SHIRE OF WANNEROO

SHIRE OF WANNEROO
TOWN PLANNING SCHEME NO. 1
AMENDMENT 837 - YANCHEP/TWO ROCKS

ENVIRONMENTAL REVIEW

ALAN TINGAY & ASSOCIATES

JUNE 1999

REPORT NO: 99/12

Alan Tingay
& Associates
environmental
scientists

AN INVITATION TO COMMENT ON THIS ENVIRONMENTAL REVIEW

The Shire of Wanneroo invites people to make a submission on this Environmental Review (ER).

The Environmental Review (ER) was prepared for Amendment 837 to the Shire of Wanneroo Town Planning Scheme No. 1 for the proposed rezoning of land in the Yanchep - Two Rocks area from primarily 'Rural' and 'Residential Development' to 'Urban Development', 'Centre' and 'Industrial Development' zones.

In accordance with the Environmental Protection Act, 1986 as amended this ER has been prepared to describe the proposed Amendment and its likely impact on the environment.

The ER is available for public review in accordance with the advertising period determined by the Western Australian Planning Commission from 18 June 1999 to 30 July 1999.

After receipt of comments from Government agencies and from the public the Shire of Wanneroo will forward submissions to the Environmental Protection Authority (EPA). The EPA will prepare an Assessment Report with recommendations to the Government, taking into account issues raised in public submissions.

Why write a submission?

A submission is a way to provide information, express your opinion and put forward your suggested course of action - including any alternative approach.

It is useful if you indicate any suggestions you have to improve the proposal.

All submissions received by the Shire of Wanneroo will be acknowledged. Submissions will be treated as public documents and may be quoted in full or in part in each report unless specifically marked confidential.

Submissions may be fully or partially utilised in compiling a summary of the issues raised or where complex or technical issues are raised, a confidential copy of the submission (or part of it) may be sent to the proponent.

The summary of issues is normally included in the EPA's Assessment Report.

Why not join a group?

If you prefer not to write your own comments, it may be worthwhile joining a group or other groups interested in making a submission on similar issues.

Joint submissions may help to reduce the work for an individual or group, while increasing the pool of ideas and information.

If you form a small group (up to ten people) please indicate all the names of the participants. If your group is larger, please indicate how many people your submission represents.

Developing a submission

You may agree or disagree with, or comment on, the general issues discussed in the ER or the specific proposals. It helps if you give reasons for your conclusions, supported by relevant data. You may make an important contribution by suggesting ways to make the proposal environmentally more acceptable.

When making comments on specific items in the review document:

- clearly state your point of view.
- indicate the source of your information or argument if this is applicable.
- suggest recommendations, safeguards or alternatives.

Points to keep in mind

By keeping the following points in mind, you will make it easier for your submission to be analysed:

- Attempt to list points so that the issues raised are clear. A summary of your submission is helpful.

- Refer each point to the appropriate section, chapter or recommendation in the ER.

- If you discuss different sections of the ER, keep them distinct and separate, so there is no confusion as to which section you are considering.

- Attach any factual information you wish to provide and give details of the source. Make sure your information is accurate.

Remember to include:

- your name,
- your address,
- the date, and
- whether you want your submission to be confidential.

The closing date for submissions is: 30 July 1999

Submissions should be addressed to:

Shire of Wanneroo
c/- City of Joondalup
PO Box 21
JOONDALUP WA 6919

Attention: Ian Bignell

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF APPENDICES

SUMMARY

This Environmental Review has been prepared to accompany a proposed Amendment to the Shire of Wanneroo Town Planning Scheme (TPS) No. 1 for the rezoning of land in the Yanchep-Two Rocks area. Amendment 837 to the TPS No. 1 proposes to rezone lots 201 and 202 Breakwater Drive from 'Rural' to 'Rural Community'. Amendment 837 has been initiated by the Shire of Wanneroo following direct written request from the Chairman of the Western Australian Planning Commission (WAPC) and the Office of the Minister for Planning (MFP).

The Environmental Protection Authority (EPA) decided the Amendment could have significant environmental impact and required the preparation of an Environmental Review document for assessment under Section 48A of the Environmental Protection Act, 1986.

The purpose of this Environmental Review is to provide information related to the proposed Amendment that will enable the community to comment on the proposal and the EPA to evaluate the potential impacts on the environment. The EPA issued instructions that identify the key factors that should be addressed to assist preparation of the document.

The EPA issued final instructions for the preparation of the Environmental Review on 19 February 1999 and revised final instructions on 11 March 1999 (Appendix 1). The instructions outline the environmental issues or key factors that the EPA has identified as relevant to the proposed Amendment to the Shire of Wanneroo TPS. This report provides information regarding these key environmental issues so that the potential impact of the proposed rezoning can be assessed.

The proposed Rural Community comprises an area of some 510ha located at the north-eastern corner of Tokyu Corporation's landholding at Yanchep. The area presently supports cattle grazing. The land is located adjacent to state forest and an area reserved for 'Parks and Recreation'. The proposed extension of the Mitchell Freeway will eventually form the eastern border of the project area.

This Environmental Review describes the existing environment in the Amendment area, the significant environmental and planning issues and the approaches proposed to minimise the environmental impact of any development. The important environmental factors and approaches proposed for their management are summarised in Table S1 while Table S2 summarises the management measures proposed.

The commitments made for managing the environment will be implemented through provisions of the Shire of Wanneroo TPS. Proposed Scheme provisions are included in Section 4.

TABLE S1

SUMMARY OF ENVIRONMENTAL FACTORS

Environmental Factor	Present State of the Environment	Proposal in Scheme which could Potentially Impact the Environment	Potential Impacts	Proposed Management	Predicted Outcome
Biophysical					
Terrestrial Flora - Vegetation Communities	The subject land has been classified largely as a degraded area. Degraded areas include areas that are parkland cleared with their flora comprising weed or crop species with isolated native trees or shrubs. The site has been predominantly cleared with scattered Tuarts remaining. The site accommodates three remaining significant stands of trees, one of which is an isolated stand of Tuarts and the other two stands are groves of Tuarts. Most of the Tuart woodland has had its entire understorey cleared for grazing and cropping and remains in a parkland state. A portion of obviously disturbed vegetation is present in the north-western and north-eastern corners of the site. Areas of regionally significant vegetation occupy areas adjacent to the Amendment area and are currently reserved, or proposed for reservation for conservation.	General land use plan.	Restricted clearing of local vegetation and increased potential for a variety of impacts to affect the adjacent reserves and regionally significant vegetation. Potential impacts could include intrusion by domestic pets, weed invasion, increase in fires and litter, and the use of nutrients and pesticides.	The subdivider shall prepare a Vegetation Management Plan at LSP stage, to ensure the long-term viability of remnant vegetation that may be affected directly or indirectly by development of the subject lots to the requirements of Council with the concurrence of the DEP and CALM. This plan shall include: • Description of vegetation and vegetation values. • Retention of significant areas of vegetation on the property. • Retention of mature trees and all three significant stands of trees except where utilities such as roads or construction of buildings is necessary or in those areas identified as prospective for small scale agricultural activities. • Isolation from the adjacent Parks and Recreation areas to the satisfaction of relevant State agencies and will include opportunities for firebreaks, bridle paths and fencing as required. • Management arrangements for the keeping of horses which will address soil and vegetation protection. Restrictions on the keeping of horses to a rate of one horse per lot on conventional lots. In cluster subdivision, horses may only be kept on common land and not on individual lots. • Clear delineation of significant tree stands through use of dual use paths, roads and the like. • Details on site maintenance arrangements - including weed control. • Allocation of responsibilities and identification of timing for the implementation of the Vegetation Management Plan.	The proposed planning provisions will protect the majority of trees from clearance and ensure that the large healthy trees and undergrowth remain in good condition through a Vegetation Management Plan. Although the removal of a small number of isolated Tuart and other trees may be necessary, this will not effect the overall conservation status of the area as all three "significant" stands of vegetation will be retained. Planning Controls will ensure that the nature of development adjacent to regionally significant vegetation in reserves is compatible with the conservation status of these reserves and is undertaken in accordance with the requirements of the agency responsible for management of the reserves.
Terrestrial Flora - Declared Rare and Priority Flora	No rare and endangered flora has been recorded within the Amendment area. Populations of the Declared Rare *Eucalyptus argutifolia* occur in areas adjacent to the Amendment area which are reserved under the MRS. Nearby reservations or regionally significant vegetation may support further populations of DRF or Priority Flora.	Land use plan adjacent to existing or proposed reserves.	Populations of DRF in adjacent reserves and regionally significant vegetation may be impacted as a result of increased pressures associated with development of the area.	As above.	Declared Rare & Priority Flora are protected within adjacent existing and proposed reserves.

