satisfaction with Lake Bryde was very high for all recreational activities. Many respondents stressed that the natural features were what attracted them to the site in the first place, and that these should be protected and maintained into the future.

There was a degree of overlap between the recreational activities and the improvements suggested by the respondents (see table on following page). Water skiing, nature appreciation and swimming shared the desire for more water in the lake during summer and improving water quality.

Alternative sites

One third of the respondents believed that there were no other alternative sites that could fulfil their recreational needs. Holland's Tank, the local nature reserves and the breakaway ridges were suggested as alternative sites for nature and landscape appreciation and picnicking. The following lakes were suggested as alternative sites however distance was a major deterrent for most respondents: Lake Moodiarup, Lake Grace, Lake Nougup, Lake King and Lake Towerinning. One respondent suggested that if they could no longer swim at Lake Bryde they would consider putting a pool in at their home.

Factors which could make the recreational experience more enjoyable

Items mentioned by respondents	Water skiing	Nature appreciation	Picnicking	Swimming
Nothing – keep it the way it is, natural	✖✖✖✖✖	✖✖✖✖	✖✖	✖✖✖
Better access to the water – ramp, beach	✖✖		✖	
Clean up dead trees & sticks	✖✖	✖	✖	
More water in the lake during summer	✖✖	✖		✖✖
Better facilities – toilet, BBQ, seating	✖✖		✖	
Remove the dam	✖	✖✖		
Improve water quality	✖	✖		✖✖

NB. The number of crosses does not directly correlate to the number of respondents, as some people mentioned more than one item.

Broader management considerations

Specific conservation issues

Nearly 40% of the respondents knew that Lake Bryde contained an 'Ecologically Threatened Community'. The source of this information was by word of mouth, the Department of Conservation and Land Management and community meetings. A number of respondents were sceptical about the listing, saying that you can never be too certain that it doesn't occur elsewhere. Others pointed out that the threatened community was also found in East Lake Bryde.

The vast majority of respondents agreed that preserving the ecologically threatened community was a management priority for Lake Bryde. Many respondents clarified their response saying that they did not want to see the Lake "shut up" for that purpose alone.

Water supply issues

Opinions were equally divided on whether water in the lake should be used for water supply during drought. Some respondents indicated that stock don't drink the water because they don't like the taste. Others did not see the point of pumping water to the holding dam just for it to evaporate, especially when there were other water supplies in the district.

Salinity issues

There was a high level of concern over the impact of salinity on the natural vegetation and wildlife of the Lake. It was noted that salinity was not only a problem for Lake Bryde, but also the farmers in the district. As a consequence, an integrated solution was needed. Some respondents suggested engineering solutions, whilst others suggested modifying those land uses that had an adverse impact on the Lake. Many respondents have tried planting trees to address the problem.

Some respondents were disillusioned with the process, particularly with the high turn-over of agency staff and attending numerous meetings over the years to see nothing materialise.

There was a high level of divergence and confusion over the impact of removing impediments to surface water flow. Some respondents believed that there would be no impact, as the hydrodynamics of the Lake had not changed for the duration of their lives (it was indicated that the Lake is filled one in every three years). One respondent noted that after the 1998 floods some trees surrounding the Lake died because the water could not drain away fast enough. Another respondent indicated that the vegetation on the northern side had degraded the most because this was where the water ponded for a long periods of time. Others were annoyed that nothing had happened with regards to re-routing the road. This reflects the general sentiment that something needs to be done sooner than later.

6.4 Conclusion

Lake Bryde is an integral part of the social fabric of the local community. It is a regional asset that facilitates an active and healthy connection between people and nature. It provides recreational opportunities for people living locally and for adjacent local communities.

The fact that the vast majority of recreational pursuits at Lake Bryde involved the family cannot be undervalued, especially at a time where this traditional unit of society has come under extreme pressure. Putting this into perspective, the national average for time spent with the family in recreation and leisure activities is a mere 38% of the total time. Only a further 18% of people spend this time with family and friends (McLennan 1998).

It is considered important by the local community to maintain the natural appeal of Lake Bryde, but it is recognised that some improvements are needed to either maintain or increase the recreational amenity for local users of the site. These include better facilities (such as toilets, BBQ's and seating) and improved access to the water (such as a cemented ramp and a small beach area). Opportunities exist to market the value of Lake Bryde to a wider audience by making links with other popular natural features in the district, and providing a social and historical context for the experience. Perhaps the latter could be captured in a small information bay at the site.

Some local suggestions for improvements to the Lake will be more controversial. These include removing the dam, cleaning up the dead trees and sticks and keeping more water in the Lake. Before any of these actions are undertaken an analysis of the expected benefits verses the costs is necessary. The benefits and costs need to taken into consideration environmental (En), social (So) and economic (Ec) factors. The table below lists some of the factors that need to be weighed up in the decision making process.

The costs and benefits of proposed actions

Action	Costs	Benefits
Remove dam	• Material to fill dam (Ec) • Labour and machinery to do job (Ec) • Plants needed to rehabilitate site (Ec & En) • Loss of water supply during drought (Ec & So)	• Improved landscape and recreation amenity (So) • Help to restore natural water flow regime (En)
Clean up dead trees and sticks	• Labour and machinery to do job (Ec) • Disposal of trees and sticks (Ec & En) • Potential that habitat for some types of birds may be lost (En) • Potential for soil destabilisation (En) • Encourages people to treat the symptoms not the cause of salinity (So)	• Improved landscape and recreation amenity (So)
Keep more water in the Lake during summer	• Materials to construct water retention device (Ec) • Labour and machinery to do the job (Ec) • Disturbs natural drying and wetting cycles of the Lake (En) • Potential to adversely impact on biodiversity of Lake (En)	• Improved landscape and recreation amenity (So) • More people use Lake encouraging greater family and community cohesion and more interest in the management of the Lake (So)

The local community perceived the threat of salinity on Lake Bryde in terms of its detrimental impact on the vegetation surrounding the Lake and on the wildlife of the region, especially birdlife. Even where water skiers noted that salinity would not affect their recreational pursuits, they were very concerned by the impact of salinity on the amenity of the area.

If nothing is done to protect the Lake from salinisation the social consequences will be serious. At least one third of those people surveyed could not see any alternative sites fulfilling their recreational needs. Holland's Tank was suggested as a potential substitute for nature appreciation and picnicking but water skiers would need to travel further a field to find a suitable lake. This could potentially fragment the social base of the local community.

The majority of Lake Bryde is under the jurisdiction of the Department of Conservation and Land Management. The management of the Threatened Ecological Community at the site is a high priority. Just under a half of the survey sample were aware of the threatened community, and the majority of those sampled agreed that its protection was a management priority. However, the local community did not want to see the Lake managed for this value alone. This is an important point to consider in any proposals to modify the wetting and drying cycle of the Lake to enhance the survival of the threatened community.

A small part of the Lake, including the dam, is under the management of the Water Corporation. A point of conflicting local views was the issue of using the lake for water supply during drought. The extent to which the Lake is still used for this purpose needs to be clarified first. The outcome will guide the nature of further discussions on this topic.

In general the respondents held a strong sense of ownership of Lake Bryde and many landholders have taken an active role in landcare in order to protect the natural and social values of the Lake. However, there is a degree of frustration that the numerous studies, reports and meetings conducted in the past have not returned clear solutions for them to implement on the ground. Some respondents believe that the proposed road re-alignments should be implemented without delay.

The management of salinity has been a learning curve for both government agencies and landholders, and the outcome today is a more pragmatic approach to the problem. High value public assets are being identified and concerted government efforts are being channelled to protect these. As such, Lake Bryde has been identified as a recovery catchment for natural biodiversity and a number of surface water management strategies have recently been proposed (Farmer et al 2002).

It is important to acknowledge that any actions taken to protect biodiversity values in the Lake Bryde Recovery Catchment will also have a social impact on Lake Bryde and the surrounding district. Therefore, it is crucial that the results of this survey are factored into the decision making process.

Acknowledgements

We greatly appreciated the enthusiasm and honesty expressed by the people who participated in this survey. We extend our thanks to Sandra Hohloch from the Department of Conservation and Land Management for providing background reading material. We also acknowledge the Lake Bryde Recovery Catchment Team for their support.

7. Comparative Assessment

A assessment is made of nature conservation, social and recreational values with the potential impacts of the proposed surface water management compared with taking no action (the 'Do Nothing' scenario).

7.1 Coleman/Meney Assessment

The project Brief required that there be an assessment of the impacts of the potential impacts of the surface water management proposals by following the methodology set out by the report "Impacts of Rural Drainage on Nature Conservation Values" (Coleman and Meney, 2000). This approach was adopted in an amended for and the assessment is included as Appendix Two. As noted in this report, the approach is not well suited to the required assessment for the Lake Bryde Recovery Catchment due in part to the need for design specifications to quantify the benefits or impacts. Application of the process did provide a preliminary assessment for a set of environmental parameters for the major receiving water bodies. These are summarised in Table 1 of Appendix Two.

A subsequent and more detailed characterisation of these water bodies has been completed (Coleman and Meney, 2002).

7.2 Comparative assessment of proposed projects

Using information derived from the ecological assessment (Section 4.2), specific site assessment (Section 5) and the Coleman-Meney assessment method (Appendix Two) the potential impacts for each of the 14 projects proposed by Farmer et al.,(2002) have been tabulated (Table 4). The table includes comparison with the "Do Nothing" scenario as described in Section 2.

Table 4. Summary impact assessment of surface water management proposals.

PROJECT	Nature Conservation Values	Benefits and Impacts of Proposal	Impacts of 'Do Nothing'	Comments
Lake Bryde Rd Valley	Very high conservation values in the lake and adjacent woodlands.	Increased regeneration potential for lake-bed vegetation by reducing the period and frequency of inundation. Road re-location could have a high impact on woodland communities. Water skiing opportunities could be for a reduced period but should occur with similar frequency (i.e. with high flow events)	Recovery potential of lake-bed vegetation is low without management action. Rising groundwater could eventually affect fringing vegetation and adjacent woodlands. Groundwater interception with Lake Bryde may occur sooner than would occur if inundation is reduced. Vegetation adjacent to the Lake Bryde Road will continue to degrade due to inundation and salinity.	The hydroperiod of the lake has altered significantly since clearing the catchment for agriculture. The salt load in the lake has also increased significantly. A reduced hydroperiod and reduced potential for substantial salt load increases is required for regeneration of the TEC at this site.
Ryan's Rd	Medium conservation value. Extensive areas severely degraded by surface water inundation and possibly by high groundwater tables.	Improved flow to reduce inundation near Ryans Road will enable regeneration of natural vegetation. This will be of conservation benefit but will also assist with grroundwater control. Detention of surface water on the existing discharge area will have minimal impact on conservation values. Reduced flow to the valley floor near Lake Bryde will reduce inundation potential.	The site will continue to degrade (waterlogging, salinity and soil erosion). The potential for an increasing salt load that is discharge towards Lake Bryde.	Re-design of existing drainage works to include a detention basin on a groundwater discharge site will provide a net benefit for conservation values.
Fourteen Mile Rd/Oliver's	High conservation status in Yate Swamp. The Road Reserve has medium	Medium impact. Regeneration potential is high but with contraction of the successional Melaleuca schrubland.	Minor impact to Yate Swamp, good regeneration potential. Continuing degradation of inundated area in the reserve	The proposal is to divert catchment run-off away from the Yate Swamp to a lake on private property (the 'Diversion

	conservation values. The Diversion Lake has limited conservation value although one section of waterway between the Fourteen Mile Road Reserve and the lake is of high conservation wetland value.	The Reserve adjacent to the Yate Swamp should regenerate with reduced inundation. The Road Reserve (Fourteen Mile Road) with recent degradation due to waterlogging and salinity will have improved opportunity for regeneration. The Diversion Lake will be further degraded by increased salt load. The waterway to it will be degraded by increased salt load and inundation.	adjacent to the Yate Swamp. The Fourteen Mile Road Reserve will continue to degrade. The Diversion Lake may degrade further although the riparian vegetation of the waterway may be protected by fresh seepage from adjacent deep sands.	Lake') west of the swamp but to make provision for rediversion of water to the Yate Swamp for environmental water provision. The environmental water requriement for the Yate Swamp is not known. The swamp will receive some in flow from road run-off and possibly some from within the Lake Bryde Reserve.
'Oliver's' upper watershed	Limited to fragmented and degraded riparian vegetation in low-order waterways.	Surface water run-off reduction will provide a net benefit for nature conservation on the valley floor.	Inundation of the valley floor will continue as a result of run-off from the catchment. The salt load contribution to the valley floor will increase as catchment salinity increases.	The proposed water harvesting will add to conservation values by providing summer and drought water supply for some water birds.
Lakeland Valley (Newdegate Rd – Bairstow Rd) (Private Land - Roe Location 2586)	Conservation status is low. The waterway is well fenced which should allow conservation values to increase in the short term although these areas are threatened by rising water tables in the medium to long term.	Impact of the proposed waterway is expected to be low. The existing 'W- drain' shows that some local vegetation will readily regenerate following disturbance. Increased flow through this area should not significantly increase the salinity risk by recharge through leakage as there are relatively impermeable clay soils in the valley floor.	The site will continue to be at increasing risk from shallow water tables and salinity.	Construction of the proposed low velocity waterway through this property should have only low impact (if any) in the medium to long term on nature conservation values of this property. It should significantly benefit conservation values in the Lake Bryde Reserve by reduced inundation.

Lakeland Valley (Newdegate Rd – Bairstow Rd) (Lakeland Nature Reserve).	Conservation status is high.	High impact during construction. The proposed waterway may cause recharge to near-surface aquifers increasing the risk of salinity and waterlogging.	Some low lying areas will continue to have significant degradation due to inundation and salinity.	Conveying discharge water from the 'Diversion Lake" on Roe Location 2586 would have a detrimental effect on conservation values by increasing inundation and salt load of the receiving water bodies.
Lakeland Valley (Bairstow Rd – Mallee Hill Rd)	Conservation status is high. Characte of individual lakes varies significantly. A community of Muehlenbeckia horrida ssp abdita in two lakes but now dead.	Increased inundation and salt load to receiving water bodies that have intrinsically high nature conservation values.	The reserve will continue to be threatened by shallow water tables. The lakes, although currently degraded, will adapt to changing conditions.	The proposed waterway would sequentially fill the receiving water bodies during flow events causing increased inundation and salt load. There would be little opportunity for the increased salt load to be flushed by a high flow event before degradation to the site occurs.
Days Creek/Needilup Rd	Medium conservation values in Road Reserves.	Surface water run-off reduction will provide a net benefit for nature conservation on the valley floor.	Inundation will continue and the salt load will continue to increase in the valley floor as a result of increasing catchment salinity.	Potential for fresher flows from Days Creek to be diverted to Lake Bryde as required.
Lake Bryde Eastern inflow	High woodland conservation values.	Reduction of surface water run-off from the catchment will reduce the potential for inundation of the small swamp and adjacent woodland east of Lake Bryde. Removing the 50cm sill would also reduce inundation of the woodland and swamp but would increase the hydroperiod in Lake Bryde.	Potential increased salinity impact over time on the woodland and swamp.	An estimated 100,000 M3 of water is detained east of Lake Bryde following a high flow event (Farmer et al., 2001). This is approximately 10% of the volume of the lake. Discharging this water to the Lake Bryde would increase the hydro-period there.
East Lake	High conservation status with a regenerating Muehlenbeckia	Proposals are primarily to reduce catchment water run-off. Some	Fringing vegetation near lake inflow may continue to be	East Lake Bryde is associated with extensive lenses of deep

Bryde	horrida ssp. abdita dominated community.	improvement to the fringing vegetation could be expected.	degraded by accumulation of salt from evaporation of low-flow discharge.	transmissive sandy textured soils to the south . These areas should ensure that salinity risk to the lake is limited.
South Lake Bryde Flats	Extensive areas severely degraded by inundation and high groundwater tables.	Surface water run-off reduction from the catchment will provide a net benefit for nature conservation. Increased flow from the site will assist in situ regeneration but will increase peak flow to the valley floor near Lake Bryde. This will be detrimental if is adds to inundation of the valley floor or increases the hydroperiod and salt load of Lake Bryde.	Inundation will continue to occur and the salt load will continue to increase in the valley floor.	Removing water from this site is locally advantageous but should be integrated with other surface water management works to provide a net benefit for conservation.
Upper South Lake Bryde (East Road)	Limited to fragmented riparian vegetation in low-order waterways and remnant vegetation patches on public and private land.	Surface water run-off reduction will provide a net benefit for nature conservation in the valley floor.	Inundation will continue to occur and the salt load will continue to increase in the valley floor.	
Holland's Soak Rd Sub-catchment	Limited to fragmented riparian vegetation in low-order waterways and remnant vegetation patches on public and private land.	Surface water run-off reduction from the catchment will provide a net benefit for nature conservation in the valley floor.	Inundation will continue and the salt load will continue to increase in the valley floor.	Groundwater from this sub-catchment is contributing to the increasing risk of salinity in the Lakelands Nature Reserve. Groundwater is causing an impact on the western boundary and in isolated patches within the Reserve.
Mallee Hill Rd South-West Sub-Catchment	Limited to fragmented riparian vegetation in low-order waterways and remnant vegetation patches on public and private land.	Surface water run-off reduction from the catchment will provide a net benefit for nature conservation.	Inundation will continue and the salt load will continue to increase in the valley floor.	Surface water and groundwater impacts from this sub-catchment will affect land north of Mallee Hill Road.

Lakeland East Slopes	Limited to fragmented riparian vegetation in low-order waterways and remnant vegetation patches on public and private land.	Surface water run-off reduction from the catchment will provide a net benefit for nature conservation.	Inundation will continue and the salt load will continue to increase in the valley floor.	

7.3 Assessment of potential impact on receiving environments

Assessment of the potential impact of proposed surface water management strategies on nature conservation values requires that there is a focussed assessment on the receiving water bodies because most of the works proposed relocate water within the catchment. The primary concept of the proposed works is to alter surface water flow capacity. This is intended to reduce prolonged inundation at one location by redirecting the water to another location – the receiving environment. While there will be benefits to nature conservation at the location with reduced inundation, there may be deleterious impacts to the receiving environment. A comparative assessment of these sites is made using information derived from the ecological assessment (Section 4.2), specific site assessment (Section 5) and the Coleman-Meney assessment method (Appendix Two). The table includes comparison with the "Do Nothing" scenario as described in Section 2. Social and recreational value impacts from Section 6 are also considered.