Environmental Factor	Present State of the Environment	Proposal in Scheme which could Potentially Impact the Environment	Potential Impacts	Proposed Management	Predicted Outcome
Terrestrial Fauna – Stygofauna and troglobitic fauna	Caves and karstic features in the region may potentially support subterranean fauna or stygofauna. Limited investigations of groundwater within the subject area determined that stygofauna are present in the area in low numbers and with a low diversity.	Land use plan in, and adjacent to, areas where karstic terrain is suspected.	Any lowering of the water table as a result of development has the potential to deprive stygofauna of water or result in the destruction of the root mat habitat favoured by stygofauna. Any changes to groundwater quality as a result of development may impact on the stygofauna. The destruction of remnant Tuart Woodlands will result in a destruction of habitat.	The three remaining stands of trees and the majority of scattered native trees will be retained to preserve the potential primary habitat of stygofauna. The main contributor to nutrients in a Rural Community development is the method of sewage effluent disposal and the areas used for agriculture. The subdivider shall prepare a Drainage, Nutrient and Water Management Plan, at LSP stage, to the requirements of council on the advice of DEP, WRC and Water Corporation to ensure: • groundwater extraction bores are located in areas where drawdowns will not impact on areas of karst or potentially significant stygofauna habitats. In all cases however, the borefield will be located at least 200m from high risk karst areas to avoid any potential impacts on stygofauna; • the rate, quantity and quality of wastewater infiltrating the amendment area is maintained at levels compliant with the minimum requirements of the protection of a Priority 3 Groundwater Source Protection Area; • provision of details on the size and location of groundwater extraction bores and predictions of the area of impact of these bores; • agricultural activities do not adversely impact on karstic zones in terms of water quality and quantity; • best practice Water Sensitive Urban Design principles are incorporated to maximise on-site water infiltration generally; • provide measures to facilitate the removal of pollutants and nutrients; • the habitat of stygofauna is protected in respect of nutrient and groundwater levels; • the plan will require utilisation of nutrient attenuating, sewage disposal mechanisms; • ensure effluent disposal areas are not sited over areas rated as high risk for karst phenomena; • include a requirement to submit a report demonstrating compliance with the criteria on the Plan; and • include contingency plans in the event that the criteria are temporarily not achieved. The subdivider shall prepare a Karst Management Strategy at LSP stage, to the requirements of council on the advice of DEP, WRC and a geotechnical consultant to avoid development over high risk karst subject to further assessment by a geotechnical engineer and environmental scientist. Detailed investigations in accordance with the programs described in (Table 1, attached in Section 4) will be undertaken to determine the presence of large karst structures within the building envelopes on the property. Development will not be approved in areas or close to any location where large karstic structures are known or suspected to be present unless deemed acceptable by a qualified geotechnical engineer and environmental scientist. Development will also only be permitted where investigations indicate that structures can be safely erected. Appropriate geotechnical investigations will be required in the areas	Management measures and planning controls will minimise any potential impacts on stygofauna by ensuring appropriate development occurs where there is a significant potential for stygofauna to exist.

Environmental Factor	Present State of the Environment	Proposal in Scheme which could Potentially Impact the Environment	Potential Impacts	Proposed Management	Predicted Outcome
				which have been identified as within the zone where karstic features may potentially occur. It is recognised that the completion of the geotechnical investigations, staged as necessary, will be required prior to subdivision approval being granted. Preliminary Ground Penetrating Radar Work will be undertaken at Local Structure Plan stage. Detailed investigations, including drilling, will take place where necessary prior to subdivision application stage.	
Terrestrial Fauna – Specially Protected (Threatened) Fauna	Two species of Threatened fauna have been recorded within the Amendment area. These species and other Threatened fauna also occur, or are expected to occur, in habitats in the adjacent existing or proposed reserves.	General land use plan	The very limited clearing of vegetation for development may remove some habitats for species listed as threatened, but the impact is unlikely to be significant given the retention of the majority of remnant vegetation on the site and extent of areas proposed for Parks and Recreation or Regional Open Space in the region.	The management provisions for regionally and locally significant vegetation described in Sections 3.2.1 will provide for the protection of associated fauna habitats.	Significant and representative areas of habitat suitable for the identified Specially Protected (Threatened) Fauna will be retained in the Parks and Recreation areas adjacent to the Amendment area, which link and adjoin State Forest and Yanchep National Park. In addition the retention of the majority of remnant vegetation in the amendment area will preserve any habitat on the site.
Karst Wetlands	The Tamala Limestone aquifer underlies the entire project site and this is where karst wetlands could potentially occur. Studies of the stygofauna in Yanchep National Park have found highly abundant and diverse stygofauna communities occur in the root mats of overlying Tuart Woodlands and in the underground streams that intersect karst formations in the area. However, limited investigations of groundwater and karst within the subject area determined that stygofauna are present in the area in low numbers and with a low diversity. The presence of karst wetlands on the subject land is unlikely given the stygofauna species found and apparent absence of root mats.	Land use plan in, and adjacent to, areas where karstic terrain is suspected.	Any lowering of the water table as a result of development has the potential to deprive stygofauna of water or result in the destruction of the root mat habitat favoured by stygofauna (Jasinska *et al.*, 1996). Any changes to groundwater quality as a result of development may impact on the stygofauna and karst wetlands. The destruction of remnant Tuart Woodlands would potentially result in a destruction of habitat.	The three remaining stands of trees and the majority of scattered native trees will be retained to preserve the potential primary habitat of stygofauna. The main contributor to nutrients in a Rural Community development is the method of sewage effluent disposal and the areas used for agriculture. The subdivider shall prepare a Drainage, Nutrient and Water Management Plan, at LSP stage, to the requirements of council on the advice of DEP, WRC and Water Corporation to ensure: • groundwater extraction bores are located in areas where drawdowns will not impact on areas of karst or potentially significant stygofauna habitats. In all cases however, the borefield will be located at least 200m from high risk karst areas to avoid any potential impacts on stygofauna; • the rate, quantity and quality of wastewater infiltrating the amendment area is maintained at levels compliant with the minimum requirements of the protection of a Priority 3 Groundwater Source Protection Area; • provision of details on the size and location of groundwater extraction bores and predictions of the area of impact of these bores; • agricultural activities do not adversely impact on karstic zones in terms of water quality and quantity; • best practice Water Sensitive Urban Design principles are incorporated to maximise on-site water infiltration generally; • provide measures to facilitate the removal of pollutants and nutrients; • the habitat of stygofauna is protected in respect of nutrient and groundwater levels; • the plan will require utilisation of nutrient attenuating, sewage disposal mechanisms; • ensure effluent disposal areas are not sited over areas rated as high risk for karst phenomena; • include a requirement to submit a report demonstrating compliance with the criteria on the Plan; and	Although the probability of karst wetlands occurring on the subject land is low, management resources and planning controls will minimise any potential impacts on karst wetlands both on-site and off-site by ensuring appropriate development occurs on the property.

Environmental Factor	Present State of the Environment	Proposal in Scheme which could Potentially Impact the Environment	Potential Impacts	Proposed Management	Predicted Outcome
				• include contingency plans in the event that the criteria are temporarily not achieved.	
Groundwater Quantity	There are three main aquifers underlying the site, the Tamala Limestone, the Leederville Formation, and the Yarragadee Formation. The Tamala Limestone aquifer underlies the entire project site and is the shallowest and most productive aquifer in the area. It is also the most susceptible to environmental impact. The subject land is within a Priority 3 groundwater source protection area. The Water Corporation currently draws water from the superficial aquifer in the Yanchep-Two Rocks area for public supply and proposes to continue this practice in the future.	General land use plan.	A Karst Management Strategy will be followed to avoid development over high risk karst areas subject to further assessment by a geotechnical engineer and environmental scientist.The regional groundwater throughflow is conservatively estimated to be around 2000ML/yr. A simple lumped parameter analytical groundwater model was used by Aquaterra (1999) to assess the likely drawdown impacts of pumping from within the study area. Two broad development scenarios were considered; a 1200kL/d peak demand and a 5200kL peak demand scenario. The predicted drawdowns after one years pumping at the annual average of 2360kL/d are all less than 0.4m at a distance of 200m from the bores.	The Aquaterra (1999) assessment indicated that, even in the worst case, drawdowns could be restricted to less than 0.5m, 200m from the borefield. The borefield will be located at least 200m from high risk karst areas to avoid any potential impacts on stygofauna.	The low density nature of the proposed development will keep the drawdown to an acceptable level and provide protection to stygofauna on the site.
Karstic Landform	A study of the geology and geomorphology of the identified two types of suspected karstic structures in the Yanchep region (Alan Tingay and Associates,1992a). The first type of karstic structures are observed on the surface and comprise small cavities, fissures and solution pipes. The second type of karstic structures are massive collapse features. A cave of significant size is present on the south-western edge of Lot 202. A number of dolines are also present in the karstic zone. A recent karst study (Alan Tingay & Associates, 1998) indicated that high risk karst areas are generally confined to the valley floor areas on the south-western areas of the site and that these areas are localised.	Land use plan in, and adjacent to, areas where karstic terrain is suspected.	The karstic caprock may constrain development, due to the widespread small cavities associated with the leaching of the limestone by surface waters. Also, structures of considerable size, close to the surface, would have significant development implications, from a geotechnical viewpoint. Active use of such sites may be inappropriate as there is a potential for collapse or subsidence. Stormwater run-off could also potentially impact on karstic structures, if infiltration is concentrated over subsurface collapse structures and washing sand down into cavities.	The subdivider shall prepare a Karst Management Strategy at LSP stage, to the requirements of council on the advice of DEP, WRC and a geotechnical consultant to avoid development over high risk karst subject to further assessment by a geotechnical engineer and environmental scientist. Detailed investigations in accordance with the programs described in (Table 1, attached in Section 4) will be undertaken to determine the presence of large karst structures within the building envelopes on the property. Development will not be approved in areas or close to any location where large karstic structures are known or suspected to be present unless deemed acceptable by a qualified geotechnical engineer and environmental scientist. Development will also only be permitted where investigations indicate that structures can be safely erected. Appropriate geotechnical investigations will be required in the areas which have been identified as within the zone where karstic features may potentially occur. It is recognised that the completion of the geotechnical investigations, staged as necessary, will be required prior to subdivision approval being granted. Preliminary Ground Penetrating Radar Work will be undertaken at Local Structure Plan stage. Detailed investigations, including drilling, will take place where necessary prior to subdivision application stage.	The presence of karst on the subject land precludes traditional urban development. However, the proposed rural community development is well suited to an area with potential for karst. This is primarily due to the capacity to move building envelopes to the areas of no karst and avoid areas of karst or probable karst.

Environmental Factor	Present State of the Environment	Proposal in Scheme which could Potentially Impact the Environment	Potential Impacts	Proposed Management	Predicted Outcome
Pollution					
Groundwater Quality	The subject land is within a Priority 3 groundwater source protection area. The Water Corporation currently draws water from the superficial aquifer in the Yanchep – Two Rocks area for public supply and proposes to continue this practice in the future. Chemical analysis of water from existing production bores indicates the concentration of potential contaminants is within the range recommended by the relevant guidelines for drinking water.	General land use plan.	Groundwater under the Swan Coastal Plain is vulnerable to contamination due to the unconfined sand aquifer that allows rapid infiltration of surface runoff. Development within the Rural Community has limited potential to result in surface runoff or discharges that contain contaminants that may adversely affect water quality of the superficial aquifer.	The subdivider shall prepare a Drainage, Nutrient and Water Management Plan, at LSP stage, to the requirements of council on the advice of DEP, WRC and Water Corporation to ensure: • groundwater extraction bores are located in areas where drawdowns will not impact on areas of karst or potentially significant stygofauna habitats. In all cases however, the borefield will be located at least 200m from high risk karst areas to avoid any potential impacts on stygofauna; • the rate, quantity and quality of wastewater infiltrating the amendment area is maintained at levels compliant with the minimum requirements of the protection of a Priority 3 Groundwater Source Protection Area; • provision of details on the size and location of groundwater extraction bores and predictions of the area of impact of these bores; • agricultural activities do not adversely impact on karstic zones in terms of water quality and quantity; • best practice Water Sensitive Urban Design principles are incorporated to maximise on-site water infiltration generally; • provide measures to facilitate the removal of pollutants and nutrients; • the habitat of stygofauna is protected in respect of nutrient and groundwater levels; • the plan will require utilisation of nutrient attenuating, sewage disposal mechanisms; • ensure effluent disposal areas are not sited over areas rated as high risk for karst phenomena; • include a requirement to submit a report demonstrating compliance with the criteria on the Plan; and • include contingency plans in the event that the criteria are temporarily not achieved.	The water quality will be maintained through the implementation of an effective drainage, nutrient and water management plan prior to subdivision.
Social Surroundings					
Aboriginal Culture and Heritage	Only one archaeological site has been found in the Amendment area after extensive archaeological and ethnographic surveys.	General land use plan.	The archaeological site found in the study area may be disturbed as a result of development.	The known archaeological site will be retained undisturbed within the development. In order to manage the potential impact associated with the Aboriginal Heritage Site, the subdivider will undertake the following; a 3ha buffer will be retained surrounding the identified heritage site; and, the area immediately surrounding the site will be fenced and sign posted, as appropriate.	Planning controls will ensure there is no disturbance of the site.