7.3.1 LAKE BRYDE AND THE LAKE BRYDE NATURE RESERVE

Values:
Lake Bryde has very high conservation value due to the Muellhenbeckia Threatened Ecological Community. The Lake Bryde Nature Reserve also has high conservation value containing a range of Priority species. The water body of Lake Bryde and its associated environment are valued locally for waterskiing and associate social and recreational activities.

Threats:
The TEC in Lake Bryde is particularly threatened by increasing salt load and increased salt load. Without action, the salt load will continue to increase especially with large flow events. The lake has limited capacity for salt export by flushing.

The threat of additional salinity from the Ryan's Road area is clear. Increasing flow capacity from this locality without integrating with other flow enhancement proposals would be detrimental to the lake.

The medium to long-term threat is from potential regional groundwater rise. This may have had a direct impact on the lake in 1992. It is anticipated that without action, the TEC will not survive. It is further recognised that the surface water management proposals alone are probably insufficient action in the medium to long term to recover that plant community.

Impacts:
Most of the proposed surface water management proposals for the Lake Bryde Recovery Catchment will benefit nature conservation values in the lake and are not expected to have a deleterious effect (assuming that increased flow from the Ryan's Road area is diverted away from the inlet to lake). The TEC should benefit from the reduced frequency and period of lake-bed inundation. The proposal to discharge eastern flow water into Lake Bryde would increase the period of inundation in the lake which would not assist the recovery of the TEC. It is understood that there will continue to be inflow to the lake from medium to high flow events.

The local community recognises that Lake Bryde and the surrounding environment is threatened by high water tables and accept that some actions are required to maintain social and recreational opportunities at the lake. As inflow to the lake will continue with medium to high flow events, the potential for water skiing should not be significantly diminished. The social opportunity will be enhanced by improved access along Lake Bryde Road.

Relocation of Lake Bryde Road from the existing Road Reserve to a location within the Lake Bryde Nature Reserve will impact upon priority nature conservation values.

7.3.2 LAKE JANET

Values:
The conservation values of Lake Janet are considered to be high.

Threats:
Current impacts on the lake are relatively minor although regeneration potential is limited due to increased hydroperiod. This lake is also subject to the longer term threat of high regional water tables.

Impacts:
The proposed waterway will reduce the potential for low flow events to cause inflow to Lake Janet. This will reduce the frequency and period of lake-bed inundation and reduce the potential for salt load accumulation. Reduced inundation of the adjacent area will reduce the medium term threat from salinity.

7.3.3 YATE SWAMP

Values:
The Yate Swamp within the Lake Bryde Nature Reserve has high conservation value as a freshwater wetland.

Threats:
Plant communities associated with the swamp are altering to wetter conditions. The potential for impact by salinity, while not specifically established for the site, is considered to be high.

Impacts:
The proposal to divert surface water other than run-off from the road will initially result in a successional trend towards drier conditions and should reduce the short to medium term risk of salinity. The volume and frequency of environmental flow to the Yate Swamp from the road and from with the nature reserve is not known. The environmental water requirement of this wetland is not known.

7.3.4 DIVERSION LAKE

Values:
The 'Diversion Lake' is currently degraded by salinity and increased inundation and the conservation values are low. One small exceptional area located on the inlet to the lake has high wetland values that appear to be maintained by fresh seepage from adjacent sandplain soils.

Threats:
This lake is not significantly threatened beyond its current condition.

Impacts:
The proposal is to divert surface water from the Yate Swamp to the Diversion Lake. Increasing the volume of water discharged to the lake or the salt load will not have a significant impact on nature conservation values.

7.3.5 LAKELANDS NATURE RESERVE

Values:
Nature conservation values of wetlands in the Lakelands Nature Reserve are high. Muehlenbeckia horrida ssp. abdita previously occurred in two lakes but are now dead, probably as a result of increased inundation and salinity.

The lakes in this reserve vary considerably in character and the extent to which they are currently degraded.

Threats:
Wetland communities are under considerable threat from increased inundation particularly with increased run-off from agricultural sub-catchments that discharge directly to the reserve.

The medium and longer term threat of high regional water-tables is substantial.

Impacts:
The proposed waterway will have a significant direct impact on high nature conservation values during construction.

Increased water and salt load discharged to the wetlands, even though relatively small in some years, will be detrimental. The current hydroperiod is already causing degradation. Increased discharge to the reserve could also exacerbate the longer term threat from high regional groundwater tables.

7.3.6 EAST LAKE BRYDE

Values:
The conservation values of East Lake Bryde are high, including a regenerating plant community dominated by Muehlenbeckia horrida ssp. abdita. There is some impact from salt accumulation on the southern side associated with the inlet to the lake.

Threats:
While East Lake Bryde is located within the salinity risk area, the threat appears to be less than for other wetlands due to significant areas of sandplain soils adjacent to the lake. Monitoring will better establish the potential threat.

Impacts:
The proposed surface water management for the East Lake Bryde catchment will benefit nature conservation values generally by reducing salinity risk. They are unlikely to have a significant impact on environmental flows to the lake.

7.3.7 OTHER SITES

Other surface water management proposed for the Lake Bryde Recovery Catchment are expected to be beneficial for nature conservation.

8. CONCLUSIONS

The assessment of potential impact on nature conservation vales by implementing surface water management strategies proposed for the Lake Bryde Recovery Catchment was undertaken using an approach based on that described by Coleman and Meney (1999) but also included broader ecological assessment for cumulative impacts. The fundamental assessment criterion is comparison against a 'Do Nothing' scenario for which the threat of on-going surface water inundation, high regional groundwater tables and the associated risk of salinity is high.

The assessment is based on the information provided. The proposals assessed were as described by Farmer et al. (2002). Considerable other supporting documentation was also provided. The proposals are made without specification. Accordingly, the assessment is made of the general concept of the proposals. More specific information about the proposals will require more specific site assessment.

From this assessment, the following conclusions are drawn:

1. The Lake Bryde Recovery Catchment is threatened significantly by high regional groundwater tables and the associated risk of salinity in the medium to longer term.. The potential threat is greatest for wetlands and the catchment valley floor. The extent and urgency of this threat will be better established by groundwater monitoring over the next 5 years. The proposed surface water management will reduce the threatening processes but will not remove the medium to longer term risk.

2. The proposed low-velocity waterway will be beneficial for nature conservation values in the Lake Bryde Nature Reserve and in the Ryan's Road area.

The proposed waterway is intended to reduce inflow to Lake Bryde during low-flow events but not during medium to high flow events. It is likely that the medium to high flow events cause prolonged inundation in the lake and cause the salt load to increase substantially. Considering this, the proposed waterway is unlikely to have significant benefit in the recovery of the Threatened Ecological Community that occurs in the lake bed.

The proposed waterway is expected to cause only minimal impact or provide minimal benefit to Lake Janet.

3. Wetlands in the Lakelands Nature Reserve have high conservation values that are currently degrading and are further threatened by inundation and salinity. Discharge of additional run-off and salt load from the catchment by enhanced waterway flow will result in accelerated degradation of these wetlands.

The nature conservation values of the wetlands in the Lakelands Nature Reserve could be considered to be equal to if not greater than the nature conservation values in the Lake Bryde Nature Reserve.

4. The net benefit for nature conservation by relocation of Lake Bryde Road may not be positive. Improved conditions for vegetation regeneration can be achieved with the proposed waterway under 'Option 1'. This option will also improve road access for social and recreational opportunities at Lake Bryde by reduced periods of inundation.

5. The Yate Swamp should benefit from less inundation in the short term. The potential for there to be adequate environmental flow from road run-off and from run-off within the reserve for longer-term maintenance of a sustainable wetland ecosystem is not known

6.	The 'Diversion Lake' is currently degraded and is unlikely to be further degraded in a significant way by discharging addition water to this wetland. The suggestion to provide an outlet for excess water from this lake to be discharged to wetlands in the Lakelands Nature Reserve would increase further the impact on those receiving wetlands.

7.	Excess inundation of natural vegetation from eastern flows to Lake Bryde are at risk of in situ degradation however this risk is considered less that the additional risk to recovery of the conservation values within the lake if that water were to be released into the lake.

8.	The nature conservation values of East Lake Bryde are high and the medium to longer-term threat from high regional groundwater tables is generally lower that for other wetlands within the Lake Bryde Recovery Catchment. The proposed surface water management is not expected to have negative impact on these values.

9.	Lake Bryde is important for local social and recreational opportunities. The threats to the lake and its associated environment are well understood. While there is a general local view that the water skiing opportunity should not be diminished in favour of recovering the threatened plant community, especially as it is thought that it may not recover in the medium to long term, there is acceptance that management works are required for net social, recreation and conservation benefit. The proposed management should not significantly reduce the social or recreational opportunity.

10.	The evaluation method initially required for the assessment was limited by the need for more specific information about the proposals. More appropriate use of this method for drainage proposals that intercept groundwater rather than for surface water management proposals.

While some benefits can be identified for all surface water management proposals, decisions should be based upon net medium to long-term benefits for nature conservation values collectively within the Lake Bryde Recovery Catchment. Some off-site impacts may exceed the value of onsite benefits.

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IMPACT ASSESSMENT
OF SURFACE WATER MANAGEMENT
PROPOSED FOR THE
LAKE BRYDE RECOVERY CATCHMENT

APPENDICES

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IMPACT ASSESSMENT
OF SURFACE WATER MANAGEMENT
PROPOSED FOR THE
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November 2002

Prepared for the Department of Conservation and Land Management (Katanning Office)

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APPENDICES

APPENDIX ONE

Department of Conservation and Land Management

Environmental Impact Assessment of Surface Water Management Proposals within Lake Bryde Recovery Catchment

WATER AND SALT BALANCE MODELLING

November, 2002

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Introduction

Background

The surface water management strategy (Farmer *et. al.*, 2002) prepared by the Engineering and Water Management group of the Department of Agriculture Western Australia as part of the Lake Bryde Recovery Catchment project proposed various surface water management options.

As part of the environmental impact assessment of the proposed surface water management options, a water and salt balance for Lake Bryde and the Lakeland Nature Reserve was commissioned by Viv Read & Associates (VRA) as lead consultant to CALM.

Objectives

The objective of this report is to provide a better understanding of the past and present hydrological regime of Lake Bryde and its associated wetlands to Lakelands Nature Reserve, and to assess the impact of various surface water management options.

Limitations of Report

The report is based on monthly spreadsheet model over the period 1979 to 2000 (22 years inclusive). Simulations of the effect of the various surface water management options have been performed to assess the impact if a similar rainfall regime (1979 to 2000) was to be repeated.

The study undertaken to prepare this report, particularly the development of the water and salt balance model, has been performed as a desktop study only. While the sub-catchments have been broadly divided topographically, it has been assumed that runoff generated from the top end of the catchment can flow to the downstream catchment outlet. In reality, various flow impeding obstacles exist, in the form of minor topographical divides.

The assumptions adopted for developing the water and salt balance model are described in each section. The water and salt balance model parameters were calibrated against recorded data for Lake Bryde. These parameters were then applied to the remaining catchments downstream.

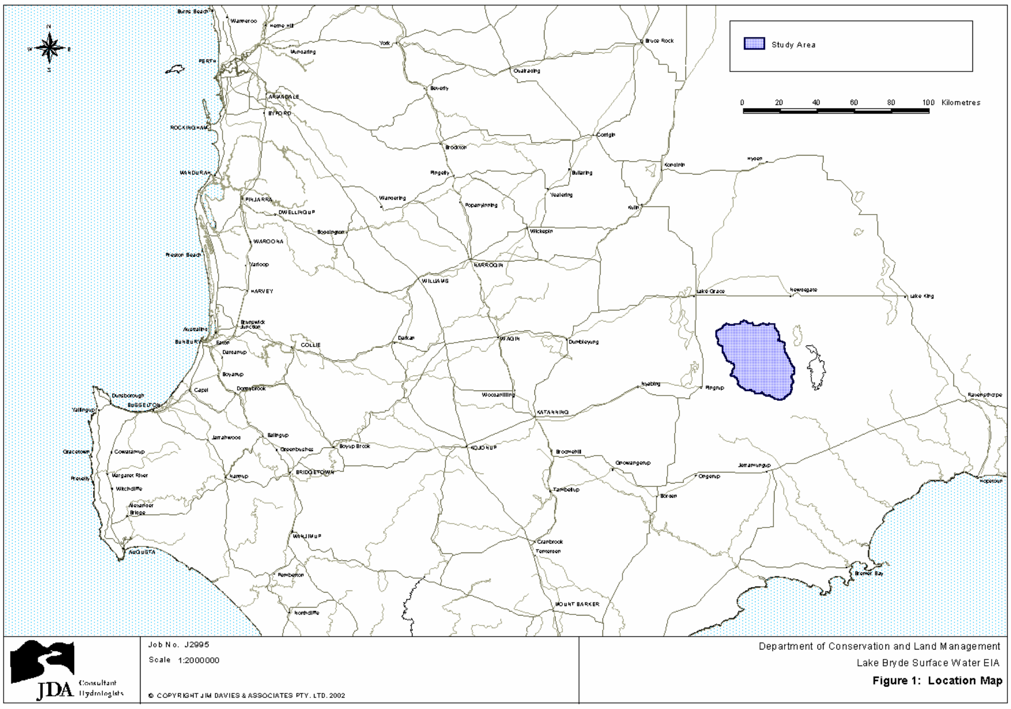


Figure 1: Location Map

Catchment Details

Catchment Definition

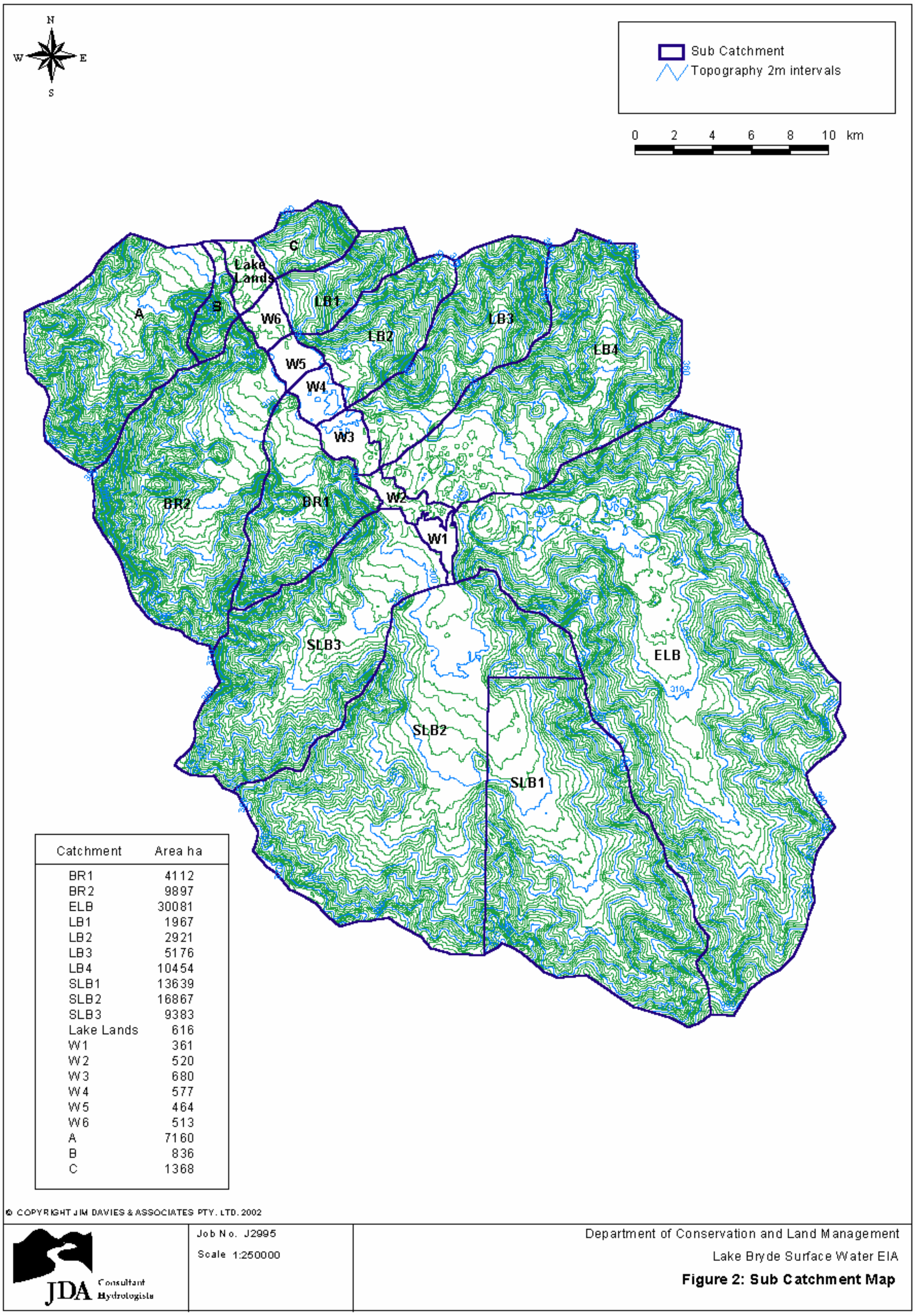
Lake Bryde is located 40km north east of Pingrup, approximately 300km south east of Perth, in Western Australia (Figure 1). The project area covers the upper portion of the Lake Bryde chain of wetlands catchment (south of Mallee Hill Rd) as shown in Figure 2. This area includes parts of the Lake Magenta, Lake Bryde and Lakeland Nature Reserves.

For this study, the catchment was divided into 16 separate sub-catchments, including 6 sub-catchments (designated with a W) on the valley floor that have been distinguished as a waterway. These sub-catchments were divided based on the shedding and shedding/receiving areas as outlined in Farmer *et. al.* (2002) and further refined topographically. The proportion of shedding and shedding/receiving areas in each sub-catchment that contributes to the waterway was also estimated (Table 1).

Based on field inspection, it is assumed that there is no flow contribution into Lake Bryde or the Lakeland Nature Reserve from sub-catchments ELB, LB3, LB4, A , B and C, which discharge to large, terminal areas.

Data Sources

The necessary data required to develop, calibrate and simulate the hydrological regimes with the water and salt balance model are outlined below.