TABLE S2

SUMMARY OF PROPOSED MANAGEMENT MEASURES

Issue	Objective	Environmental Management Recommendations	Timing (Phase)	Whose Requirements	Specification (Performance Indicator)
Biophysical					
Vegetation Communities	Maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities.	The subdivider shall prepare a Vegetation Management Plan at LSP stage, to ensure the long-term viability of remnant vegetation that may be affected directly or indirectly by development of the subject lots to the requirements of Council with the concurrence of the DEP and CALM. This plan shall include: • Description of vegetation and vegetation values. • Retention of significant areas of vegetation on the property. • Retention of mature trees and all three significant stands of trees except where utilities such as roads or construction of buildings is necessary or in those areas identified as prospective for small scale agricultural activities. • Isolation from the adjacent Parks and Recreation areas to the satisfaction of relevant State agencies and will include opportunities for firebreaks, bridle paths and fencing as required. • Management arrangements for the keeping of horses which will address soil and vegetation protection. Restrictions on the keeping of horses to a rate of one horse per lot on conventional lots. In cluster subdivision, horses may only be kept on common land and not on individual lots. • Clear delineation of significant tree stands through use of dual use paths, roads and the like. • Details on site maintenance arrangements - including weed control. • Allocation of responsibilities and identification of timing for the implementation of the Vegetation Management Plan.	Local Structure Plan (LSP) & subdivision application stages.	1. CALM, Shire of Wanneroo or agency with management responsibility for the reserves. 2. DEP, Shire of Wanneroo and CALM where appropriate.	1. & 2. Submission of LSP & subdivision application together with Vegetation Management Plan.
Declared Rare and Priority Flora	Protect Declared Rare and Priority Flora, consistent with the provisions of the Wildlife Conservation Act, 1950.	As above.	As above.	As above.	As above.
Stgyofauna and troglobitic fauna	i) Ensure that stygofauna and troglobitic fauna are adequately protected, in accordance with the Wildlife Conservation Act, 1950; and ii) Maintain the abundance, diversity and geographical distribution of stygofauna and troglobitic fauna.	The subdivider shall prepare a Drainage, Nutrient and Water Management Plan, at LSP stage, to the requirements of council on the advice of DEP, WRC and Water Corporation to ensure: • groundwater extraction bores are located in areas where drawdowns will not impact on areas of karst or potentially significant stygofauna habitats. In all cases however, the borefield will be located at least 200m from high risk karst areas to avoid any potential impacts on stygofauna; • the rate, quantity and quality of wastewater infiltrating the amendment area is maintained at levels compliant with the minimum requirements of the protection of a Priority 3 Groundwater Source Protection Area; • provision of details on the size and location of groundwater extraction bores and predictions of the area of impact of these bores; • agricultural activities do not adversely impact on karstic zones in terms of water quality and quantity; • best practice Water Sensitive Urban Design principles are incorporated to maximise on-site water infiltration generally; • provide measures to facilitate the removal of pollutants and nutrients; • the habitat of stygofauna is protected in respect of nutrient and groundwater levels; • the plan will require utilisation of nutrient attenuating, sewage disposal mechanisms; • ensure effluent disposal areas are not sited over areas rated as high risk for karst phenomena;	LSP and prior to development of a site.	DEP, in consultation with CALM and Water & River Commission.	Submission of LSP and individual subdivision applications.

Issue	Objective	Environmental Management Recommendations	Timing (Phase)	Whose Requirements	Specification (Performance Indicator)
		• include a requirement to submit a report demonstrating compliance with the criteria on the Plan; and • include contingency plans in the event that the criteria are temporarily not achieved. The subdivider shall prepare a Karst Management Strategy at LSP stage, to the requirements of council on the advice of DEP, WRC and a geotechnical consultant to avoid development over high risk karst subject to further assessment by a geotechnical engineer and environmental scientist. Detailed investigations in accordance with the programs described in (Table 1, attached in Section 4) will be undertaken to determine the presence of large karst structures within the building envelopes on the property. Development will not be approved in areas or close to any location where large karstic structures are known or suspected to be present unless deemed acceptable by a qualified geotechnical engineer and environmental scientist. Development will also only be permitted where investigations indicate that structures can be safely erected. Appropriate geotechnical investigations will be required in the areas which have been identified as within the zone where karstic features may potentially occur. It is recognised that the completion of the geotechnical investigations, staged as necessary, will be required prior to subdivision approval being granted. Preliminary Ground Penetrating Radar Work will be undertaken at Local Structure Plan stage. Detailed investigations, including drilling, will take place where necessary prior to subdivision application stage.			
Specially Protected (Threatened) Fauna	Protect Threatened Fauna and Priority species and their habitats, consistent with the provisions of the Wildlife Conservation Act, 1950.	As for Vegetation Communities.	As above.	As above.	As above.
Karst Wetlands	Maintain the integrity, functions and environmental values of karst wetlands.	As for Stygofauna and troglobitic fauna	LSP and prior to subdivision of a site	DEP, in consultation with CALM and Water & River Commission.	Submission of LSP and individual subdivision applications and Drainage, Nutrient and Water Management Plan.
Groundwater Quantity	Maintain the quantity of groundwater so that existing and potential uses, including ecosystem maintenance, are protected.	As for Stygofauna and troglobitic fauna	LSP and subdivision approval stages.	1. Water Corporation. 2. DEP, in consultation with Water & Rivers Commission	Submission of LSP and subdivision application and Drainage, Nutrient and Water Management Plan.
Karstic Landform	Maintain the environmental, scientific, cultural and recreational values of karst landforms.	The subdivider shall prepare a Karst Management Strategy at LSP stage, to the requirements of council on the advice of DEP, WRC and a geotechnical consultant to avoid development over high risk karst subject to further assessment by a geotechnical engineer and environmental scientist. Detailed investigations in accordance with the programs described in the Environmental Review will be undertaken to determine the presence of large karst structures within the building envelopes on the property. Development will not be approved in areas or close to any location where large karstic structures are known or suspected to be present unless deemed acceptable by a qualified geotechnical engineer and environmental scientist. Development will also only be permitted where investigations indicate that structures can be safely erected. Appropriate geotechnical investigations will be required in the areas which have been identified as within the zone where karstic features may potentially occur. It is recognised that the completion of the geotechnical investigations, staged as necessary, will be required prior to subdivision approval being granted. Preliminary Ground Penetrating Radar Work will be undertaken at Local Structure Plan stage. Detailed	LSP and prior to subdivision of a site.	DEP and CALM.	Submission of LSP and individual development applications.

Issue	Objective	Environmental Management Recommendations	Timing (Phase)	Whose Requirements	Specification (Performance Indicator)
		investigations, including drilling, will take place where necessary prior to subdivision application stage.			
Pollution					
Groundwater Quality	Maintain or improve the quality of groundwater to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA 1993) and the NHMRC/ARMCANZ Australian Drinking Water Guidelines - National Water Quality Management Strategy.	As for Stygofauna and troglobitic fauna	LSP and subdivision approval stages.	DEP, in consultation with Water & Rivers Commission.	Submission of LSP and subdivision application and Drainage, Nutrient and Water Management Plan.
Social					
Aboriginal Culture and Heritage	Ensure that the proposal complies with the requirements of the Aboriginal Heritage Act, 1972, and ensure changes to the biological and physical environment resulting from the project do not adversely affect cultural associations within the area.	In order to manage the potential impact associated with the Aboriginal Heritage Site, the subdivider will protect on a lot not less than 3ha, the identified heritage site and the area immediately surrounding the site will be fenced and sign posted, as appropriate.	As Above.	DEP and Aboriginal Affairs Department.	Submission of LSP and subdivision application.

1. INTRODUCTION

1.1 Location

The subject land referred to in this document consists of Lots 201 and 202 Breakwater Drive, Two Rocks in the Shire of Wanneroo (Figure 1).

The proposed Rural Community comprises an area some 510ha located at the north-eastern corner of Tokyu Corporation's landholding at Yanchep. The area presently supports cattle grazing. The project area is currently zoned "Rural" in the Metropolitan Regional Scheme (MRS) and Shire of Wanneroo Town Planning Scheme (TPS) No. 1, and was identified in the Yanchep Structure Plan (Department of Planning & Urban Development, 1993) as an area requiring further investigation (Figure 2). The land is located adjacent to State Forest and an area zoned for "Parks and Recreation". The proposed extension of the Kwinana Freeway will eventually form the eastern border of the project area.

1.2 Background

Amendment 837 has been initiated by the Shire of Wanneroo following direct written request from the Chairman of the Western Australian Planning Commission (WAPC) and the Office of the Minister for Planning (MFP). The following information summarises the evolution of Amendment No. 837 and is extracted from Richard Pawluk & Associates (1999).

1991 Structure Plan

In 1991, Tokyu Corporation engaged various specialist consultants to carry out comprehensive site assessments and prepare a structure plan for its 6,800ha site in response to the North-West Corridor Structure Plan, proposed by the Department of Planning and Urban Development. The environmental and engineering assessments undertaken by Alan Tingay & Associates and Cossill & Webley, respectively, confirmed the presence of karst in the north-eastern area of the landholding (Cossill & Webley, 1993 and Alan Tingay & Associates, 1992a). This karst area formed the northern extension of the well known submerged cave system located in Yanchep National Park on a generally north-south alignment.