Lake Bryde Water Depth

Measurements of Lake Bryde water depths were obtained form the Department of Conservation and Land Management (CALM). These measurements are taken on a staff gauge in Lake Bryde. Jim Lane (CALM) performed most measurements. The data set extends from June 1979 to November 2000 with measurements recorded every two months prior to 1986, and then measurements only during the months of September and November between 1987 to 2000.

Lake Bryde Salinity Concentration

Salinity concentrations in Lake Bryde, also obtained from CALM, were also measured mostly by Jim Lane (CALM). The extent and frequency of measurements is similar to the that taken for the lake water depths.

Rainfall Data

Monthly rainfall data recorded for Pingrup between 1926 to 2000 was obtained from the Bureau of Meteorology, and used without correction factor for the study area. Average annual rainfall recorded at Pingrup is 361mm as shown on Figure 3.

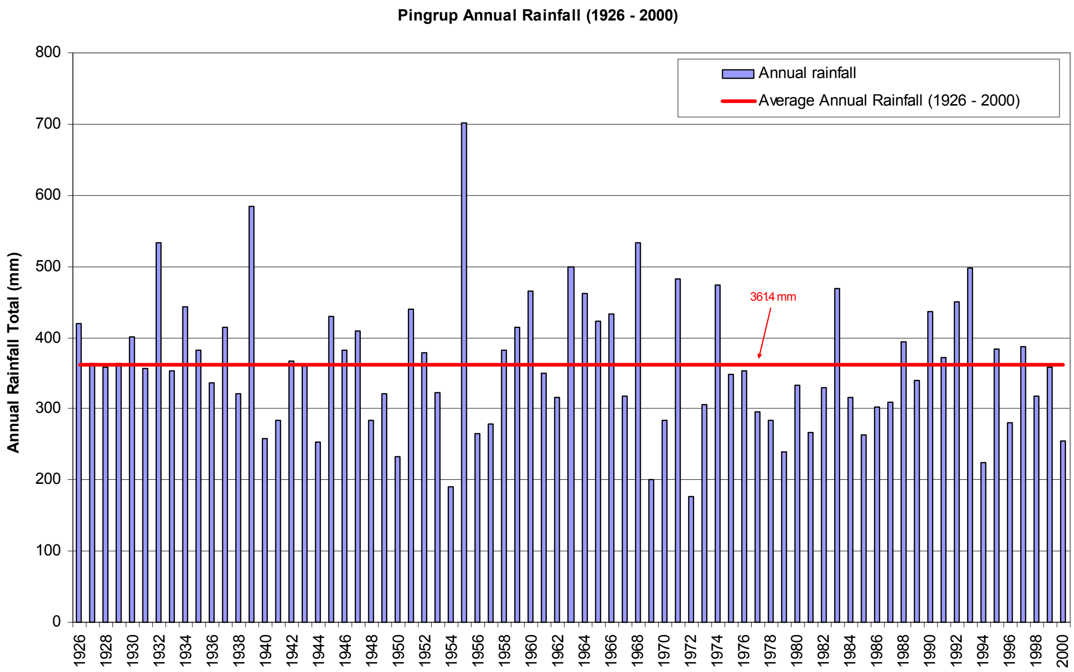


Figure 3 Pingrup Annual Rainfall

Evaporation Data

Average monthly Class A pan evaporation data was obtained from Luke *et. al.* (1988) for Pingrup. This data was applied with a correction factor for evaporation from dams, to simulate lake surface water evaporation.

TABLE 1: SUB-CATCHMENT DETAILS

Sub-Catchment	Total Area (ha)	% Shedding	% Shedding/Receiving
SLB1	13,639	60	40
SLB2	16,867	60	40

SLB3	9,383	60	40
BR1	4,112	50	50
BR2	9,897	60	40
LB1	1,967	70	30
LB2	2,921	70	30
LB3	5,176	50	50
LB4	10,454	50	50
W1	361	-	100
W2	520	-	100
W3	680	-	100
W4	577	-	100
W5	464	-	100
W6	513	-	100
TOTAL	**77,531**		

Water & Salt Balance Model

Description of the Model

A monthly water and salt balance spreadsheet model with sub-catchments was developed to simulate the hydrological regime in Lake Bryde and downstream to the Lakeland Nature Reserve.

The model includes simulation of Lake Bryde contents and salinity, assuming only incident rainfall, catchment runoff, lake overflow and evaporation.

Water Balance

The water balance component was calculated as catchment generated runoff minus evaporation. Catchment runoff was determined by using three different runoff coefficients based on an exponential relationship with monthly rainfall depth. These coefficients were developed to simulate shedding, shedding/receiving and pre-clearing characteristics (eg. Lake Magenta Nature Reserve).

A stage-volume relationship was adopted for Lake Bryde assuming a maximum storage capacity of 1,000,000 m^3 at 2 m depth and a surface area of 500,000 m^2. Monthly runoff greater than this storage capacity is assumed to bypass Lake Bryde and continue to flow downstream towards the Lakeland Nature Reserve. No other outflow of water from Lake Bryde is modelled, except for evaporation from the lake water surface.

Interaction between surface water and groundwater is not considered in the model.

Salt Balance

The salt balance component is calculated as a user specified annual salt concentration multiplied by the catchment generated runoff. It assumes that at any given volume in the lake, the water is completely mixed (uniform salinity), and if the lake is empty, the salt contained in the lake is mobilised at the next inflow event.

The model assumes no flushing of salt mass from Lake Bryde to the Lakeland Nature Reserve.

Model Calibration

Water Depth

To simulate observed water levels in Lake Bryde between 1979 and 2000, the model was calibrated against observed data as shown in Figure 4, by altering sub-catchment runoff coefficients.

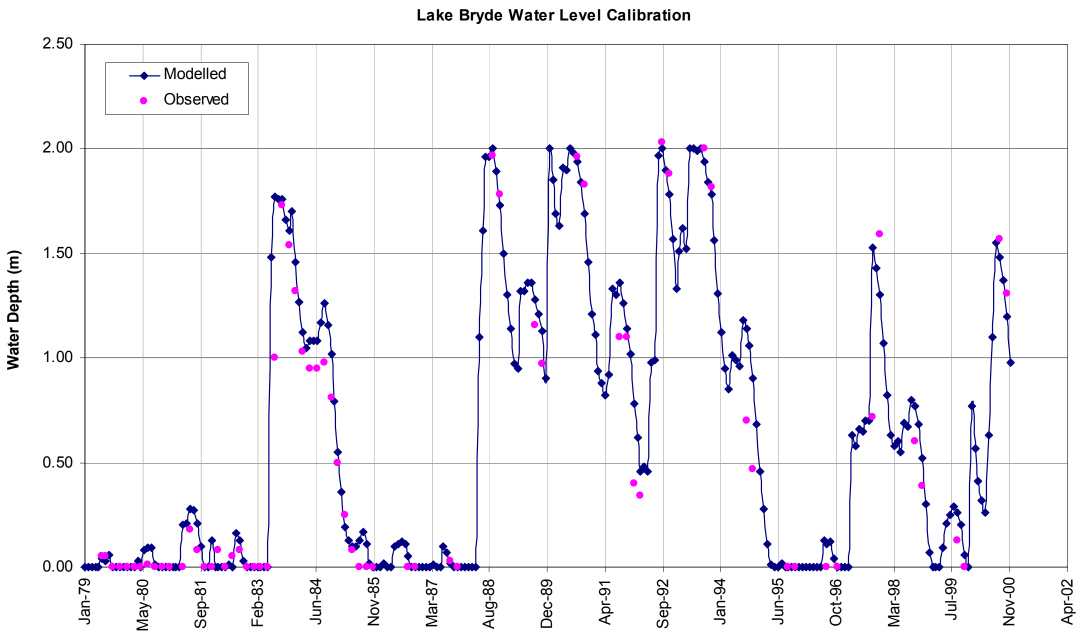


Figure 4 Lake Bryde Water Level Calibration

These results show an extremely good match with the observed water depths. The rise in water depth was matched by the runoff inflow and the decrease matched solely by evaporation. These results were achieved by the use of a runoff calibration parameter in the model. The parameter effectively increased or decreased the inflow runoff volume by a specified factor.

The three catchment runoff coefficient relationships and the runoff calibration parameter used to calibrate Lake Bryde were then applied to the remainder of the catchments in the model.

Salt Mass

The model simulated observed salt mass in Lake Bryde 1979 to 2000, by adjustment of runoff salt concentration for each year, or for a period of years as shown in Table 2. These salt concentrations were used for calibrating Lake Bryde and subsequently were applied to the remainder of the catchment.

TABLE 2: MODELLED ANNUAL SALT CONCENTRATION

	Modelled Salt Concentration (mg/L)
1979-1980	50
1981-1982	100
1983-1991	**Year**
1992	850
1993-2000	50

Figure 5 shows both observed and modelled salt mass accumulative from 1979 to 2000. A reasonably good fit is achieved, especially prior to 1992 when loads are generally increasing. After 1992 the observed data shows some indication of a slight negative trend, perhaps indicating flushing of salt either by overflow or seepage to the lake bed. The modelled salt mass shows an increase after 1992 due to the absence of a flushing or salt loss mechanism in the model.

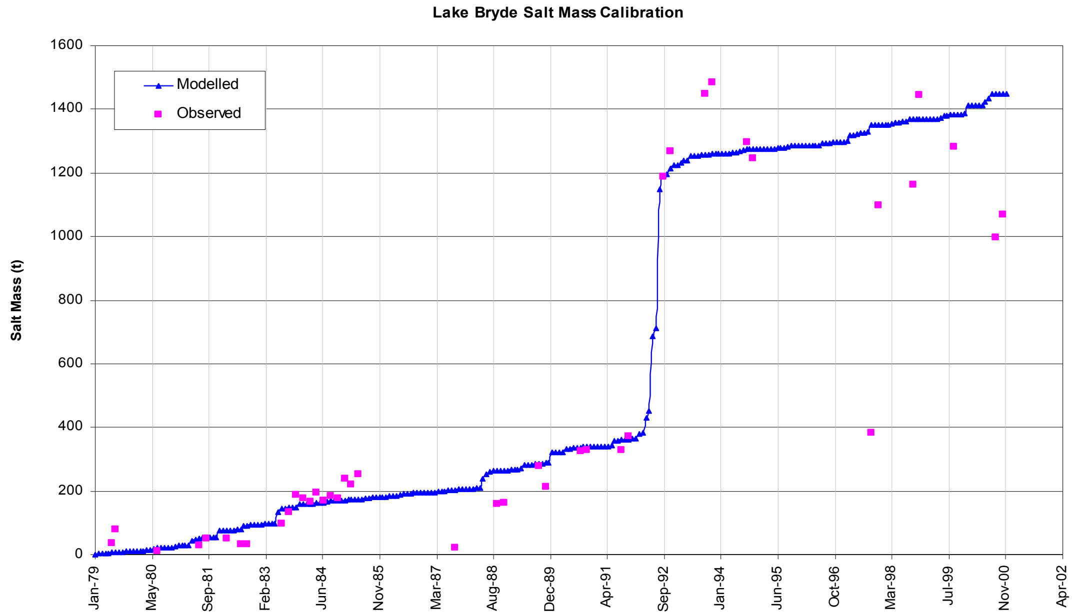


Figure 5 Lake Bryde Salt Mass Calibration

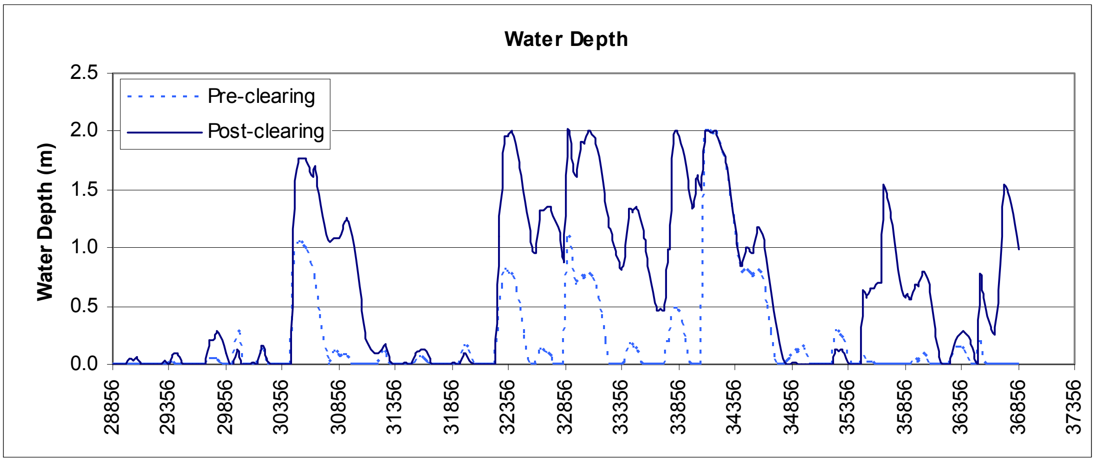
The cause for the rapid increase in the observed salt mass in Lake Bryde in 1992 is not known. However, it is suggested that above average rainfall in the years prior to 1992 may have caused groundwater rise allowing salt to evaporate and accumulate on the catchment surface before being carried into Lake Bryde by 1992 runoff.

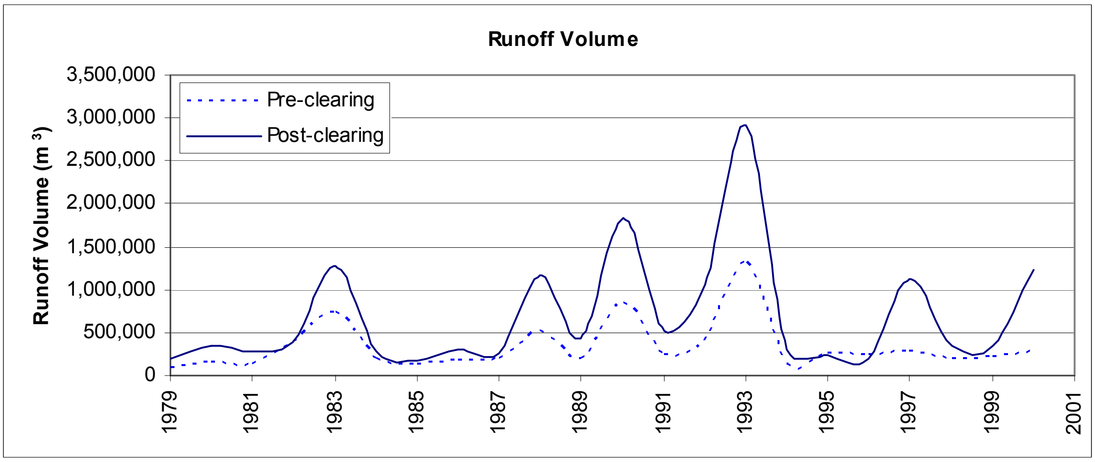
A similar major increase in lake salt mass has been reported for Lake Toolibin, again using CALM data in 1992 (JDA unpublished report to CALM, 1992).

Rainfall received between 1963 and 1967 is the only other period where annual rainfall has been above average, similar to the years leading up to 1992 (Figure 3). Unfortunately, there is no historical data for Lake Bryde during that period to verify if there was an increase in salt concentration due to this rainfall pattern.

Modelling scenarios - Lake Bryde Pre and Post Clearing

Simulations of the water and salt balance in Lake Bryde under pre-clearing and post clearing scenarios are shown in Figure 6. For the pre-clearing scenario, the runoff coefficient relationship used for the Lake Magenta Nature Reserve was applied to the entire Lake Bryde catchment.





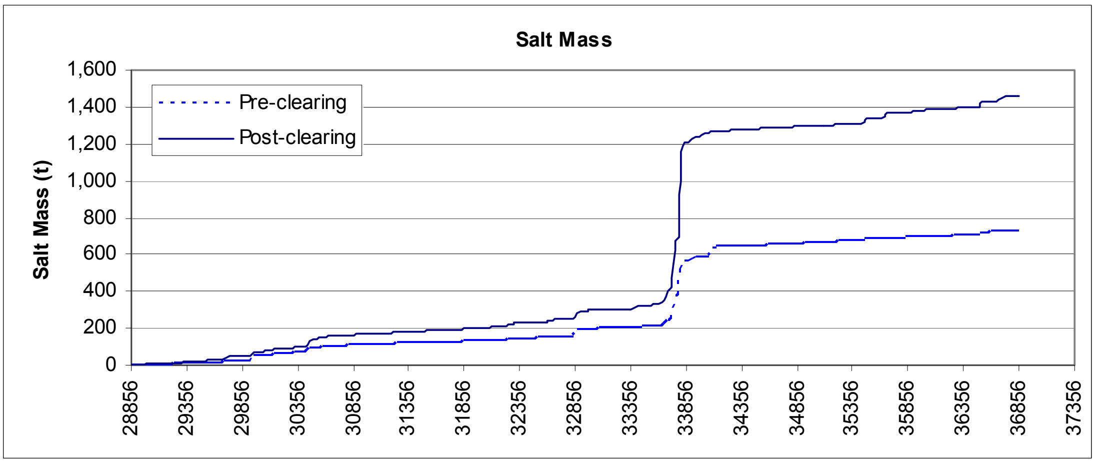


Figure6 Lake Bryde Pre and Post Clearing

Water Level

Figure 6 shows that the under current post clearing scenario, Lake Bryde has filled to half capacity (1.0 m depth) in 9 years and reached full capacity (2.0 m depth) in 5 years. Note that when the lake reached half capacity, particularly between 1988 and 1994, it remained half full and did not empty rapidly. Figure 6 also shows that under the pre-clearing scenario, Lake Bryde would have filled to half capacity in only 3 years and to full capacity in only 1 year. In addition, during most years the lake emptied rapidly after filling.

Annual Runoff Volume

The annual runoff volumes for the pre-clearing scenario average approximately 300,000 m^3/yr compared to approximately 750,000m^3/yr post clearing. This represents an increase factor of 2.5 in the volume of runoff generated between the two scenarios.

Salt Mass

The modelled salt mass for both scenarios are quite similar prior to 1992. However, the salt mass increases by 400 tonnes during 1992 due to the sudden increase in runoff volume for the pre-clearing scenario. For the post clearing scenario, the salt mass increases by 800 tonnes during 1992, representing twice the pre-clearing increase. This is expected as the increase in runoff volumes was double between the two scenarios. Similar trends in salt mass after 1992 were modelled for both scenarios. The assumption of salt concentrations being equal pre and post clearing probably over estimates the pre-clearing salt mass.