The 1991 Structure Plan designated the area now identified as Lots 201 and 202 as being suitable for Rural Community development (a derivation of special rural development) essentially because of its unsuitability for standard residential or industrial development (or any other more intensive form of development).

1993 North-West Corridor Structure Plan

The 1993 North West Corridor Structure Plan (NWCSP) prepared by the then Department of Planning and Urban Development was generally consistent with the 1991 Yanchep Structure Plan. The land the subject of Amendment 837 was uncoloured on the NSCSP and identified as requiring further investigation. Matters

requiring investigation were: (a) the suitability of the site for a general aviation aerodrome and (b) the extent of karst.

The subsidence risk associated with karst landforms arises both from the potential for collapse of cave features and from the penetration of small scale solution/weathering pipes to the overlying unconsolidated sand, leading to localised subsidence as surface sands flow into the cavity. Ministry for Planning representatives recognised the risks were greater for standard residential development and negligible for more spacious rural residential development.

1995/1996 Metropolitan Region Scheme Amendment No. 975/33

This Amendment (St. Andrews) zoned the Yanchep/Two Rocks area generally in accordance with the NWCSP. The zoning of subject site remained unchanged (Rural) to reflect its rural residential potential.

Amendment No. 975/33 also created Parks and Recreation reservation to the south and west of the subject site.

Memorandum Of Understanding

On December 11, 1995, four parties signed a Memorandum of Understanding (MOU) relating to the entire Tokyu Corporation landholding. The signatories were the WAPC, WA Land Authority, Tokyu Corporation and Yanchep Sun City. The MOU confirms various commitments and obligations applying to the four parties.

Clause 7.2 of the MOU confirms (i) the subject site is to be used as a Special Rural Community, (ii) rezoning is required under the City of Wanneroo TPS No. 1 and (iii) the WAPC will use its best endeavours to progress this rezoning.

Shire Of Wanneroo Local Rural Strategy

This Local Rural Strategy (LRS) was commenced in 1996, at which time the Shire's former planning consultant, Mr Tim Auret, met with Richard Pawluk & Associates and borrowed the 1993 structure plan prepared specifically for this site. Although this LRS is still in draft form, the subject site has always been designated for some form of rural residential development.

WAPC Letter – 1998

In February 1998 the Chairman of the WAPC Mr Simon Holthouse forwarded a letter to the Shire of Wanneroo requesting the initiation of an amendment to TPS No. 1, to rezone the subject site to Rural Community consistent with Clause 7.2 of the MOU. This letter confirmed Tokyu Corporation had completed its obligations under the MOU and now the WAPC was required to use its best endeavours to secure rezoning of Lots 201 and 202.

Office Of The Minister For Planning

On May 6, 1998, the Shire of Wanneroo was forwarded a written request from the Office of the Minister for Planning further requesting initiation of an amendment to rezone the subject site consistent with the MOU and agreements reached at various meetings of the St Andrews Implementation Group chaired by Mr John Forbes, Coordinator of Urban Development.

Shire Of Wanneroo

Since May 1998, the Shire of Wanneroo has engaged consultants to complete preparation of a suitable amendment. Various negotiations have taken place with the Department of Environmental Protection (DEP) to ensure satisfaction of its requirements.

The Shire of Wanneroo permits a minimum lot size of 1ha in rural residential subdivision. Amendment 837, as initiated by the Shire, allows for a minimum lot size of 1ha and a gross average lot size of 2ha i.e. 255 lots on 510ha site. This is subject to land capability assessment and site analysis. In order to encourage the opportunity for cluster development, the Amendment allows for 300 cluster lots of between 2,000m^2 and 4,000m^2. Again, this is subject to land capability assessment and site analysis.

1.3 Environmental Assessment Process

Recent legislative changes have linked planning and environmental processes. The Planning Legislation Amendment Act, 1996 enables the Environmental Protection Authority (EPA) to assess all Town Planning Schemes, Redevelopment Schemes, Regional Planning Schemes, and all subsequent Amendments.

Under the amended legislation the proponent is no longer the landowner but a Government instrumentality termed the 'responsible authority'. The responsible authority for the proposed rezoning in the Two Rocks area is the Shire of Wanneroo.

The Shire of Wanneroo referred Amendment 837 to the EPA pursuant to the Planning Legislation Amendment Act. The EPA decided the Amendment could have significant environmental impact and required the preparation of an Environmental Review document for assessment under Section 48A of the Environmental Protection Act, 1986.

The purpose of an Environmental Review document is to provide information related to the proposed Amendment which will enable the members of the community to comment on the proposal and the EPA to evaluate the potential impacts on the environment and provide advice to the Minister for the Environment. Instructions are issued by the EPA which identify key factors that should be addressed and assist the preparation of the Environmental Review document.

The Environmental Review is available for public comment during the advertising period for the Shire of Wanneroo TPS Amendment No. 837. Submissions on the

Environmental Review will be forwarded by the Shire of Wanneroo to the Environmental Protection Authority (EPA) for independent evaluation and assessment under the provisions of the Environmental Protection Act.

Following the advertising period all submissions will be considered and summarised. The Shire of Wanneroo will respond to submissions and then the EPA will then evaluate the potential impact of the proposed rezoning and release an assessment report. If the proposed rezoning is considered acceptable, the Minister for the Environment may apply environmental conditions to the Amendment in order to minimise the impact on the environment before granting approval for the proposed rezoning.

The general process for consideration and determination of Metropolitan Region Scheme and Local Authority Amendments together with the process for determination of submissions on this Environmental Review is shown in Figure 3.

Advice on how to prepare a submission on the Environmental Review is provided at the beginning of this report.

1.4 Scope of this Environmental Review

The EPA issued final instructions for the preparation of this Environmental Review on 11 March 1999. A copy of the table of environmental factors is contained in Appendix 1. The instructions outline the environmental issues or key factors that the EPA was identified as relevant to the proposed amendment to the Shire of Wanneroo TPS Amendment No. 837. These include Terrestrial Flora, Terrestrial Fauna, Wetlands, Groundwater, Land (karst), Groundwater (quality and quantity), and Culture and Heritage. This report provides information regarding these key environmental issues so that the potential impact of the proposed rezoning can be assessed.

The format of this report is based on that recommended by the EPA in its instructions.

1.5 Land Development Process

Amendment 837 to the Shire of Wanneroo Town Planning Scheme No. 1 will, if approved, rezone the land from "Rural" to "Rural Community".

Following Ministerial Approval, future developers will be required to obtain approvals to subdivide from the Western Australian Planning Commission (WAPC) before proceeding to develop. The application will be referred by the WAPC to the relevant local authority (in this instance the Shire of Wanneroo) and service authorities for comment. Future subdivision proposals are assessed against the requirements of the approved district scheme and, if approved, may be subject to a range of conditions.

Subdivision works may commence following issue of the necessary approvals. The developer is required to ensure that all conditions have been fulfilled prior to seeking approval of the survey diagram required by the Titles Office for preparation of Titles to the subdivided lots. Normally, the developer obtains a letter of verification from the relevant agencies that the respective conditions have been fulfilled. The letters and survey diagram are submitted to the WAPC for clearance prior to Titles being prepared and issued.

Once the subdivision has been completed, a developer wishing to build on a subdivided lot requires both development approval and a building license from the local authority. If granted, the development approval and building licence will be subject to conditions to be fulfilled during the construction phase before the local authority can certify completion of the development.

2. PROJECT DESCRIPTION

2.1 Site Plan and Siteworks

The new proposed zoning "Rural Community" has been created specifically for the development of this site.

The new zoning does not require the development of a structure plan prior to zoning proceeding and is intended to provide for a flexible development within a range of specific planning and environmental controls which will ensure that any development, when it proceeds, is consistent with modern environmental and planning practice.