Lakeland Nature Reserve

The model was used to simulate the water and salt balance for the Lakeland Nature Reserve, including Lake Bryde (in some scenarios). Due to the flat topography of the waterway sub-catchments, it has been assumed that flow into these sub-catchments spread out over the valley floor where it evaporates, and that each waterway sub-catchment can freely flow into the next downstream sub-catchment.

The following four scenarios have been simulated for the Lakeland Nature Reserve:

Scenario 1. Existing waterway with Lake Bryde

This scenario, representing existing conditions, simulates the entire catchment with overflow from Lake Bryde flowing directly into the first waterway sub-catchment. It assumes evaporation from all the area of the waterway sub-catchments.

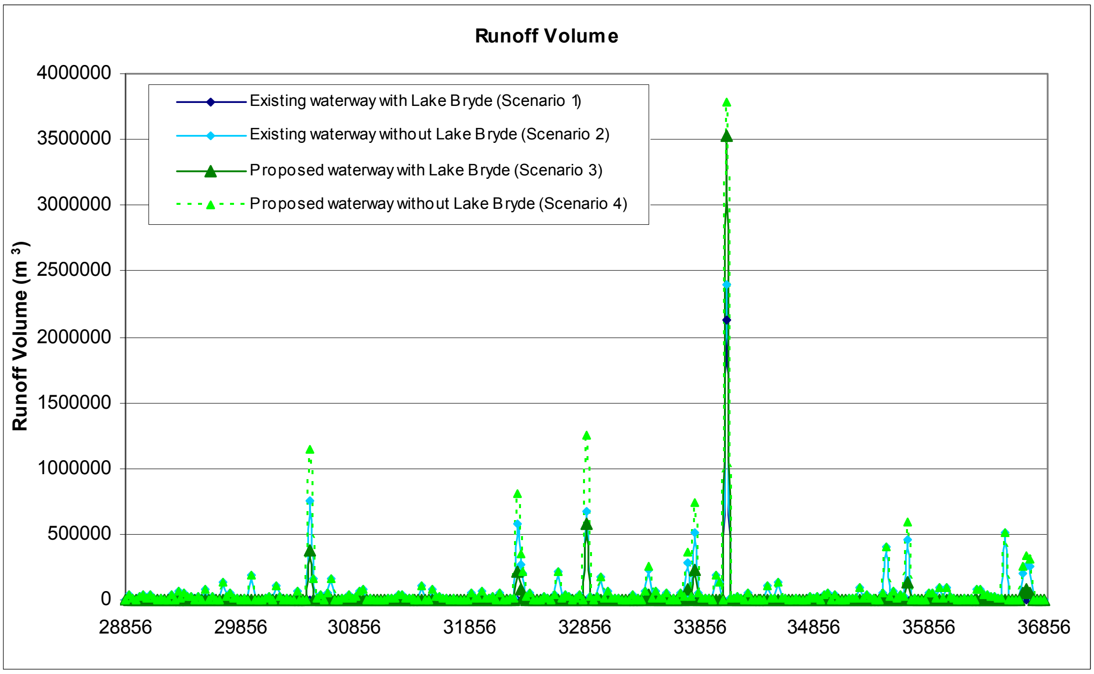
Scenario 2. Existing waterway without Lake Bryde

This scenario simulates the entire catchment but without the storage capacity of Lake Bryde in the system. All runoff generated from the Lake Bryde catchment flows directly into the first waterway sub-catchment (flows effectively bypassing Lake Bryde). It assumes evaporation from all the area of the waterway sub-catchments.

Scenario 3. Proposed waterway with Lake Bryde

This scenario simulates the entire catchment with overflow from Lake Bryde flowing directly into the first waterway sub-catchment. To simulate an open drain as a proposed waterway, it is assumed that evaporation only occurs from 20% of the area of the waterway sub-catchments.***Scenario 4. Proposed waterway without Lake Bryde***

This scenario simulates the entire catchment but without the storage capacity of Lake Bryde in the system. All runoff generated from the Lake Bryde catchment flows directly into the first waterway sub-catchment (flows effectively bypassing Lake Bryde). To simulate an open drain as a proposed waterway, it is assumed that evaporation only occurs from 20% of the area of the waterway sub-catchments.



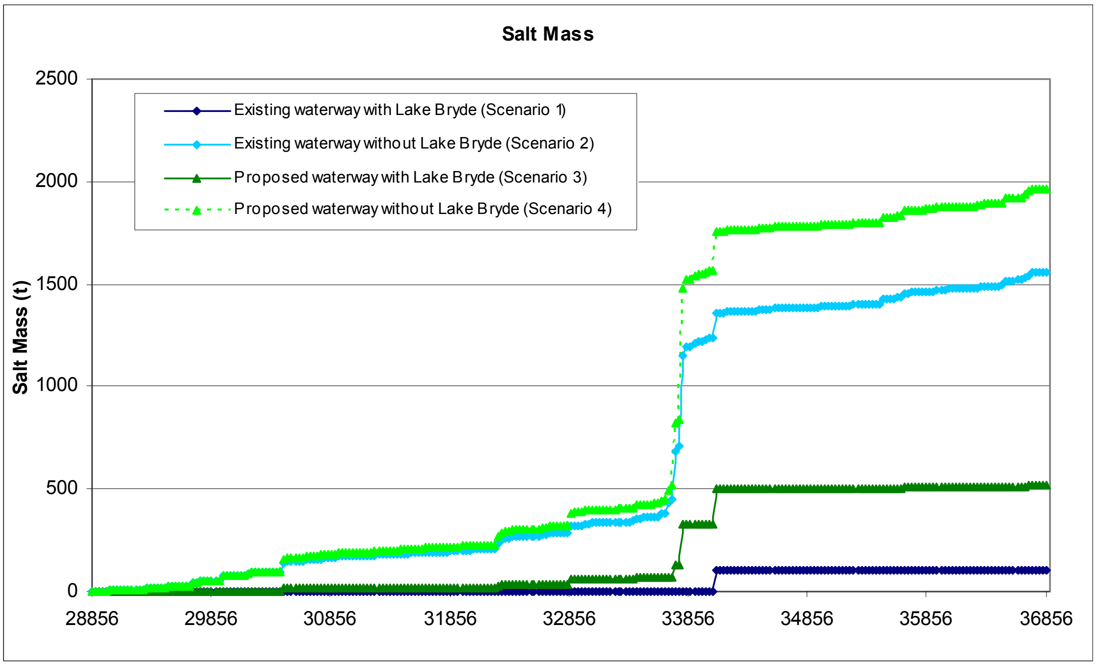


Figure 7 Lakeland Nature Reserve Modelled Scenarios

Runoff Volume

presents the runoff volumes to the Lakeland Nature Reserve under the four above mentioned scenarios. It can be seen that over the 22 year simulation period, Scenario 4 has the greatest runoff volume with Scenario 1 having the lowest runoff volume.

Compared to the existing situation (Scenario 1), increases in runoff volumes are expected as Scenarios 2 and 4 lose the 1 million cubic metre storage volume of Lake Bryde from the system. In addition, Scenarios 3 and 4 have evaporation affecting a lower percentage of the catchment area. These reductions in storage volume and water loss result in greater runoff volume reaching the Lakeland Nature Reserve.

It has been suggested that the 6 main lakes in the Lakeland Nature Reserve could be used as a disposal point for the runoff (Farmer *et. al.,* 2002). A preliminary calculation of the storage volume in these lakes (assuming maximum storage capacity at 1m depth) indicates there are approximately 1.3 million cubic metres. This does not include the flat areas between and around the lakes that could possibly increase the storage capacity.

From Figure 7, it can be seen that under all scenarios (1 to 4), the volume of runoff reaching the Lakeland Nature Reserves is below 1.3 million cubic metres. Rainfall during 1992 was the only time when runoff exceeded 1.3 million cubic metres for all scenarios. This indicates that the Lakeland Nature Reserve could be capable of storing the runoff generated under all scenarios for the majority of rainfall events if a similar rainfall period 1979 to 2000 was to be repeated.

Salt Mass

The salt masses of the four scenarios 1 to 4 are also shown in Figure 7. The salt mass is a reflection of the runoff volume and exhibits a similar rank of the scenarios. Scenario 4 has the greatest cumulative salt mass of 2,000 tonnes with Scenario 1 (existing) the lowest with approximately 200 tonnes. The difference in salt mass between the scenarios with and without Lake Bryde is effectively 1,200 tonnes, the stored salt mass in Lake Bryde.

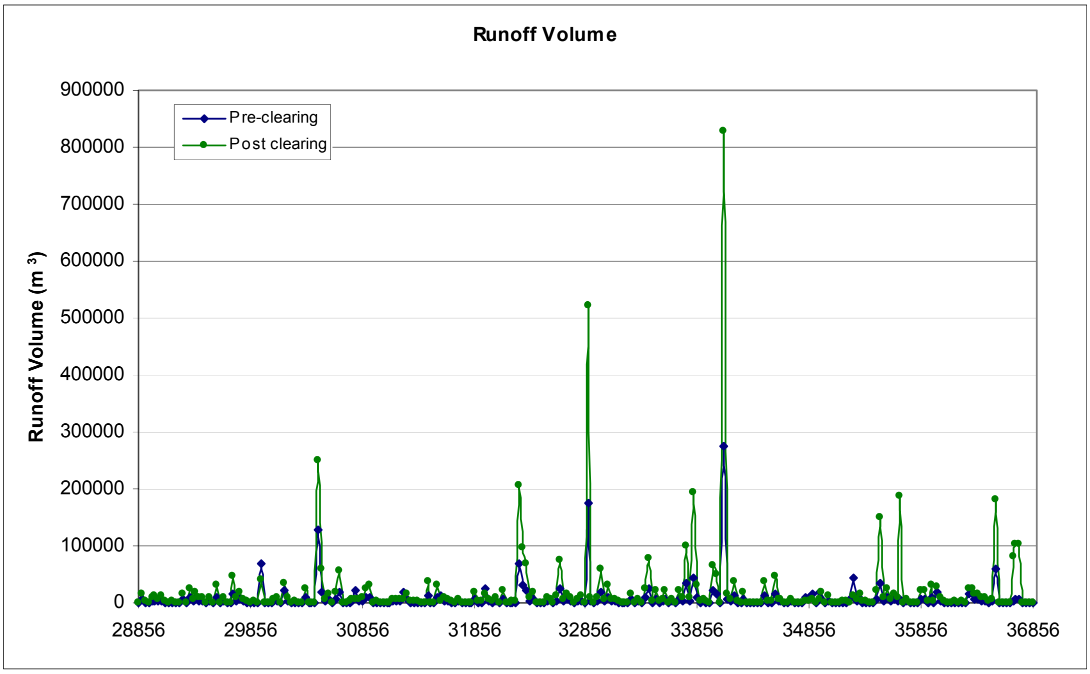
East Inflow to Lake Bryde Pre and Post Clearing

Runoff generated from sub-catchment LB4 does not flow into the waterway sub-catchments. Anecdotal evidence (Farmer *et. al.*, 2002) indicates that the flow becomes trapped in a localised depression situated immediately east of Lake Bryde. It slowly infiltrates and if the flow is sufficient, it may overflow into Lake Bryde and consequently is known as the East Inflow.

Figure 8 presents the runoff volumes and cumulative salt mass modelled for the 1979 to 2000 hydro period. Pre-clearing and post clearing scenarios have been simulated.

Runoff Volume

Figure 8 indicates the runoff volumes generated between the two scenarios vary quite considerably. For the large events (>50,000m^3), post clearing volumes are more than twice those generated under the pre-clearing scenario.



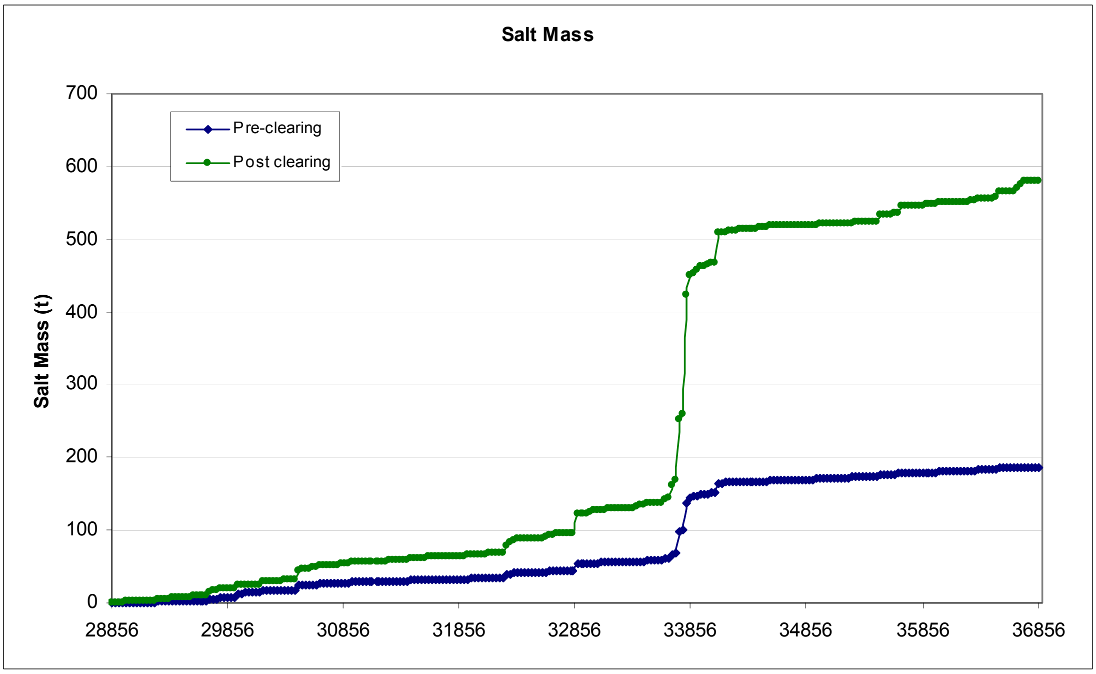


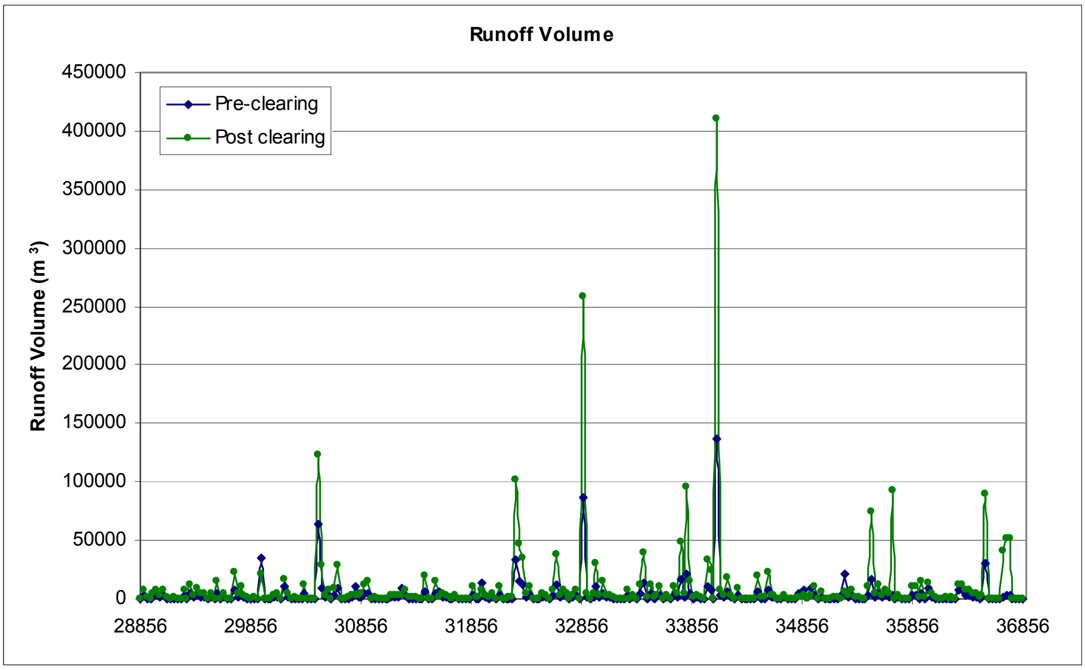
Figure 8 East Inflow to Lake Bryde Pre and Post Clearing

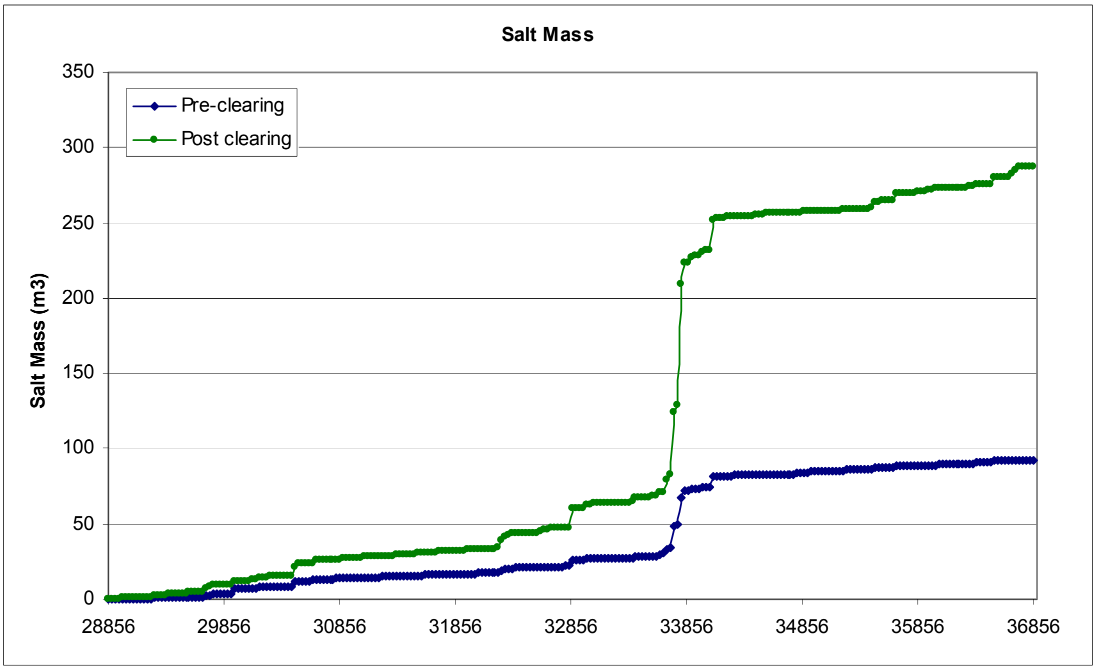
Salt Mass

The cumulative salt mass shows a large increase in 1992, similar to the other sub-catchments previously modelled. As the salt mass is directly proportional to the volume of runoff, the increase in salt mass between the two scenarios is as expected.

Yate Swamp Pre and Post Clearing

Similar to sub-catchment LB4, runoff generated from the Yates Swamp Catchment (sub-catchment LB3) dos not flow into the waterway sub-catchments. For the purposes of this desktop study, it has been assumed that all runoff generated from this catchment flows into Yate Swamp. Figure 9 presents the pre and post clearing modelling results for the simulated runoff volume and salt mass.





Pre and Post Clearing

Runoff Volume

Figure 9 and Table 3 indicate that the runoff volume generated from the pre-clearing scenario is approximately 60% less than the post clearing scenario.

Table 3 also shows the change in the volume of runoff if a 16,000m^3 surface water dam is constructed in this sub-catchment. The dam effectively reduces the annual average volume of runoff by 16,000m^3, as expected, and this only represents a minor volume.

Salt Mass

Cumulative salt mass is shown on Figure 9 and indicates an increase with clearing, particularly after 1992.

Runoff Volume from Newdegate Road

Table 3 presents the volume of runoff that would be generated from a 1.1 kilometre section of Newdegate Rd, assuming a width of 8m and a runoff coefficient of 0.8. These volumes are considerably less than those generated from the modelled sub-catchment pre and post clearing.

TABLE 3: ANNUAL RUNOFF VOLUMES FOR YATE SWAMP

Date	Pre-clearing Runoff (m^3)	Post-clearing Runoff (m^3)	Pre-clearing Runoff – with dam (m^3)	Post-clearing Runoff – with dam (m^3)	Road Runoff Only (m^3)
1979	10,950	32,905	-	7,837	1,684
1980	20,467	61,504	-	45,981	2,344
1981	16,351	49,154	1,773	36,905	1,877
1982	50,434	51,821	37,431	38,650	2,320
1983	93,642	214,695	77,865	199,792	3,300
1984	25,023	44,596	15,665	32,176	2,221
1985	16,902	24,955	3,329	13,322	1,859
1986	21,855	48,778	7,748	33,692	2,124
1987	24,251	41,544	8,505	27,408	2,171
1988	67,599	202,876	59,734	194,771	2,780
1989	25,502	76,506	10,911	61,462	2,390
1990	107,729	323,231	96,944	310,277	3,072
1991	30,291	90,915	13,946	75,318	2,620

1992	52,877	188,766	39,437	176,398	3,170
1993	169,848	509,606	155,607	497,419	3,505
1994	17,268	51,838	5,514	40,173	1,576
1995	34,566	28,761	19,844	12,840	2,704
1996	29,728	24,778	18,775	14,826	1,971
1997	34,831	211,535	21,482	199,071	2,726
1998	24,563	59,534	12,550	47,184	2,242
1999	26,399	55,300	10,296	41,518	2,528
2000	37,205	233,865	28,563	226,697	1,799
Total	938,280	2,627,465	645,920	2,333,714	59,982
Annual Average	42,649	119,430	29,360	106,078	2,408

References

Luke, G.L., Burke, K.L. & O'Brien, T.M. (1988). *Evaporation Data for Western Australia – Technical Report 65.* Perth: W.A. Department of Agriculture, Division of Resource Management.

APPENDIX TWO

Assessment of Potential Impacts

Using Coleman and Meney Evaluation Criteria

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Disclaimer

The information contained in this report is based on sources believed to be reliable. While every care has been taken in the preparation of this report, actis Environmental Services gives no warranty that the said base sources are correct and accepts no responsibility for any resultant errors contained herein and any damage or loss, howsoever caused, suffered by any individual or corporation.

Summary

The Lake Bryde Project is designed to modify the flow of water in the Lake Bryde Wetland Complex to increase conservation amenity as well as social and commercial values that have been affected by increased runoff from cleared land and subsequent groundwater table rise. The project includes a number of changes in the catchment. These changes have been modelled by JDA.

The Evaluation Criteria as designed by Coleman and Meney (2000) are only partially appropriate for the Lake Bryde Project. These limitations are:

- The criteria calculations were designed for drainage from farming land to watercourses, which in most cases were public land. Not as in this case where the discharge is from one wetland to another.
- The criteria calculations were designed for deep drains not surface water runoff removal.
- In this case where there are entire catchment changes the criteria must use change of flow rather than output of drain to make sense.
- Quick self-analysis not possible without someone who is very familiar with the objectives, wetland process and spreadsheet programming.
- The proposal does not include design specifications and therefore it is not possible to quantify the changes. This is particularly noticeable when trying to distinguish between salinity and salt load.

Notwithstanding these limitations it was possible to use the Criteria to evaluate the project.

Part of the Criteria requires that the proposals have clearly defined objectives with detailed specifications to monitor and evaluate the potential changes. While the objectives were clear, the evaluation clearly highlighted the lack of quantifiable design data for the proposed changes. This did not allow for quantitative analysis of the impacts. It was however possible to provide a level of mainly subjective evaluation using the six criteria points.

The criteria evaluation found that there were five wetlands of importance that would be affected by the proposed changes. These have been summarised in Table 1. A potential effect of the proposed changes to the catchment has been described as 'Impact' and 'No Impact'

Table 1 Matrix of principal wetlands and evaluated criteria

	Flooding	Hydroperiod	Salinity	Salt Load	pH	Ionic Composition
Yate Swamp	No Impact	Impact	No Impact	No Impact	No Impact	No Impact
Lake Bryde	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Lake Janet	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Diversion Lake	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact
Lakelands	Impact	Impact	Impact	Impact	No Impact	No Impact

The evaluation showed that the likely impact of the changes would be in Lakelands and Lake Janet. The Yate Swamp will have a reduced hydroperiod, which is thought to be negative.

Introduction

The Lake Bryde Wetland Complex is an area that has a high natural biological diversity and is under increasing pressure from surrounding land use practices. The Lake Bryde Wetland Complex for the purpose of this submission has been defined as those lakes and substantial wetlands from East and South Lake Bryde to the north-western boundary of Lakelands.

The Department of Conservation and Land Management (the Department) manages the Lake Bryde Wetland Complex, which was selected in July 1999 as a recovery catchment due to its high natural diversity values.

The main aims of the project to date have been to determine the key processes threatening the long-term survival of species and ecological processes; and to document values within the system. The Department has contracted a number of consultants to undertake this work. Their reports have identified a number of nature conservation and physical diversity values threatened by changes in surface and ground water hydrology. The Department believes that these changes will, if left unmanaged, continue to cause degradation of the wetland system.

The Department of Agriculture (Engineering Water Management Group) in a joint project with the Department of Conservation and Land Management has completed a surface water assessment and developed strategies. This work addresses problems both at a macro catchment scale and at specific locations within the Lake Bryde Recovery Catchment. The project focussed on surface water management on farms, and engineering options to improve water flow at and between valley floor impedance points. To assist in the assessment and strategy development, data was collected on soil-landscape characteristics. Fourteen management recommendations have been developed based on the above work. These involve works on both Crown and freehold land.

The modifications to the surface water and groundwater hydrology will change the flow of water in the wetland complex. The Department determined that the likely impacts to the complex will be significant and contracted the authors to assess the impact. The evaluation guidelines as described by Coleman and Meney (2000) are to be used and modified as part of the evaluation.

The evaluation criteria by Coleman and Meney (2000) was specifically designed for deep groundwater drainage but has been previously modified by the authors to be used for groundwater pumping at other sites.

Objective

Assess the impacts on nature conservation values of the surface water management proposal described in "Surface water assessment and proposals for the Lake Bryde Recovery Catchment", Department of Agriculture (Engineering and Water Management Section) (Final Draft) according to the methodology set out in the report "Impacts of Rural Drainage on Nature Conservation Values", Coleman and Meney (2000).

Criteria

Fundamentals of Criteria

The criteria were designed to identify the key changes to the catchment. To this end they asked for answers that detailed the cost/benefits of proceeding with the project. The proponent had to state clearly the design expectations and how it was going to be achieved.

One of the important elements of the criteria is the identification of the primary and final receiving water bodies. The important wetlands are easy to misidentify in project proposals, and the guidelines provide a method of identifying important wetlands.

Although the criteria were designed for deep drains constructed in private land, it is possible to select the fundamental processes in the criteria. These were:

1. Is there an increased risk of flooding due to the changed drainage and is this less than 10% of existing average water volumes?
2. Will the changed water regime affect the hydroperiod in the wetlands? An increased hydroperiod was defined as the amount of water that would be evaporated from the water body in 45 days of median evaporation.
3. Is there likely to be an increased salinity in the final receiving wetland? A significant increase was defined as 10 per cent change in salinity.
4. Is there likely to be an increased salt load in the final receiving wetland? A significant increase was defined as 10 per cent change in salt load.
5. Is the pH of the proposed discharge water two units of the receiving water?
6. Is the ionic composition of the discharge water approximately the same as the receiving water?

Criteria Suitability

In the format of the original report by Coleman and Meney (2000) the criteria are of limited value for the Lake Bryde project. This is because the criteria were designed for quite a different scenario than the current project. These differences are listed below.

- The criteria calculations were designed for drainage from farming land to watercourses, which in most cases were public land. Not as in this case where the discharge is from one wetland to another.
- The criteria calculations were designed for deep drains not surface water runoff removal.
- In this case where there are entire catchment changes the criteria must use change of flow rather than output of drain to make sense.
- Quick self-analysis not possible without someone who is very familiar with the objectives, wetland process and spreadsheet programming.
- The proposal does not include design specifications and therefore it is not possible to quantify the changes. This is particularly noticeable when trying to distinguish between salinity and salt load.

Most if not all problems with the criteria by Coleman and Meney (2000) are issues of calculating the changes in the catchment not the individual criterion. The criteria listed in Chapter 0 are still relevant. The method of calculating the variation from normal in the quick self-assessment has been made redundant for this study. The Coleman and Meney (2000) criteria stated that the process was not suitable for extensive surface drainage, and the self-assessment process defaulted the Lake Bryde to a full technical assessment on a number of points. For instance the issue of extensive surface drainage, conservation values and the massive changes to flow would have required the proposal to have a technical assessment of the potential impacts.

Evaluation

In view of the comments on the suitability of the criteria it was decided not use the self-assessment and to evaluate the proposed changes on individual criteria, referring to the technical assessment where appropriate. Much of the assessment is based on onsite observations and technical input from JDA and the hydrological work completed by SKM.

The first step in the criteria is to identify the primary receiving wetlands and the more important final or terminal wetlands. In this case, the primary wetland is the constructed channel. The primary wetlands have been evaluated elsewhere in the conservation. The major impact being the clearing and deepening contours low in the catchment. These areas already have some water flow.

The proposed changes will have an impact on four individual lakes and a group of lakes that are interconnected. The four individual lakes are the Yate Swamp, Lake Bryde, Lake Janet and an un-named lake on the Department's cleared farmland. The group of lakes in the area known as Lakelands completed the study.

Most of the lakes in the Lake Bryde catchment are terminal lakes by the definition of Coleman and Meney (2000) in the sense that large amounts of water do not often flow from one lake to another in the system unless there is an episodic flood. For instance, JDA modelled the flow from Lake Bryde to Lakelands, without seepage in the channels connecting them, and found that the flow between the lakes would only have occurred once in the previous twelve years (1992). Seepage would have meant that less water would reach the Lakelands region from Lake Bryde.

Yate Swamp

Flooding

It is anticipated that the catchment of the Yate Swamp will be decreased with the proposed modifications. Therefore the flooding episodes would not be increased but decreased. It was estimated that the catchment of the Yate Swamp is 5,200 ha assuming that the entire catchment LB3 of the JDA report feeds into the Yate Swamp.

It is unlikely to do this as there is a lake on farmland (WP 137) that is obviously fed from the same catchment. Therefore the likely size of the Yate Swamp catchment is between 2,600 and 5,200 ha before changes to the road. Most of the catchment is cleared and would have an increased runoff compared to the natural pre clearing period. The modifications to the Yate Swamp catchment will reduce the catchment on the north-eastern side of the road to less than 100 ha including that within the Lake Bryde Reserve.

The Yate Swamp will not flood more often than under natural situations.

Hydroperiod

As for the flooding analysis, the hydroperiod will not be increased but rather decreased. With hydroperiod a significant decrease is considered detrimental. Assuming that the catchment is 2,600 ha and the proposed catchment size is to be 100 ha then there would be a significant change in hydroperiod.

It is considered very likely that there will a detrimental change to the Yate Swamp due to decreased hydroperiod.

Salinity

The natural salinity in the catchment would have been quite low before the area was cleared. It is expected that the salinity in the Swamp would be increasing as the dryland salinity becomes more prevalent in the region. The changes to the catchment drainage are unlikely to increase the salinity in the Yate Swamp. It is not definite as the reduced water flow may allow the salt from albeit a smaller salt load to increase to a higher concentration.

It is probable that the salinity in the Yate Swamp will not increase due the changes to the catchment drainage.

Salt Load

The salt load would be reduced with the proposed changes. The remaining catchment is mainly uncleared and would only contribute to the salt load if the entire area becomes salt stressed.

Salt load is not a concern.

pH

There are no changes to the source of water and therefore no likely changes to the pH of the pre and post catchment drainage changes.

Ionic Composition

There are no changes to the source of water and therefore no likely changes to the ionic composition of the pre and post catchment drainage changes.

Lake Bryde

Flooding

The proposed changes will reduce the amount of water running into Lake Bryde.

The flooding frequency will not be increased.

Hydroperiod

The changes to the runoff into Lake Bryde are not expected to be major. The objective is to decrease the incidence of high salinity flows into the Lake and divert them to downstream lakes. At no stage in the proposal is the amount specified, but it is inferred that the high salinity flows are the smaller initial flows after summer/autumn. The runoff from the cleared sections is expected to be much higher than when they were not cleared. Estimates place the difference to be in the region of two and half times more water after clearing (JDA report).

It is expected that the diversion of water will be less than the increase from changes in land use.

Salinity

The salinity in Lake Bryde is a combination of water volume and salt load. The changes to the runoff into Lake Bryde are expected to divert the high salinity low volume runoffs into Lake Bryde. This is slightly at odds with the comments that the increased salinity in Lake Bryde is due to flows from the East Lake Bryde Catchment during peak flows. The last lake in the east Lake Bryde Catchment is a salt lake, and it is likely that this lake will discharge into Lake Bryde during peak events.

As a result of the diversion of small flows from Lake Bryde, it is expected that the salinity in Lake Bryde will be less, and more like that before clearing of the catchment. This conclusion needs to be validated by management practice.

Salt Load

As for salinity, the salt load in Lake Bryde will be reduced if the assumption is correct that low initial flows are the main cause of increased salt load. If the peak flows are the source of high salt loads then it will not be practical for the runoff to be diverted.

The proposed diversion around Lake Bryde will reduce the salt load, and move the balance closer to the pre clearing levels.

pH

There are no changes to the source of water and therefore no likely changes to the pH of the pre and post catchment drainage changes.

Ionic Composition

There are no changes to the source of water and therefore no likely changes to the ionic composition of the pre and post catchment drainage changes.

Lake Janet

Flooding

It is understood that the floodway will redirect the water in small floods away from Lake Janet. Large floods will still enter Lake Janet. It is expected that the smaller flows are high salinity. The design for the floodway has not been specified, and therefore it is not possible to quantify the change in volumes but the flood changes are expected to remain unchanged.

Flooding frequency in Lake Janet will remain the same after the construction of the waterway.

Hydroperiod

With the same flooding frequency, the Lake's floor will be flooded for the same period. The local catchment to the lake will not be affected.

The hydroperiod will not change after the construction of the floodway (subject to the floodway design).

Salinity

The salt from Lake Bryde will be redirected past Lake Janet. During periods of small flows, high salinity water is expected to bypass the Lake. The water quantity will not be markedly affected.

The salinity will be unaffected.

Salt Load

The salt load will be unaffected.

pH

There are no changes to the source of water and therefore no likely changes to the pH of the pre and post catchment drainage changes.

Ionic Composition

There are no changes to the source of water and therefore no likely changes to the ionic composition of the pre and post catchment drainage changes.

Diversion Lake

Flooding

The catchment of the farmland lake will be effectively doubled under the proposal and must fill more often under this scenario. This is a terminal lake and is unlikely to flood elsewhere.

The farmland lake will flood more often but it is not thought to be of major consequence because of the low conservation value and it cannot flood to another area.

Hydroperiod

The hydroperiod will be increased due to the doubling of the catchment.

Salinity

The salinity will be increased due to the doubling of the catchment.

Salt Load

The salt load will be increased due to the doubling of the catchment.

pH

There are no changes to the source of water and therefore no likely changes to the pH of the pre and post catchment drainage changes.

Ionic Composition

There are no changes to the source of water and therefore no likely changes to the ionic composition of the pre and post catchment drainage changes.

Lakeland Lakes

Flooding

The constructed waterway will, according to the modelling done by JDA, increase the amount of water moving from the Lake Bryde sub catchment to Lakelands. According to the modelling the increased water flow will be within the flood holding capability of the six main lakes for most events. During events such as happened in 1992 the capacity will be exceeded and the flood event more severe than it would have been without the constructed wetland. There are limitations to the modelling as specified in the report by JDA.

Flooding will be more severe in extreme events but the water volume will be within the capacity of the lakes for most events.

Hydroperiod

The constructed water way will increase the effective catchment of the Lakeland wetlands by 100%. This must have the effect of increasing the hydroperiod beyond the limit for many species.

The hydroperiod will be increased in an already stressed environment.

Salinity

The modelling by JDA shows an increased salt movement to Lakelands. This means that evaporation will concentrate the salts and elevate the salinity of the lakes when they are wet.

The salinity of the wetlands will be increased.

Salt Load

The modelling by JDA indicates that the salt load in the lakes will increase by 200%. This is a large increase and will have an effect on the conservation values of the wetlands.

The salt load will be increased beyond the increase specified by the criteria.

pH

There are no changes to the source of water and therefore no likely changes to the pH of the pre and post catchment drainage changes.

Ionic Composition

There are no changes to the source of water and therefore no likely changes to the ionic composition of the pre and post catchment drainage changes.