The zoning allows for either conventional special rural lots, cluster development or a hybrid of both types of development. Cluster subdivision generally permits the same lot yield as conventional subdivision in the form of a series of villages or nodes with the major portion of the site remaining in common ownership. Lot sizes are necessarily smaller, say 2,000m^2 to 4,000m^2, and the common land is collectively owned and managed by the village landowners. The size and location of lots is subject to land capability assessments and site analysis.

In addition, it is envisaged that a range of low impact land uses which are compatible with the rural nature of land may take place on the property. The types of land use under consideration are:

- boutique viticulture or horticultural developments based on small, low intensity developments and organic management principles; or

- cottage industry activities such as pottery or woodcrafts.

This environmental review proposes a flexible approach to the establishment of these additional land uses rather than providing a specific list of proposed land uses.

In view of the flexibility available for future land use on the site, the environmental review provides a number of planning and environmental principles which must be met when designing the development and offers a management framework that will ensure that all future developments other than the residential are subject to thorough review by the regulatory authorities.

2.2 Planning Principles

2.2.1 Overview

It is intended that the scheme provisions associated with the zoning will ensure that development accords with the rural nature of the zone.

The scheme will incorporate requirements that:

- minimise clearing of vegetation and impacts on vegetation;

- ensure that buildings and structures are designed to blend with the landform;
- agricultural industries are compatible with the capability of the land and account for the presence of residential areas;
- cottage or craft based industries are sited so that traffic, noise and other impacts are minimised for other residents;
- densities for conventional developments are based on a yield of 255 lots while cluster development would yield 300 lots; and
- building envelopes will be set back along Breakwater Drive to maintain the rural character of the viewscape.

The management framework to ensure these principles are met is described in subsequent sections.

2.2.2 Access and Roads

The Yanchep Structure Plan adopted by the DPUD (DPUD, 1993) includes proposals for a primary road network which includes a district distributor and road link between the existing Two Rocks town site and Wanneroo Road. This link comprises sections of roads referred to in the Structure Plan as Sunset Drive, Marmion Avenue and Caves Road with the latter being located through the area of the proposed Rural Community. This road has now been built (Figure 2) and is called Breakwater Drive.

The western and eastern boundaries of the proposed development comprise the proposed dual use path on the western side and the reserve for the extension of the Mitchell Freeway on the eastern side. It is envisaged that Breakwater Drive will intersect at grade with the freeway which would provide regional access to the development in the longer term. In the short to medium term, access to the development is provided via the Breakwater Drive connection from the existing Wanneroo Road.

All roads within the proposed development would be designed and constructed to an appropriate rural standard required by the Shire of Wanneroo. Accessways, constructed with an unsealed crushed limestone pavement, would provide vehicle access along battle axe lot legs and would form part of the strategic fire break/escape system within the development.

2.2.3 Public Utility Services

The proposed development would be serviced with both electricity and telephone supplies. Preliminary discussions have been held with Western Power and Telstra to discuss strategies for the implementation of these services.

Sewerage of special rural development would be via Aerobic Treatment Units (ATUs) or modified septic tanks or package sewage treatment plant. This is discussed in more detail in Section 3.3.1 of this report. The depth to groundwater within the area is 10m

to 40m, which will ensure adequate percolation and nutrient filtering of any wastewater overflow through the soil profile (refer to Section 3.3.1). If cluster development is pursued, the installation of small package sewage treatment units may be feasible.

Electricity supply would be provided via a connection from the existing overhead 22KV line which links the Two Rocks town site to an existing electricity supply line in Wanneroo Road. The existing line runs east from Two Rocks and is located through the southern part of the proposed Rural Community. As part of the development, the line would either be relocated into a new road reserve or retained on its existing alignment, within an easement through the rural lots. Electricity supply through the Rural Community would be within road reserves and via a reticulated system of overhead high voltage lines with transformers to provide low voltage connections for residences.

Telephone supply would be provided via the extension of the existing optic fibre cables (OFC) in Wanneroo Road, north of Yanchep Beach Road, or via the extension of the existing OFC eastwards from Two Rocks. In either case, the cables would be located within the primary road reserves. Reticulation within the development would comprise underground copper cables linked to the OFC via a remote integrated multiplexer.

Water supply will be reticulated to all lots from one or more borefields. Management of the Water Supply Scheme is currently being resolved with the Office of Water Regulation.

The borefield for water supply will be sited and designed to minimise drawdowns within areas of karstic landform. The final location and impacts will be described in the Drainage and Nutrient Water Management Plan for the site. This plan will be reviewed by relevant government agencies.

The Rural Community site is within the Yanchep Underground Water Pollution Control Area (UWPCA) and a Priority 3 Groundwater Source Protection Area as defined by the Water Authority of Western Australia. This is the lowest category for source protection and should not place any constraints on the Rural Community (refer to Section 3.3.1).

2.2.4 Regional Open Space (Parks and Recreation)

The 1991 Structure Plan (refer Section 2.1) recognises the open space spine shown on the Department of Planning & Urban Development's Yanchep Structure Plan contains an open space spine linking the Yanchep National Park to the Wilbinga Crown Land to the north (Figure 2).

The proposed extension of the National Park through the site encompasses mostly undisturbed native vegetation, and is based predominantly on the regional geomorphological feature known as the inter-barrier depression.

The Yanchep Structure Plan acknowledges however, that not all of the north-eastern corner of the area is required for regional open space. The proposed regional open space spine therefore isolates a significant portion of land (around 500ha) from the proposed Two Rocks-Yanchep community.

The proposed regional open space spine or link will, however, present opportunities to the residents for the Rural Community. In particular, it will create an effective physical and visual buffer from the more intense proposed urban development to the west, essential for the promotion of rural feel and character within the development.

Residents of the Rural Community site will also benefit from the visual appeal of the proposed regional open space link, enjoying views and vistas across the landscape. In addition, with it its aesthetic qualities, the regional open space spine may provide opportunities for active recreational pursuits such as bush walking or other similar activities.

The isolation of the Rural Community is completed by the reconfiguration of the System 6 Reserve M1 to include the Wilbinga Crown Land, combining the Caraban (System 6 Area C12) immediately to the north and the State Forest and proposed extension of the Mitchell Freeway to the east. In addition, the Perth Bushplan recognises bushland on all sides of the Amendment area as being bushplan sites with regionally significant bushland. The isolation of the Amendment area is seen as an ideal opportunity to promote a strong feeling of community and identity amongst the future residents of this area. It also provides an opportunity for a low intensity land use compatible with the surrounding land uses and contributes to the openness of the general area.

2.2.5 Fire Control Facilities

Fire control facilities will be incorporated into the proposed development to meet the requirements of the Bush Fires Board of WA and the Shire of Wanneroo.

In general, this would include clearing of fire breaks along the external site boundaries and the construction of limestone accessways between roadways to provide access for fire tenders and other vehicles. Where possible, east/west aligned roads will be avoided as these are not as effective as fire breaks. Fires are often wind driven and because prevailing winds in the region are generally easterly or south-westerly, north/south orientated roads provide better fire breaks. Eight metre wide "bridle paths" throughout the estate will act as very effective fire breaks and accessways for firefighters.

A water supply for fire fighting use will also be provided as part of the development. In general, this would comprise a groundwater bore supply to a storage tank located on a hardstand area adjacent to a roadway. Typically water storage of 25,000 litres will be provided for 50 residences and located in a manner to enable a 20 minute turnaround time for fire fighting vehicles. Buildings on the development will be sited, designed and landscaped to resist fire, and include a firefighting capacity.

2.3 Environmental Management Principles

Prior to a detailed subdivision being prepared a local structure plan will be prepared. The local structure plan and subdivision concept will be designed in accordance with sound environmental management principles. The main principles that will guide the development will be:

- clearing of vegetation should be minimised as far as possible;
- agricultural activities will be sited, designed and operated in order to minimise the need for clearing of vegetation and minimise impacts on groundwater and stygofauna;
- development will occur in a manner which does not impact on karstic landform or stygofauna;
- groundwater extraction will be controlled to prevent significant drawdowns within karstic areas;
- effluent disposal and agricultural activities will occur in a manner which prevents adverse impacts on groundwater quality from nutrients or chemicals;
- impacts on groundwater level, groundwater quality will be monitored for a period following development to ensure management controls are effective;
- land uses on the site will be planned to prevent conflicts between residential and other land uses; and
- where possible, Tuart trees will be preserved or replanted in order to preserve the habitat for stygofauna.