References

Coleman, M. U. and K. Meney (2000). Impacts of Rural Drainage on Nature Conservation Values Proposed Evaluation Guidelines, CALM.

APPENDIX THREE

LAKE BRYDE SURVEY: 28/04/2002

LOCATION	1. Yate Swamp						
LAT/LONG	**GENERAL DESCRIPTION**	**ASSEMBLAGE**	**DOMINANTS**	**ASSOCIATED PERENNIAL FLORA**	**ECOSCAPE COMMUNITY**	**%LIVE/DEAD**	**RECRUITMENT AGES**
WP4 0668556 6310290		*Eucalyptus occidentalis/E. flocktoniae* Low Woodland over closed *Melaleuca* Tall Shrubland	*Eucalyptus occidentalis (Yate), E. flocktoniae, Melaleuca strobophylla, M. lateriflora ssp. lateriflora, M. uncinata*	none	**1B**	Yates = <10% (inc. juveniles <20 yrs old; salmon gums <10)	Yates ~ 5 yrs; *M.uncinata* ~5yrs
WP 2 0668661 6310179		*Eucalyptus occidentalis/E. flocktoniae* Low Woodland over closed *Melaleuca* Tall Shrubland	*Eucalyptus occidentalis (Yate), E. flocktoniae, Melaleuca strobophylla, M. lateriflora ssp. lateriflora, M. uncinata*	*Rhagodia preissii* ssp. *preissii, Neurachne alopecuroidea, Dodonaea ceratocarpa, Acacia sp (YSOO6)*	**1B**		*Eucalyptus occidentalis* ~ 15 yrs; *Melaleuca strobophylla* ~ 15 yrs
WP 3 0668674 6310131	Edge of main lake bed	*Eucalyptus occidentalis* Low Woodland.	*Eucalyptus occidentalis*	*Lepidosperma viscidum (YS007), Melaleuca uncinata (juveniles), Hakea adnata ssp needlii, Melaleuca acuminata*	**1B/4A**		
	Within lake bed	*Melaleuca strobophylla* Tall Shrubland	*Melaleuca strobophylla, Rhagodia sp*	none	**4B**	Yates = <10%	*Eucalyptus occidentalis* ~ 2-3 yrs; *Melaleuca strobophylla* ~ 15 yrs
WP 5 0668567 6310427	Swamp periphery	*Eucalyptus salmonophloia, Eucalyptus eremophila* Open Woodland with *Melaleuca* Open Scrub	*Eucalyptus eremophila, Eucalyptus salmonophloia, Melaleuca uncinata, M. acuminata, M. adnata, M. laxiflora*	*Melaleuca depauperata, Melaleuca sp* (R77), *Grevillea oligantha, Hakea adnata ssp needlii, Hakea lissocarpha Tetraria capillaris, Dianella revoluta, Lepidosperma viscidum*	**2B**	*Eucalyptus salmonophloia* ~70% crown death	*Melaleuca strobophylla*

LOCATION	2. East Lake Bryde						
LAT/LONG	**GENERAL DESCRIPTION**	**ASSEMBLAGE**	**DOMINANTS**	**ASSOCIATED PERENNIAL FLORA**	**ECOSCAPE COMMUNITY**	**%LIVE/DEAD**	**RECRUITMENT AGES**
MC WP 88 676706 6307096	Zone 1: Playa	*Muehllenbeckia horrida* Dwarf Scrub with *Samphire*	*Muehllenbeckia horrida, Halosarcia doleiformis, H. pergranulata, Tecticornia verrucosa, Disphyma crassifolium*		**TEC**		*Muehllenbeckia horrida* 1yr
	Zone 2: ~5-15m	*Eucalyptus occidentalis* Woodland over *Melaleuca strobophylla* Shrubland	*Melaleuca strobophylla, Eucalyptus occidentalis*	*Melaleuca hamulatorum* ssp *cymbifolia*	**1A/4B**		
	Zone 3	*Eucalyptus occidentalis* Open Woodland with *Melaleuca hamulatorum* ssp *cymbifolia* recruitments	*Eucalyptus occidentalis, Melaleuca hamulatorum* ssp *cymbifolia*		**1A/4B**		*Eucalyptus occidentalis* ~ 2 - 10yrs (Very healthy condition)
	Zone 4	*Eucalyptus perangusta, E. phenax* with Mixed Shrubland	*Eucalyptus perangusta, E. phenax Melaleuca brophyi, M. uncinata, M. acuminata*	*Santalum acuminata, Sollya* sp. (EB32), *Desmocladus asper, Schoenus* sp. (EB029), EB30, R75	**6A**		

LOCATION	3. Lake Bryde						
LAT/LONG	GENERAL DESCRIPTION	ASSEMBLAGE	DOMINANTS	ASSOCIATED PERENNIAL FLORA	ECOSCAPE COMMUNITY	%LIVE/DEAD	RECRUITMENT AGES
	Lake Bryde south lake margins	*Eucalyptus occidentalis* Low Woodland over *Melaleuca strobophylla* Low Woodland over Open Scrub of *Melaleuca hamulatorum subsp cymbifolia* and *M. lateriflora* ssp. *lateriflora*	*Eucalyptus occidentalis, Melaleuca strobophylla, Melaleuca hamulatorum subsp cymbifolia, M. lateriflora* ssp. *lateriflora*	*Halosarcia pergranulata*	**1B**		
	Lake Bryde south lake bed	*Muehllenbeckia horrida* subsp *abdita* Dwarf Scrub over *Tecticornia verrucosa* Open Dwarf scrub	*Muehllenbeckia horrida* subsp *abdita, Tecticornia verrucosa*	*Halosarcia syncarpa, Wilsonia humilis, Wilsonia rotundifolia*	**none, TEC**	*Muehllenbeckia horrida* subsp *abdita* >90%	
WP MC 1 669908 6307658	Lake Bryde inlet/outlet drain - well incised channel	*Melaleuca strobophylla* Low Woodland over Open Scrub of *Melaleuca hamulatorum subsp cymbifolia* and *M. lateriflora ssp. lateriflora.*	*Melaleuca strobophylla, Melaleuca hamulosa, M. lateriflora* ssp. *lateriflora*	*Halosarcia pergranulata*	**1A/1B, TEC**		
	Lake Bryde outlet drain - surrounding	*Eucalyptus flocktoniae, E kondininensis* Low Woodland over *Atriplex paludosa ssp. baudinnii, Rhagodia preissii* Dwarf Scrub over very open herbs.	*Eucalyptus kondininensis, Eucalyptus flocktoniae, Atriplex paludosa* ssp. *baudinnii, Rhagodia preissii*	*Halosarcia pergranulata, Disphyma crassifolium*	**5**		
WP MC 2 669894 6307499	Broad sedimented channel	*Melaleuca hamulatorum subsp cymbifolia/ M. strobophylla* Low Woodland	*Melaleuca strobophylla, Melaleuca hamulatorum subsp cymbifolia*	*Halosarcia pergranulata, Disphyma crassifolium*	**1A/1B**	~ 20% tree loss	
WP MC 3 669784 6307442	Start of inlet/outlet	*Melaleuca lateriflora ssp lateriflora* Low Woodland	*Melaleuca lateriflora* ssp *lateriflora*		**1B**		
WP MC 4 669771 6307757	Lake bed, sandy rise	*Melaleuca hamulatorum subsp cymbifolia* Low Woodland with *Muehllenbeckia horrida* subsp *abdita* Dwarf Scrub	*Melaleuca hamulatorum subsp cymbifolia, Muehllenbeckia horrida* ssp. *abdita*		**1A, TEC**	*Muehllenbeckia sp* ~ 30% loss, Old dead *Eucalyptus occidentalis* into lake	
WP MC 5 669816 6307861	Lake bed	*Muehllenbeckia horrida* subsp *abdita* Dwarf Scrub over *Tecticornia verrucosa* Open Dwarf scrub	*Muehllenbeckia horrida* subsp *abdita, Tecticornia verrucosa*	*Halosarcia syncarpa, Wilsonia humilis, Wilsonia rotundifolia, Ruppia* sp, *Chara* sp.	**none, TEC**	*Muehllenbeckia sp* ~ 90% loss, Old dead *Eucalyptus occidentalis* into lake	
WP 29 0670029 6308620	Main inlet to Lake Bryde	*Melaleuca* Low Woodland on margins with *Muehllenbeckia horrida* subsp *abdita, Tecticornia verrucosa* Dwarf Scrub on lake bed	*Melaleuca hamulatorum subsp cymbifolia, Melaleuca strobophylla, Muehllenbeckia horrida* subsp *abdita, Tecticornia verrucosa*		**1A/1B, TEC**	*Muehllenbeckia* sp = < 10%; Yates <10%	Mass recruitment of *Melaleuca strobophylla* ~ 5yrs; young yate seedlings ~1-2yrs; live old yates ~40m from shoreline
	~20m from lake edge	*Eucalyptus occidentalis* Low Woodland with Open Scrub of *Melaleuca lateriflora* ssp. *lateriflora*	*Eucalyptus occidentalis, Melaleuca lateriflora ssp. lateriflora*		**1B**		
	~rise above inlet channel	*Eucalyptus salmonophloia* Open Woodland over *Pittosporum angustifolium , Olearia dampieri* Low Scrub over Open Herbs.	*Eucalyptus salmonophloia, Pittosporum angustifolium, Olearia dampieri, Lepidobolus preissianus, Pimelea argentea, Austrostipa spp, Lepidosperma viscidum, Schoenus sp.*		**5**		

LOCATION	4. Lake Bryde Upland - Proposed Road						
LAT/LONG	GENERAL DESCRIPTION	ASSEMBLAGE	DOMINANTS	ASSOCIATED PERENNIAL FLORA	ECOSCAPE COMMUNITY	%LIVE/DEAD	RECRUITMENT AGES
WP 50 0667266 6308133	Road from Lake Janet back to Lake Bryde	*Eucalyptus phenax* and *E. salmonophloia* Woodland over *Melaleuca S*hrubland	*Eucalyptus phenax, E. salmonophloia, Melaleuca acuminata, Melaleuca brophyi*	*Rhagodia sp, Desmocladus myriocladus, Lepidosperma viscidum, Santalum acuminatum, Eucalyptus sporadica, Eucalyptus perangusta (R77), Leptospermum erubescens and Lepidobolous preissianus*	**6A**		
WP 51 0667352 6308070		Mixed *Eucalyptus* Woodland with *Melaleuca S*hrubland (2m)	*Eucalyptus sporadica, Melaleuca depauperata, M. uncinata, M. adnata*	*Eucalyptus kondininensis, Gahnia lanigera, Melaleuca lateriflora ssp. lateriflora*	**6A**		
WP 52 0667421 6307997		*Melaleuca lateriflora* ssp *lateriflora S*hrubland	*Melaleuca lateriflora* ssp. *lateriflora*		**1B**		
WP 53 0667514 6307923		as above	as above		**1B**		
WP 54 0667589 6307880		Mosaic of Mixed Mallee Woodland with scattered *Eucalyptus kondininensis* over Shrubland	*Eucalyptus perangusta, E. sporadica, Eucalyptus scyphocalyx, Melaleuca aff brophyi, M. aff subtrigona (R84), Olearia sp, Darwinia inconspicua, Desmocladus myriocladus, Lomandra micrantha ssp. teretifolia*	*Eucalyptus kondininensis, Leptospermum erubescens, Santalum acuminatum, Lepidosperma viscidum, Gahnia lanigera, Acacia (R85)*	**6A**		
WP 55 0667648 6307798	Waterlogged flat	*Melaleuca lateriflora* ssp *lateriflora S*hrubland	*Melaleuca lateriflora* ssp. *lateriflora*		**1B**	Emergent mallees dead in flat	
WP 56 0667692 6307798		Mixed Mallee Woodland	*Eucalyptus sporadica, E. phenax, E. perangusta*		**6A**		
WP 57 0667752 6307784		Open Mallee Woodland of *Eucalyptus sporadica* with Melaleuca Shrubland	*Eucalyptus sporadica, Melaleuca* aff *brophyi*		**6A**		
WP 58 0667852 6307769		Mixed Mallee Woodland	*Eucalyptus scyphocalyx, Melaleuca depauperata, M. aff brophyi*	*Desmocladus myriocladus, Leucopogon sp (R89), Gahnia lanigera, Lepidosperma viscidum*	**6A**		
WP 59 0667959 6307754		Mallee Woodland with *Melaleuca S*hrubland	*Eucalyptus phenax, Melaleuca adnata*	(R75), *Hakea adnata ssp needlii*	**2B**		

WP 60 0668047 6307746		Open Mallee Woodland with *Melaleuca* Shrubland	*Eucalyptus calycogona, Melaleuca uncinata,* R75, *Cryptandra* sp (R87), R91, *Melaleuca adnata, Melaleuca brophyi*	*Grevillea prostrata, Melaleuca glaberrima*	**3A & 2B (40m N)**		
WP 61 0668147 6307717		*Melaleuca uncinata* Shrubland with emergent *Eucalyptus flocktoniae*	*Melaleuca uncinata, Eucalyptus flocktoniae, Cryptandra* sp (R87)	*Gahnia lanigera, Santalum acuminatum, Grevillea prostrata, Grevillea oligantha* (+60m)	**2B**		
WP 62 0668245 6307698		Mixed *Melaleuca* Shrubland with Emergent Mallees	*Melaleuca uncinata, M. depauperata, M. aff brophyi, Eucalyptus phenax*	*Leptospermum erubescens, Lepidosperma pruinosum,* R99, R91, R92, *Leucopogon* sp	**6A**		
WP 63 0668343 6307699		Mixed *Melaleuca* Shrubland with Emergent Mallees	*Melaleuca uncinata, M. depauperata, M. aff brophyi, Eucalyptus scyphocalyx, Eucalyptus phenax*	*Hakea corymbosa* (R100), R101, *Daviesia decurrens, Gahnia ancistrophylla, Lasiopetalum rosmarinifolium*, R104, R105	**8B**		
WP 64 0668448 6307689		Mixed *Melaleuca* Shrubland with Emergent Mallees	*Eucalyptus scyphocalyx, Melaleuca depauperata*	*Hakea corymbosa, Acacia sp* (R107)	**8B**		
WP 66 0668650 6307656		*Eucalyptus sporadica* Woodland with *Melaleuca* Shrubland	*Eucalyptus sporadica, Eucalyptus scyphocalyx, Melaleuca uncinata, M. depauperata*	*Stylidium repens, Desmocladus myriocladus*	**8B**		
WP 67 0668751 6307643		Mixed *Melaleuca* Shrubland with Emergent Mallees	*Eucalyptus scyphocalyx, Eucalyptus perangusta, E. suggrandis ssp. alipes, Melaleuca uncinata, M. depauperata*		**2B?/6A?**		
WP 68 0668857 6307650		*Melaleuca uncinata* Closed Shrubland with emergent Mallee Woodland	*Melaleuca uncinata, Eucalypus perangusta, Eucalyptus scyphocalyx*		**2B/6A**		
WP 69 0668978 6307658		*Melaleuca uncinata* Closed Shrubland with emergent Mallee Woodland	*Melaleuca uncinata, Eucalypus perangusta, Eucalyptus scyphocalyx*		**2B/6A**		
WP 70 0669050 6307647		*Melaleuca uncinata* Closed Shrubland with emergent Mallee Woodland	*Melaleuca uncinata, Eucalypus perangusta, Eucalyptus scyphocalyx*	*Conostephium roei, Lomandra effusa, Leptospermum erubescens*	**6A**		
WP31 0669344 6307337	Near Ecoscape plot LB024	*Eucalyptus urna* Tall Open Woodland with Closed *Melaleuca* Scrub and *Olearia sp* Dwarf Scrub	*Eucalyptus flocktoniae, Eucalyptus phenax, Olearia ramosissima, Exocarpus aphyllus, Melaleuca adnata, Melaleuca brophyi* ms, *Melaleuca depauperata, Templetonia sulcata*	*Eucalyptus salmonophloia, Hakea linearis, Santalum acuminatum, Hakea laurina, Dianella sp, Gahnia lanigera, Tetraria capillaris, Desmocladus asper, Melaleuca coronicarpa, Lomandra* spp.	**3A**		
WP 30 0669538 6307380	Proposed road start at Lake Bryde entry road	as above	as above	as above	**3A**		
	Extending ~150m from road corner	Low Heathland of *Verticordia* spp, *Hakea* sp. over rushland of *Lepidobolus preissianus*	*Verticordia spp, Lepidobolus preissianus, Olearia sp, Pimelea argentea*	*Acacia saligna, Hakea sp., Grevillea sp, Acacia erinacea*	**6A/7A?**		

LOCATION	5. Waterway - Lake Bryde to Lake Janet						
LAT/LONG	**GENERAL DESCRIPTION**	**ASSEMBLAGE**	**DOMINANTS**	**ASSOCIATED PERENNIAL FLORA**	**ECOSCAPE COMMUNITY**	**%LIVE/DEAD**	**RECRUITMENT AGES**
WP 32 0669090 6307243	Start of waterway	Mixed Open Mallee Forest over Mixed *Melaleuca S*hrubland (1.5-2m)	*Melaleuca lateriflora ssp lateriflora, Melaleuca uncinata, M. acuminata, Eucalyptus calycogona (R66), Eucalyptus flocktoniae, E. suggrandis ssp. alipes (R69), Eucalyptus sporadica (R64), Desmocladus myriocladus*	*Schoenus* sp (R63), *Gahnia ancistrophylla, Chorizandra sp. (R68), Eremophila* sp.	**3A**	*Eucalyptus calycogona* = 10-20%	
WP 33 0668816 6307213	Existing road culvert	*Melaleuca* Medium Shrubland (1.5-2m)	*Melaleuca lateriflora* ssp *lateriflora*	*Halosarcia pergranulata*	**1A**	*Melaleuca lateriflora ssp lateriflora* = 10 - 20%	
WP 34 0668788 6307221		as above	as above	as above	**1A**		
WP 35 0668720 6307320		Mallee Woodland with Mixed *Melaleuca* Shrubland	*Eucalyptus suggrandis* ssp. *alipes, Melaleuca brophyi, Melaleuca depauperata, Melaleuca uncinata*	*Eucalyptus sporadica* (R64), *Gahnia lanigera, Grevillea sp* (R71), R72, *Acacia brachyclada* (R70)	**2A**		
WP 36 0668573 6307357		Mallee Woodland with mixed *Melaleuca* shrubland	*Melaleuca uncinata, M. acuminata, Eucalyptus calycogona, E. suggrandis ssp. alipes, Desmocladus myriocladus, Chorizandra sp.*	*Halosarcia pergranulata*	**2A**	*Eucalyptus suggrandis* ssp. *alipes* >90%; *Gahnia* >90%; *Melaleuca uncinata* 10-20%	