These principles will be implemented through a management framework incorporated in the scheme provisions associated with the development.

2.4 Management Framework for Implementing Planning and Environmental Management Principles

The scheme provisions incorporate a management framework which allows the State agencies to provide detailed comment on the development at appropriate stages.

It is proposed that the scheme will require the following to be completed and assessed by relevant agencies:

- a Vegetation Management Plan;
- a Drainage, Nutrient and Water Management Plan;
- a detailed program for geotechnical investigations; and
- an Aboriginal Heritage Management Plan.

In addition, any proposal for agricultural or horticultural development other than those conducted on a conventional lot will be required to demonstrate conformance with the overall Drainage, Nutrient and Water Management Plan before they can be approved. Provisions will be included in the scheme to address this requirement.

This framework will ensure that the potential environmental impacts is successfully managed through the planning assessment process. The planning principles outlined in Section 2.2 will be enforced through a range of tools including:

- Local Structure Plan;
- review of the subdivision plans; and
- restrictions on titles which constrain the nature of developments and positioning of building envelopes.

3. EXISTING ENVIRONMENT, IMPACTS AND MANAGEMENT

3.1 Introduction

The Environmental Protection Authority (EPA), in its instructions for this Environmental Review, specified several environmental factors which it considers are particularly important for its assessment of the proposed Amendment. Relevant environmental factors are defined as those which potentially have significant environmental impacts, and form the principal basis of the EPA assessment report to the Minister for the Environment.

The discussion of potential environmental implications of the Amendment presented in this section of the Environmental Review, addresses each of the relevant key factors. For each factor, the EPA objective and a description and analysis of the environmental implications associated with the Amendment are provided. This is followed by a description of how the Amendment will incorporate provisions for environmental management where appropriate.

3.2 Biophysical

3.2.1 Vegetation Communities

EPA Objective

Maintain the abundance, species diversity, geographic distribution and productivity of vegetation communities.

Existing Environment

The property contains the vegetation system known as the Spearwood system which includes the vegetation of the Spearwood dunes. The vegetation survey of Tokyu Corporation's Yanchep property (Alan Tingay and Associates, 1992b) identified the Spearwood system as Alliance D consisting of three types known as D1, D2 and D3 (Figure 4). These can be summarised as follows:

- Alliance D- sand over limestone vegetation
- Type D1 *Banksia attenuata* (Banksia low Woodland)
- Type D2 *Eucalyptus marginata/ Eucalyptus decipiens* (Jarrah Woodland)
- Type D3 *Eucalyptus gomphocephala* (Tuart Woodland)

The methodology of the flora survey (extracted from Alan Tingay and Associates, 1992b), is contained Appendix 2. In relation to vegetation condition, the subject land has been classified largely (approximately 95%) as a degraded area (Alan Tingay and Associates, 1992b), refer to Figure 5. A degraded area is defined as an area that is completely, or almost completely, without native species in the structure of the vegetation. It includes areas that are parkland cleared with their flora comprising weed or crop species with isolated native trees or shrubs. The property once supported a Tuart Woodland vegetation community. A corridor of slightly disturbed

vegetation runs along the western boundary of Lot 201, adjacent to the ROS (Refer to Figure 5). There are two small areas of vegetation classified as "obvious disturbance" in the north western and eastern corners of the site and two centrally located stands of trees classified as "disturbed".

The vegetation on the subject land has been predominantly cleared with scattered Tuarts remaining. The site however, accommodates three remaining significant stands of trees, two of which are isolated stand of Jarrah (Figures 4 and 5, classified as disturbed). The other stand is a grove of Tuarts (classified as disturbed), just south of the Jarrah stands (Alan Tingay and Associates, 1992b). Most of the Tuart woodland on the property has had its entire understorey cleared for grazing and cropping and remains in a parkland state with a reduced Tuart tree density.

No declared rare or priority flora were identified on the property during the Yanchep-Two Rocks area vegetation survey in 1991 (Alan Tingay and Associates, 1992b).

In the Yanchep region there are a series of conservation reserves, namely Yanchep National Park, Caraban Management Priority Area (MPA) and Ridges MPA (Figure 6). These substantially consist of flora and vegetation of the Spearwood dunes (Alan Tingay and Associates, 1992b). The location of Bushplan sites with regionally significant bushland is shown in Figure 7.

The vegetation communities and the condition of the vegetation in the Yanchep-Two Rocks area and adjacent land are shown in Figures 4 and 5. The information presented is based on information contained in Alan Tingay & Associates, 1992a; Trudgen, 1990; and CALM, 1989. The vegetation condition scale used includes Undisturbed, Slight Disturbance, Disturbed, Obvious Disturbance, Severe Disturbance and Degraded. These categories are described in more detail in Appendix 3.

The vegetation survey results suggest no community types listed as Threatened Ecological Communities (English and Blyth, 1997) occur within the Amendment area.

Conservation Status

High quality vegetation within the region is located in areas adjacent to the Amendment area. These areas are either already reserved for conservation or are designated for reservation under the MRS and are currently being considered for inclusion in the draft Bushplan for Perth. The draft Bushplan is a Government report that has identified areas of land of regional conservation value on the Swan Coastal Plain within the Perth Metropolitan Region. The extent of land nominated under bushplan as sites with regionally significant bushland is depicted in Figure 7.

The areas currently vested with CALM/National Parks & Nature Conservation Agency (NPNCA) or designated for reservation as "Parks and Recreation" under the MRS immediately adjacent or close to the Amendment area support several representative vegetation types, the closest to the amendment area are:

- Immediately adjoining the north-eastern section of the Amendment area linking Yanchep National Park with vegetation to the north at Wilbinga is a large block of high quality *Banksia*, Tuart and Limestone Heath vegetation which is reserved as Parks and Recreation in the MRS.

- A large area of Slightly Disturbed vegetation comprising several vegetation types including Limestone Heath and Sand over Limestone vegetation types is reserved as Regional Open Space to the south of the area, adjoining Eglinton North.

- The Wilbinga area, which is proposed for conservation, contains most of the vegetation types of the Quindalup and Spearwood Dunes in this particular region. A notable exception is the lack of Tuart and Jarrah Woodlands at Wilbinga. The Old Quindalup Dune Heath alliance is extensive near the coast with small areas of Young Quindalup Dune Heath alliance. The Limestone Heath alliance is very extensive throughout the area whilst the Sand over Limestone alliance is less extensive and limited to large pockets of *Banksia* Woodland type. Most of the vegetation is Undisturbed or Slightly Disturbed.

- The Caraban Management Priority Area (MPA) lies immediately to the east of Wilbinga and immediately to the north of the Amendment area. The most extensive vegetation in this MPA is the Sand over Limestone alliance, most of which is *Banksia* Woodland type with a relatively small area of Tuart Woodland. There is also a large area of Limestone Heath alliance and some Old Quindalup Dune Heath. The vegetation is all Undisturbed or Slightly Disturbed.

- Yanchep National Park chiefly comprises Tamala Limestone and Sand over Limestone soils and the corresponding vegetation alliances. In particular, it contains extensive areas of the Sand over Limestone vegetation alliance with large areas of both *Banksia* Woodland and Tuart Woodland types. There is also a substantial area of Limestone Heath, wetland vegetation and a small area of Old Quindalup Dune Heath alliance. All of the vegetation is considered to be in Slightly Disturbed or Undisturbed condition.