WP 37 0668470 6307341	Old broad inundation flat, degraded	*Melaleuca* Medium Shrubland (1.5-2m)	*Melaleuca lateriflora* ssp *lateriflora*	*Halosarcia pergranulata*	**1A**	*Melaleuca lateriflora* ssp *lateriflora* = 20 - 30%	
WP 38 0668349 6307367		as above	as above	as above	**1A**		
WP 39 0668257 6307379	Slightly elevated sandy rise	Open Mallee Woodland of *Eucalyptus sporadica* with *Melaleuca* Shrubland	*Eucalyptus sporadica* and *Melaleuca brophyi*	Rhagodia sp	**3A**		
WP 40 0668084 6307424		Open Mallee Woodland of *Eucalyptus sporadica* with *Melaleuca* Shrubland	*Eucalyptus calycogona* and *Melaleuca lateriflora* ssp *lateriflora*	*Halosarcia indica bidens*	**1B**	>90% *Eucalyptus calycogona*; 70-90% *Melaleuca lateriflora* ssp. *lateriflora*	
WP 41 0667972 6307490		as above	as above		**1B**	*Eucalyptus calycogona (R 66)* = <10%	
WP 42 0667942 6307482	sandier rise	Open Mallee woodland of *Eucalyptus perangusta*	*Eucalyptus perangusta, Melaleuca brophyi, Leptospermum erubescens, Gahnia ancistrophylla, Gahnia lanigera*	*Olearia sp, Acacia acutata, Exocarpus aphyllus, Desmocladus myriocladus, Tetraria capillaris*	**6A**		
WP 43 0667667 6307660	waterlogged flat	*Melaleuca lateriflora* ssp *lateriflora* Closed Shrubland	*Melaleuca lateriflora* ssp *lateriflora*	none	**1A**	*Melaleuca lateriflora* ssp *lateriflora* 50-70 % dead	
WP 44 0667553 6307661	Mid channel	as above	as above	as above	**1A**	*Melaleuca lateriflora* ssp *lateriflora* 10% dead	
WP 45 0667456 6307763		Open Mallee Woodland of *Eucalyptus suggrandis* ssp. *alipes* (R69) with *Melaleuca* Shrubland	*Eucalyptus suggrandis* ssp. *alipes, Melaleuca uncinata, Melaleuca brophyi*		**1B**		
WP 46 0667406 6307909		*Melaleuca lateriflora* ssp *lateriflora /Melaleuca uncinata* Shrubland	*Melaleuca lateriflora* ssp *lateriflora* and *Melaleuca uncinata*	*Wilsonia humilis*	**1B**	Mallees dead	Mass recruitment of *Melaleuca uncinata*

LOCATION	6. Lake Janet						
LAT/LONG	**GENERAL DESCRIPTION**	**ASSEMBLAGE**	**DOMINANTS**	**ASSOCIATED PERENNIAL FLORA**	**ECOSCAPE COMMUNITY**	**%LIVE/DEAD**	**RECRUITMENT AGES**
WP 127 0667325 6308384	Zone 1: Playa	Samphire	*Tecticornia verrucosa, Halosarcia pergranulata, Halosarcia lepidosperma*	*Wilsonia humilis*	**not identified**	*Melaleuca hamulatorum ssp. cymbifolia* dead on Nth side (first 10m)	
	Zone 2: Lake edge extending 2-10m	*Melaleuca hamulatorum ssp. cymbifolia* with *Halosarcia pergranulata*	*Melaleuca hamulatorum ssp. cymbifolia, Halosarcia pergranulata, Maireana brevifolia*	*Threlkedia diffusa*	**not identified**		*Melaleuca uncinata, M lateriflora ssp. lateriflora* ~ 5yrs
	Zone 3: Lunette fringe ~5-10m	*Melaleuca strobophylla* with *Melaleuca lateriflora* ssp. *lateriflora*	*Melaleuca strobophylla, Melaleuca lateriflora* ssp. *lateriflora*		**1B**		
	Zone 4:	*Eucalyptus kondininensis* over mixed shrubland of *Acacia sp. (LJ ???)* and *Melaleuca thyoides*	*Eucalyptus kondininensis, Melaleuca thyoides, Melaleuca uncinata, Atriplex paludosa* ssp. *baudinii, Enchylaena tomentosa, Rhagodia preissii* ssp *preissii*	*Acacia sp., Melaleuca lateriflora* ssp *lateriflora, Austrostipa sp* (LJ132), *Lepidosperma brunonianum* (LJ134), , *Dianella sp.* (LJ135), *Hakea kippistiana?*	**1A**		
WP 128 0667306 6308501	Possible inlet?, Zone 4	*Eucalyptus sporadica* Woodland with *Melaleuca* Shrubland	*Melaleuca brophyi, M. uncinata, Eucalyptus sporadica, Melaleuca depauperata, Leptospermum erubescens*	*Melaleuca uncinata, Melaleuca lateriflora ssp. lateriflora, Gahnia ancistrophylla, Desmocladus asper, Melaleuca subtrigona*	**6A**		
WP 129 0667142 6308424	Zone 4: north side	as above	as above	as above	**6A**		
WP 132 0667158 6308236	Inlet/outlet channel	*Melaleuca hamulatorum* ssp. *cymbifolia* Shrubland with *Eucalyptus suggrandis* ssp *alipes*	*Melaleuca hamulatorum* ssp *cymbifolia, Eucalyptus suggrandis* ssp *alipes, M. strobophylla*		**1B**	*Melaleuca hamulatorum ssp. cymbifolia* dead	
WP 133 0666919 6308217	100m from WP 132	*Melaleuca* Shrubland with *Eucalyptus suggrandis* ssp *alipes* Woodland to north	*Melaleuca lateriflora* ssp *lateriflora, Eucalyptus suggrandis* ssp *alipes*		**1B**	*Melaleuca lateriflora ssp lateriflora* deaths 10-20%	
WP 134 0667193 6307991	Proposed waterway bypass	*Melaleuca lateriflora* ssp *lateriflora* Closed Shrubland	*Melaleuca lateriflora* ssp *lateriflora* (2m)		**1B**		
WP 135 0666773 6308230	Watercourse from Lake Janet into private land	*Melaleuca lateriflora* ssp *lateriflora* Closed Shrubland	*Melaleuca lateriflora* ssp *lateriflora*		**1B**		

LOCATION	7. Fourteen Mile Road Lake; Road intercepts lake						
LAT/LONG	**GENERAL DESCRIPTION**	**ASSEMBLAGE**	**DOMINANTS**	**ASSOCIATED PERENNIAL FLORA**	**ECOSCAPE COMMUNITY**	**%LIVE/DEAD**	**RECRUITMENT AGES**
WP 136 0667546 6308886	West Lake, Zone 1: Playa	Samphire	*Halosarcia indica bidens, H. syncarpa, H. doleiformis, H. halocnemoides* ssp. *halocnemoides H. pergranulata* ssp. *pergranulata, Frankenia* sp, *Maireana brevifolia*	*Atriplex paludosa* ssp. *baudinii, Melaleuca lateriflora* ssp. *lateriflora,*	**1A**	*Melaleuca thyoides* >90%	
	West Lake, Zone 2:~18m	*Melaleuca thyoides* Shrubland	*Melaleuca thyoides*		**6A**	*Melaleuca thyoides* >90% for first 10m; *Eucalyptus sporadica, E. perangusta >90%*	
	West Lake, Zone 3, rise of lunette	*Eucalyptus phenax, Eucalyptus perangusta* Woodland with *Melaleuca brophyi* Shrubland	*Eucalyptus phenax, Eucalyptus perangusta, Melaleuca brophyi*	*Gahnia* sp in upper half	**6A**	*Eucalyptus sporadica, E. perangusta >90%* for first 5m	
	East Lake Zone 1: Playa	*Melaleuca thyoides* Shrubland with *Halosarcia* spp	*Melaleuca thyoides*		**1A**		
	East Lake Zone 2:	Degraded *Eucalyptus kondininensis* Woodland over *Melaleuca* Woodland	*Eucalyptus kondininensis, Melaleuca* sp (EL141) (5-7m), *Atriplex paludosa* ssp. *baudinii*		**1A**		
LOCATION	**8. Diversion Lake - private land**						
WP 137 0666561 6311308	Zone 1: Playa	Samphire					
	Zone 2: ~5m	*Melaleuca lateriflora* ssp *lateriflora* Closed Shrubland with emergent *Melaleuca uncinata*				*Melaleuca* sp (DL142) >80%	
	Zone 3: ~20m	*Melaleuca thyoides* Shrubland	*Melaleuca thyoides*		**1A**	*Eucalyptus kondininensis* 100%	
	Zone 4: ~50m	*Eucalyptus flocktoniae* Woodland	*Eucalyptus flocktoniae, Melaleuca adnata, Melaleuca uncinata, M. acuminata, Olearia ramosissima, Gahnia lanigera, Exocarpus aphyllus,*		**2B**		
WP 138 0666778 6311733	Channel to diversion lake	Mixed shrubland with *Eucalyptus eremophila, E. perangusta*	*Eucalyptus eremophila, E. perangusta, Melaleuca brophyi*	*Gahnia lanigera, Gahnia ancistrophylla, Schoenus* sp	**2B**		

LOCATION	9. NW Floodway Extension						
LAT/LONG	**GENERAL DESCRIPTION**	**ASSEMBLAGE**	**DOMINANTS**	**ASSOCIATED PERENNIAL FLORA**	**ECOSCAPE COMMUNITY**	**%LIVE/DEAD**	**RECRUITMENT AGES**
WP 76 0665201 6310902	From private land, valley flats	*Melaleuca* Shrubland with peripheral emergent mallees	*Melaleuca lateriflora* ssp. *lateriflora, Melaleuca uncinata*	*Eucalyptus suggrandis* ssp. *alipes* (F110), *Melaleuca acuminata* (F111) on periphery of channel	**1B**		
WP 77 0665155 6310978	~50 x 50m patch	Open *Eucalyptus suggrandis* ssp. *alipes* Woodland with Myrtaceous Shrubland	*Eucalyptus suggrandis* ssp. *alipes, Calytrix sp (F112), F 113, F114*	*Desmocladus asper, Neurachne alopocuroidea, Acacia sp,* Myrtaceae sp.	**2A**		
WP 78 0665106 6311063		Open Mallee Woodland of *Eucalyptus sporadica* and *Eucalyptus perangusta* over *Melaleuca* Shrubland to 1m	*Eucalyptus sporadica, E. perangusta, Melaleuca sp* (R53)	*Gahnia ancistrophylla,* Myrtaceae sp (F116), *Leptospermum erubescens* , *Santalum acuminatum, Melaleuca* aff. *subtrigona, Melaleuca thyoides*	**6A**		
WP 79 0664985 6311305		Mixed *Melaleuca* Tall to Medium Shrubland	*Melaleuca lateriflora* ssp. *lateriflora*	*Melaleuca uncinata,* Chenopod sp.	**1A/1B**		
WP 80 0664914 6311349		Mixed *Melaleuca* Tall to Medium Shrubland	*Melaleuca uncinata*	*Melaleuca lateriflora* ssp. *lateriflora*	**1A/1B**		
WP 81 0664864 6311376		Mixed *Melaleuca* Tall to Medium Shrubland	*Melaleuca uncinata*	*Melaleuca lateriflora* ssp. *lateriflora*	**1A/1B**		
WP 82 0664791 6311465		Mallee Woodland of *Eucalyptus suggrandis* ssp *alipes* with *Melaleuca thyoides, M. lateriflora* ssp. *lateriflora*	*Eucalyptus suggrandis* ssp. *alipes* , *Melaleuca thyoides, M. lateriflora* ssp. *lateriflora*	none	**1B**		
WP 83 0664732 6311521		Open *Melaleuca thyoides* shrubland	*Melaleuca thyoides*	Chenopod sp.	**not represented, ~1A**		
WP 84 0664649 6311604	Edge of drainage channel	Open Mallee Woodland of *Eucalyptus sporadica* and *Eucalyptus perangusta* over *Melaleuca* Shrubland to 2m	*Eucalyptus sporadica, E. perangusta, Melaleuca brophyi*	In waterway; *Melaleuca lateriflora* ssp *lateriflora* (2m)	**6A**		
WP 85 0664555 6311626		Low Closed *Melaleuca lateriflora* ssp. *lateriflora* Shrubland 1-2m	*Melaleuca lateriflora* ssp. *lateriflora*	*Eucalyptus suggrandis* ssp. *alipes,* Myrtaceae sp	**1B/6D**		

WP 86 0664457 6311663	Extends 50m W, 200m S, 100m N	Low Closed *Melaleuca lateriflora* ssp. *lateriflora, Melaleuca uncinata* Shrubland 1-2m	*Melaleuca lateriflora* ssp. *lateriflora, Melaleuca uncinata*		**1B**		
WP 87 0664430 6311676	Sandy rise	Low Mixed Heathland with scattered emergent mallees	*Leptospermum erubescens, Melaleuca* aff *subtrigona, Desmocladus myriocladus*	*Eucalyptus suggrandis ssp. alipes, Eucalyptus perangusta, Hakea corymbosa (R100), Leucopogon sp, F119, Lomandra micrantha ssp. micrantha (R85), Exocarpus aphyllus*	**2A**		
WP 88 0664328 6311698	Track intercept	Low Mixed Heathland with scattered emergent mallees	*Leptospermum erubescens, Melaleuca* aff *subtrigona, Desmocladus myriocladus*	*Eucalyptus suggrandis ssp. alipes, Eucalyptus perangusta, Hakea corymbosa (R100), Leucopogon sp, F119, Lomandra micrantha ssp. micrantha (R85), Exocarpus aphyllus, Calytrix sp (F112)*	**2A**		
WP 89 0664267 6311722	Bare sandy-clay pan	*Melaleuca uncinata, M. lateriflora* ssp *lateriflora* Thicket to *Melaleuca lateriflora* ssp *lateriflora* shrubland	*Melaleuca uncinata, M. lateriflora ssp lateriflora*	*Wilsonia humilis* on pan	**1A/1B**		
WP 90 0664081 6311802	as above	as above	as above	as above	**1A/1B**		
WP 91 0663950 6311840		Low Mixed Heathland with scattered emergent mallees	*Leptospermum erubescens, Melaleuca aff subtrigona, Eucalyptus suggrandis ssp. alipes , E. perangusta, Hakea corymbosa* (R100), *Melaleuca hamulosa, Melaleuca brophyi, Calytrix sp*	*Desmocladus myriocladus, Leucopogon sp (F121), F119, Lomandra micrantha* ssp. *micrantha (R85)*	**2A**		
WP 92 0663746 6311837	Sandy edge of sandy clay pan	Low Mixed Heathland with scattered emergent mallees to low *Melaleuca uncinata, M. lateriflora* ssp. *lateriflora* thicket to medium *Melaleuca halmaturorum ssp cymbifolia, M. hamulosa* shrubland	*Leptospermum erubescens, Melaleuca aff subtrigona, Desmocladus myriocladus, Melaleuca halmaturorum ssp cymbifolia, M. hamulosa*		**2A**		
WP 93 0663598 6311899		Low Closed *Melaleuca lateriflora* ssp. *lateriflora, Melaleuca uncinata* Shrubland 1-2m	*Melaleuca lateriflora* ssp. *lateriflora, Melaleuca uncinata*		**1B?**		
WP 94 0663483 6312063	Degraded	Low Closed *Melaleuca lateriflora* ssp. *lateriflora, Melaleuca uncinata* Shrubland 1-2m	*Melaleuca lateriflora* ssp. *lateriflora, Melaleuca uncinata*	Dead *Gahnia ancistrophylla*	**1B?**	*Gahnia ancistrophylla* >90%	

WP 95 0663443 6312277	Degraded	Low Closed *Melaleuca lateriflora* ssp. *lateriflora, Melaleuca uncinata* Shrubland 1-2m	*Melaleuca lateriflora* ssp. *lateriflora, Melaleuca uncinata*	Dead *Gahnia ancistrophylla*	**1B?**	*Gahnia ancistrophylla* >90%	
WP 96 0663400 6312305		Low Closed *Melaleuca lateriflora* ssp. *lateriflora, Melaleuca uncinata* Shrubland 1-2m	*Melaleuca lateriflora* ssp. *lateriflora, Melaleuca uncinata*		**1B?**		
WP 97 0663330 6312277	Depression	Tall Closed *Melaleuca* Shrubland	*Melaleuca lateriflora* ssp. *lateriflora, M. hamulosa, M. thyoides M. halmaturorum* ssp *cymbifolia, M. uncinata*	*Gahnia ancistrophylla*	**1B?**		
WP 98 0663252 6312485		Low Closed *Melaleuca* Shrubland with scattered emergent mallees	*Melaleuca halmaturorum ssp cymbifolia, M. hamulosa, Melaleuca uncinata, M. lateriflora ssp. lateriflora, M. brophyi, Eucalyptus suggrandis ssp. alipes*		**1B**		
WP 99 0663118 6312619	Open Depression	Scattered *Eucalyptus perangusta* with Tall *Melaleuca uncinata* Woodland with *Melaleuca lateriflora* ssp. *lateriflora* Shrubland	*Melaleuca uncinata, Melaleuca lateriflora* ssp *lateriflora, Eucalyptus perangusta*	*Melaleuca acuminata, Tetraria capillaris, various grasses*	**1A/1B**	*Eucalyptus perangusta <10%*	A few 2 yr old juveniles of *Eucalyptus perangusta*
WP 100 0662979 6312755		as above	as above	as above	**1A/1B**		
WP 101 0662912 6312782	Track intercept	Medium Closed *Melaleuca* Shrubland	*Melaleuca uncinata, M. lateriflora* ssp. *lateriflora, M. thyoides*	*Exocarpus aphyllus, F114*	**1B**		
WP 102 0662817 6312821	Open watercourse	Tall Open *Melaleuca uncinata, M. lateriflora* ssp *lateriflora* Shrubland	*Melaleuca uncinata, Melaleuca lateriflora ssp lateriflora*		**1A/1B**		
WP 103 0662765 6313026		as above	as above	*Dodonaea* sp, Fabaceae sp	**1A/1B**		
WP 104 0662790 6313060		as above	as above		**1A/1B**		

WP 105 0662602 6313111	Degraded	Closed Shrubland *of Melaleuca lateriflora* ssp. *lateriflora* (1 - 2m)	*Melaleuca lateriflora* ssp. *lateriflora*		**1A**	*Melaleuca lateriflora* ssp. *lateriflora* ~ 30 - 60%; dead mallees	
WP 106 0662663 6313316		as above	as above		**1A**		
WP 107 0662752 6313471		as above	as above		**1A**		
WP 108 0662767 6313588		as above	as above		**1A**		
WP 109 0662710 6313672	Degraded	*Eucalyptus kondininensis* Woodland over *Melaleuca* Shrubland	*Eucalyptus kondininensis, Melaleuca thyoides, Melaleuca lateriflora* ssp *lateriflora*	*Boronia inornata* ssp *leptophylla* (F126)*, Halosarcia pergranulata, Halosarcia lepidosperma*	**1A**	*Melaleuca thyoides* ~20-40%	
WP 110 0662674 6313823		as above	as above	*Halosarcia lepidosperma*	**1A**		
WP 111 0662549 6313988		as above	as above		**1A**		
WP 113 0662506 6314231	On edge of water course	*Eucalyptus suggrandis ssp. alipes* Woodland	*Eucalyptus suggrandis ssp. alipes , Gahnia lanigera, Gahnia ancistrophylla, Darwinia inconspicua*	*Melaleuca depauperata,* F128	**8B?**		

WP 114 0662497 6314426	Track intercept	*Melaleuca* Medium *S*hrubland	*Melaleuca lateriflora* ssp. *lateriflora, M. uncinata*	*Wilsonia humilis, Halosarcia lepidosperma*	**1A**		
WP 115 0662450 6314649		*Melaleuca* Medium *S*hrubland	*Melaleuca lateriflora* ssp. *lateriflora, M. uncinata*	*Melaleuca* aff *brophyi* on edge of waterway, F129	**1B**	Dead mallees near edge	
WP 116 0662380 6314831		Low Closed *Melaleuca S*hrubland	*Melaleuca lateriflora* ssp. *lateriflora, M. acuminata*		**1A**		
WP 117 0662316 6315023	Hard pan	*Melaleuca lateriflora* ssp. *lateriflora, Melaleuca acuminata* (2 - 3m) Shrubland	*Melaleuca lateriflora* ssp. *lateriflora, M. acuminata*	*Halosarcia syncarpa*	**1A**		
WP 118 0662254 6315212		as above	as above		**1A**		
WP 119 0662157 6315390		*Melaleuca* Medium *S*hrubland	*Melaleuca lateriflora* ssp. *lateriflora, M. uncinata*		**1A**		
WP 120 0662127 6315493	NE of watercourse	Mallee Woodland of *Eucalyptus suggrandis* ssp. *alipes* over *Melaleuca* Shrubland	*Eucalyptus suggrandis* ssp. *alipes , Melaleuca uncinata, M. acuminata, F129*	*Lepidosperma brunonianum*	**6D?**		
WP 121 0662015 6315655	West of main channel; condition good	*Eucalyptus perangusta* Woodland with Tall *Melaleuca lateriflora* ssp. *lateriflora, M. uncinata* Shrubland	*Melaleuca lateriflora ssp. lateriflora (3-4m), M. uncinata, Eucalyptus perangusta*		**2A?**		
WP 122 0661879 6315805	NE of watercourse	Mallet Woodland of *Eucalyptus suggrandis* ssp. *alipes*	*Eucalyptus suggrandis* ssp. *alipes*		**6D**		
WP 123 0661748 6315885		Mallet Woodland of *Eucalyptus suggrandis* ssp. *alipes* with *Melaleuca acuminata* Shrubland	*Eucalyptus suggrandis ssp. alipes , Melaleuca acuminata*	*Melaleuca uncinata*	**6D**		
WP 125 0663527 6311303	Secondary channel along firebreak (Sth of main channel)	Low *Melaleuca S*hrubland (1 - 2m) with emergent mallee	*Melaleuca lateriflora* ssp. *lateriflora, M. uncinata*	*Eucalyptus suggrandis* ssp. *alipes, Melaleuca acuminata, M. aff brophyi*	**6D**		
WP 126 0665589 6311415	Secondary channel into main channel from farmland	*Eucalyptus kondininensis* Open Woodland with Tall *Melaleuca* Shrubland	*Eucalyptus kondininensis, Melaleuca uncinata* (3-4m), *Melaleuca thyoides* (3-4m)	*Halosarcia indica bidens, Halosarcia lepidosperma,* F112	**1A**		

LOCATION	10. Lakelands Reserve - Floodway						
LAT/LONG	**GENERAL DESCRIPTION**	**ASSEMBLAGE**	**DOMINANTS**	**ASSOCIATED PERENNIAL FLORA**	**ECOSCAPE COMMUNITY**	**%LIVE/DEAD**	**RECRUITMENT AGES**
MC WP 49	Track	*Melaleuca lateriflora ssp lateriflora* Closed Shrubland with emergent *Melaleuca uncinata*	*Melaleuca lateriflora ssp lateriflora* with emergent *Melaleuca uncinata*		**1B**		
MC WP 69 661206 6316038		*Melaleuca lateriflora ssp lateriflora* Closed Shrubland with emergent *Melaleuca uncinata*	*Melaleuca lateriflora* ssp *lateriflora, M. uncinata, Disphyma crassifolium*		**1B**		
MC WP 70 661137 6316091		*Eucalyptus suggrandis* ssp *suggrandis, E. calycogona* Open Woodland with *Melaleuca* Shrubland	*Eucalyptus suggrandis* ssp *suggrandis, Melaleuca subtrigona, Lomandra effusa, Conostephium roei, Leptospermum sp (LK02)*	*Melaleuca aff brophyi, Acacia acutata (LK03), Neurachne alopecuroidea, Melaleuca uncinata, M. lateriflora* ssp *lateriflora*	**1B/2A?**		
MC WP 71 661093 6316187		Degraded *Melaleuca* Closed Shrubland over Samphire	*Melaleuca uncinata, M. lateriflora* ssp *lateriflora, Halosarcia indica bidens, Disphyma crassifolium*		**1A?**	*Melaleuca spp* < 10%; Emergent mallees 100%;	
MC WP 72 661054 6316231		Degraded *Melaleuca* Closed Shrubland over Samphire	*Melaleuca thyoides, M. uncinata*	*Halosarcia lepidosperma, Melaleuca lateriflora* ssp. *lateriflora, M. acuminata*	**1A**	*Melaleuca thyoides, M. lateriflora* ssp *lateriflora* >80%	
MC WP 73 660963 9616486		*Melaleuca* Closed Shrubland	*Melaleuca uncinata, M. thyoides, M. acuminata*		**1A**		
MC WP 74 660860 6316576		*Melaleuca uncinata* Closed Tall Shrubland, with *Melaleuca acuminata*	*Melaleuca uncinata, M. acuminata, Disphyma, crassifolium, Halosarcia lepidosperma, Wilsonia humilis*	*Eucalyptus suggrandis* ssp. *alipes, Melaleuca lateriflora* ssp *lateriflora*	**1B**	*Eucalyptus suggrandis* ssp. *alipes* >80%	
MC WP 75 660774 6316653		as above	as above		**1B**		
MC WP 76 660721 6316653		*Melaleuca uncinata* Tall Shrubland with samphire patches	*Melaleuca uncinata (5m) , Austrodanthonia sp (LK04), Disphyma crassifolium*	*Melaleuca acuminata, Frankenia sp. (LK05), Sarcocornia blackiana, Halosarcia halocnemoides*	**1A**		
MC WP 77 660511 6316620	Lake 4	*Eucalyptus kondininensis, E. suggrandis* ssp. *alipes* Open Woodland	*Eucalyptus kondininensis, E. suggrandis ssp. alipes, Melaleuca lateriflora ssp lateriflora, M. acuminata, Acacia erinacea, Enchylaena tomentosa, Gahnia lanigera, Lomandra effusa*	*Atriplex drummondii (LK07), Austrodanthonia* sp (LK04), *Halosarcia lepidosperma, Desmocladus asper, Eucalyptus calycogona*	**1A**		

LOCATION	11. Lakelands Reserve - Receiving Lakes						
LAT/LONG	**GENERAL DESCRIPTION**	**ASSEMBLAGE**	**DOMINANTS**	**ASSOCIATED PERENNIAL FLORA**	**ECOSCAPE COMMUNITY**	**%LIVE/DEAD**	**RECRUITMENT AGES**
WP 139 0660319 6316697	Lakelands Lake 1 SW transect, Zone 1: Playa	Extensive *Halosarcia* Shrubland	*Halosarcia syncarpa, H. pergranulata, H. pergranulata* ssp *pergranulata, H. halocnemoides, H. halocnemoides catenulata, H. doleiformis, Sarcocornia blackiana*		**not identified**	*Frankenia* sp >90%, *Melaleuca* aff *brevifolium* (F123) >80%	DL145 recruiting
	Zone 2: extending ~20-30m	*Melaleuca* aff. *brevifolium* (F123) with sparse *Halosarcia* shrubland	*Melaleuca* aff. *brevifolium* (F123), *Halosarcia syncarpa*		**1A?**		
	Zone 3: ~4-10m	*Melaleuca lateriflora ssp lateriflora* with *Melaleuca hamulosa, Melaleuca* aff *brevifolium* (F123) Shrubland	*Melaleuca lateriflora* ssp *lateriflora,* Melaleuca sp *(F125)*		**1A**		
	Zone 4: ~5m	*Melaleuca uncinata* thicket with *Melaleuca lateriflora* ssp *lateriflora*	*Melaleuca uncinata, Melaleuca lateriflora ssp lateriflora*		**1A**		
	Zone 5: ~10m top of sandy lunette	Tall Shrubland of *Leptospermum erubescens* over Heath	*Leptospermum erubescens, Desmocladus asper, Desmocladus myriocladus, LK147, Leucopogon sp (LK146), Lomandra sp (R85), Lomandra (R44), R58), Conostephium roei, Gahnia lanigera, Lepidobolus preissianus, Schoenus sp (R63)*		**6A**		
	Zone 6: ~40m	*Eucalyptus kondininensis* Woodland with Mixed Shrubland	*Eucalyptus kondininensis, Eucalyptus subgrandis* ssp *alipes, Melaleuca uncinata, M. acuminata,* R58, *Gahnia sp., Acacia erinacea, Tetraria capillaris*	none	**1A**		

MC WP 78 660035 6316829	Second receiving lake Zone 1: Playa	Extensive *Halosarcia* Shrubland	*Halosarcia syncarpa, H. doleiformis, H. indica ssp bidens, H. halocnemoides, Sarcocornia blackiana*		**not identified**		
	Zone 2: extending ~20-30m	*Melaleuca lateriflora ssp lateriflora* Shrubland with *M. acuminata, M. thyoides, M. uncinata* Shrubland	*Melaleuca lateriflora ssp lateriflora, M. acuminata, M. thyoides, M. uncinata*		**1A**		Mass *Melaleuca lateriflora* ssp *lateriflora* & *M. uncinata* recruitment on Nth side
	Zone 3: ~20-50m	Mixed *Melaleuca* Shrubland with *Eucalyptus subgrandis* ssp *alipes*	*Eucalyptus subgrandis* ssp *alipes*, *Melaleuca lateriflora ssp lateriflora, M. acuminata, M. thyoides, M. uncinata*		**1A**	*Eucalyptus suggrandis ssp alipes* >80% on south side	
	Zone 4:	*Eucalyptus kondininensis* Woodland with Mixed Shrubland	*Eucalyptus kondininensis, Melaleuca uncinata, M. acuminata, Gahnia sp.*		**1A**		
MC WP 79 660039 6316921	Lunette between second & third receiving lakes (Sth side heading Nth)	Degraded *Eucalyptus kondininensis* Open Woodland	*Santalum acuminatum*, *Gunniopsis* sp (LK010), Dianella sp (LK012), grass sp (LK011)		**5**	*Eucalyptus kondininensis, Melaleuca thyoides* >90%; *Santalum acuminatum* poor	
MC WP 80 659997 6316998	Third receiving lake Zone 1: Playa	Degraded Samphire	*Halosarcia syncarpa, H. indica ssp bidens, H. halocnemoides*				

	Zone 2a: Lake edge ~10-20m	Dead *Melaleuca lateriflora* ssp *lateriflora* Shrubland with Samphires	*Halosarcia syncarpa, H. indica ssp bidens, H. doleiformis, Sarcocornia blackiana*		**1A**	*Melaleuca lateriflora* ssp *lateriflora >90%*	
	Zone 2b: ~15m	Degraded *Melaleuca lateriflora* ssp *lateriflora* Shrubland with Samphires	*Melaleuca lateriflora ssp lateriflora, Halosarcia syncarpa, H. indica ssp bidens, Sarcocornia blackiana*		**1A**		
	Zone 3: ~5-15m	*Melaleuca thyoides, M. uncinata, M. lateriflora* ssp *lateriflora* Shrubland	*Melaleuca thyoides, M. uncinata, M. lateriflora* ssp *lateriflora*		**1A**		
	Zone 4	*Eucalyptus kondininensis* Woodland with *Melaleuca* Shrubland	*Eucalyptus kondininensis, Melaleuca acuminata, M. depauperata, M. aff brophyi,*	*Eucalyptus sporadica, Lepidosperma viscidum, Gahnia lanigera, Lomandra effusa*	**1A?**		
MC WP 81 659899 6317341	Fourth receiving lake Zone 1: Playa	Samphire	*Wilsonia humilis, W. rotundifolia*	*Halosarcia syncarpa*			
	Zone 2: extending ~15-20m	*Melaleuca hamulatorum* Shrubland	*Melaleuca hamulatorum*	none	**1A**		Mass recruitment of *Melaleuca hamulatorum, M. lateriflora* ssp. *lateriflora* on E-side
	Zone 3: ~20-30m	*Melaleuca lateriflora* ssp. *lateriflora* Shrubland with Samphire	*Melaleuca lateriflora* ssp. *lateriflora, Halosarcia indica ssp bidens, H. lepidosperma, Sarcocornia blackiana, Threlkedia diffusa*	*Melaleuca acuminata*	**1A**		
	Zone 4	*Eucalyptus phenax, Eucalyptus perangusta* Woodland over Shrubland	*Eucalyptus phenax, Eucalyptus perangusta, Melaleuca brophyi, Templetonia sulcata, Gahnia lanigera*	*Grevillea oligantha, Daviesia sp, Chamelaucium ciliatum, Acacia erinacea, Atriplex sp, Desmocladus asper, Olearia ramosissima, Gahnia ancistrophylla*	**2A**		
	Zone 4: E-side	*Eucalyptus kondininensis* Woodland	*Eucalyptus kondininensis, Atriplex paludosa ssp. baudinii, Exocarpus aphyllus, Santalum acuminatum, Atriplex*	*Eucalyptus salmonophloia, Acacia erinacea*	**5**		
MC WP 82 659354 6317686	Between fourth and fifth receiving lakes	*Eucalyptus salmonophloia* Open Woodland	*Eucalyptus salmonophloia, E. kondininensis, Alyxia buxifolia, Pittosporum phylliraeiodes var microcarpa, Atriplex paludosa ssp. baudinii, Acacia erinacea*		**5**		

MC WP 83 658788 6317811	Fifth receiving lake Zone 1: Playa	Samphire	*Halosarcia pergranulata, H. syncarpa, Ruppia, Chara*				
	Zone 2: ~5m	*Melaleuca hamulatorum* Shrubland	*Melaleuca hamulatorum, Rhagodia preissii* ssp. *preissii, Halosarcia pergranulata*		**1A**		
	Zone 3: ~5-10m; slope of lunette	*M. lateriflora* ssp *lateriflora, M. uncinata* Shrubland	*Melaleuca lateriflora ssp lateriflora, M. uncinata, Halosarcia pergranulata, H. lepidosperma, Sarcocornia blackiana, Threlkeldia diffusa*		**1A**		Mass recruitment of *Melaleuca lateriflora ssp lateriflora, M. uncinata* ~1 - 3yrs
	Zone 4: top of lunette	*Eucalyptus kondininensis* Open Woodland	*Eucalyptus kondininensis, Alyxia buxifolia, Scaevola spinescens (LK025), Dodonaea ceratocarpa, Dianella sp*		**5**		
MC WP 84 659302 6318265	Connecting channel to sixth receiving lake	Degraded *Melaleuca hamulatorum* ssp *cymbifolia* Shrubland	*Melaleuca hamulatorum* ssp *cymbifolia*		**1A**	*Melaleuca hamulatorum* ssp *cymbifolia >90%*	
MC WP 85 659220 6318319	Sixth receiving lake Zone 1: Playa	Samphire	*Tecticornia verrucosa, Halosarcia pergranulata, H. syncarpa, Sarcocornia blackiana, Ruppia* sp			*Muehllenbeckia horrida* 100%	Mass recruitment of *Tecticornia verrucosa;* mass recruitment of *Halosarcia pergranulata* at N end
	Zone 2: ~2-5m	*Melaleuca hamulatorum* ssp *cymbifolia* Shrubland	*Melaleuca hamulatorum* ssp *cymbifolia*	*Halosarcia pergranulata, Tecticornia verrucosa*	**1A**	*Melaleuca hamulatorum* ssp *cymbifolia* >70% on W side	
	Zone 3: ~5-10m	*Melaleuca lateriflora ssp lateriflora* Shrubland	*Melaleuca lateriflora* ssp *lateriflora, M. uncinata*		**1A**		
	Zone 4	*Eucalyptus kondininensis* Open Woodland	*Eucalyptus kondininensis*		**5**		
MC WP 87 659279 6318827	Seventh receiving lake Zone 1: Playa	Samphire	*Halosarcia pergranulata, Tecticornia sp.*	*Ruppia* sp			
	Zone 2: ~10-15m (SE side, 0.5-1m above lake bed)	*Melaleuca hamulatorum* ssp *cymbifolia, M. strobophylla* Closed Shrubland	*Melaleuca hamulatorum ssp cymbifolia, M. strobophylla*		**1B**		
	Zone 3	*Eucalyptus occidentalis* Open Woodland over *Melaleuca uncinata*	*Eucalyptus occidentalis, Melaleuca uncinata, Schoenus sp*		**1B**		