- Ridges MPA is located in State Forest immediately east of Yanchep National Park. The EPA in its System 6 Study recommends this area (Area M4) as an addition to the existing National Park. The area predominantly supports vegetation types that are limited in occurrence within the Park itself. The most extensive vegetation in this MPA is the Sand over Limestone vegetation alliance, particularly Jarrah and *Banksia* woodland types. Vegetation in this area is considered to be in Undisturbed condition.

Potential Impacts

As outlined above the subject land is largely classified as degraded with respect to vegetation and consists of areas that are predominantly parkland cleared with their flora comprising weed or crop species with isolated native trees or shrubs. Development on the property however, has the potential to impact directly on the

remaining Tuart and Jarrah stands and remnant vegetation within the area (including the north eastern and north western areas of Lot 201) and indirectly on the adjacent Parks and Recreation areas as a result of increase population.

The potential impacts on vegetation in the adjacent Parks and Recreation areas include recreational activities, intrusion by domestic pets, weed invasion, an increase in the frequency of fires, litter, rubbish dumping, removal of firewood and the use of nutrients and pesticides from rural landuses.

Proposed Management

It is proposed that building envelopes be identified to protect existing remnant vegetation. Any agricultural activities will be restricted to "degraded" areas where minimum clearing of vegetation is required. Figure 8 provides an indication of areas which are prospective for agricultural activities. In addition, the vegetation will be protected by sensitive road alignments and their incorporation into either community titles or larger lots (Richard Pawluk and Associates, 1993).

It is also proposed that environmental management provisions be included within the scheme to specifically identify locally significant areas of vegetation on the property and demonstrate that subdivision plans comply with a general policy of vegetation management and retention (refer to Section 4). The Yanchep Structure Plan provides significant guidance as to the layout of future developments and the need to preserve locally significant areas of vegetation. It should be noted however, that the removal of a small number of isolated Tuart and other trees will be necessary. This will not effect the overall conservation status of the area as all three "significant" stands of vegetation will be retained. In addition, it is proposed that for every native tree for which removal is required, a native sapling will be planted.

Siteworks for the development of the proposed Rural Community would be limited to only those works required to clear and construct the roads and associated drainage facilities, for firebreaks and fire escapes, etc. In all cases the extent of these works will be designed to ensure minimum disturbance for the required design standards and to maximise the retention of existing vegetation. This process will be enacted through the Vegetation Management Plan as stipulated in Section 4 of this report.

The management of the adjacent Parks and Recreation areas is, or will be, the responsibility of the agencies in which the reserves are vested. In most, if not all cases, these agencies are the National Parks and Nature Conservation Authority (NPNCA) and the Department of Conservation and Land Management (CALM). Nevertheless, it is important that the TPS include provisions which will enable these agencies to have appropriate input to future planning decisions which may impact on the areas for which they are responsible.

Matters of likely interest to these agencies are potentially diverse and include the delineation and treatment of boundaries between the Rural Community and Parks and Recreation areas, provision of recreation opportunities, exclusion of weeds, fire management, and so on.

In order to provide a statutory basis for these inputs, it is proposed that the TPS require developers to comply with the requirements of relevant management agencies with respect to the delineation of boundaries and fencing, access, signage, and fire management.

The fire management controls for the site are discussed in Section 2.2.5 of this report.

Proposed Outcome

The proposed planning provisions will protect the trees from clearance and ensure that the large healthy trees are retained. Although the removal of a small number of isolated Tuart and other trees may be necessary, this will not effect the overall conservation status of the area as all three "significant" stands of vegetation will be retained.

Planning Controls will ensure that the nature of development adjacent to regionally significant vegetation in reserves is compatible with the conservation status of these reserves and is undertaken in accordance with the requirements of the agency responsible for management of the reserves.

Proposed Scheme Provisions to Implement Management Strategy

The following Scheme Provision is proposed to manage impacts associated with vegetation and flora:

Vegetation Management Plan

The subdivider shall prepare a Vegetation Management Plan at LSP stage, to ensure the long-term viability of remnant vegetation that may be affected directly or indirectly by development of the subject lots to the requirements of Council with the concurrence of the DEP and CALM.
This plan shall include:

- Description of vegetation and vegetation values.
- Retention of significant areas of vegetation on the property.
- Retention of mature trees and all three significant stands of trees except where utilities such as roads or construction of buildings is necessary or in those areas identified as prospective for small scale agricultural activities.
- Isolation from the adjacent Parks and Recreation areas to the satisfaction of relevant State Agencies and will include opportunities for firebreaks, bridle paths and fencing as required.
- Management arrangements for the keeping of horses which will address soil and vegetation protection. Restrictions on the keeping of horses to a rate of one horse per lot on conventional lots. In cluster subdivision, horses may only be kept on common land and not on individual lots.

- Clear delineation of significant tree stands through use of dual use paths, roads and the like.

- Details on site maintenance arrangements - including weed control.

- Allocation of responsibilities and identification of timing for the implementation of the Vegetation Management Plan.

3.2.2 Declared Rare & Priority Flora

EPA Objective

Protect Declared Rare and Priority Flora, consistent with the provisions of the Wildlife Conservation Act, 1950.

Existing Environment

A flora survey of the Yanchep-Two Rocks area in 1991 identified one Declared Rare Flora (DRF) species (Alan Tingay & Associates, 1992b). *Eucalyptus argutifolia* is protected under the provisions of the *Wildlife Conservation Act, 1950.* A specialist botanist was contracted to search for these plants (Alan Tingay & Associates, 1992b). No DRF species are located on Lots 201 and 202. Two discrete populations of *Eucalyptus argutifolia* occur in to the west of the property (Figure 5). The largest population consists of about 45 mallees up to 4m tall. The second population supports about 19 mallees to 1.5m tall and occurs on the slope of a limestone hill. This species is typically associated with, and generally restricted to, areas of limestone.

The two previously unknown populations of *Eucalyptus argutifolia* recorded during the 1991 survey represented a significant addition to the known populations of this Declared Rare species at the time. These populations occur beyond the boundaries of the Amendment area within an adjacent area designated for reservation under the MRS. The Wildlife Conservation Act, 1950 requires the protection of Declared Rare Flora such as *Eucalyptus argutifolia* unless specific exemption is granted.

There is potential for less disturbed areas of remnant vegetation in surrounding areas and reserves to support other Declared Rare and/or Priority species. Much of the adjoining area is identified as Parks and Recreation reserves under the MRS or is already reserved and vested with CALM.

Potential Impacts

The potential impacts on rare flora are associated with indirect effects of the increase in human population in the area. This will create a greater potential for disturbance.

Proposed Management

Provisions for consultation within the TPS Amendment will enable CALM to determine the implications of proposed developments on Declared Rare Flora in the adjacent reserves and to implement appropriate management measures.

Proposed Outcome

Rare and endangered species will be protected in existing reserves adjacent to the development.

Proposed Scheme Provisions to Implement Management Strategy

The scheme provisions for vegetation described in Section 3.2.1 will provide for the protection of rare and endangered flora species.

3.2.3 Stygofauna and Troglobitic Fauna

EPA Objective

i) Ensure that stygofauna and troglobitic fauna are adequately protected, in accordance with the Wildlife Conservation Act, 1950; and

ii) Maintain the abundance, diversity and geographical distribution of stygofauna and troglobitic fauna.

Existing Environment

Troglobitic fauna is fauna that is restricted to living in caves. Stygofauna is a sub-set of troglobitic fauna and refers to aquatic troglobytes. It is considered that stygofauna, as a subset of troglobitic fauna, are likely to be the most sensitive to environmental disturbance (Brenton Knott, pers. comm.). Hence for the balance of this report the issues relating to stygofauna and troglobitic fauna will be analysed with respect to stygofauna. However, clearly management for stygofauna can be taken to include for the management of troglobitic fauna.

Studies of the stygofauna and troglobitic fauna in Yanchep National Park have been undertaken by Jasinska *et al.* (1996), Jasinska and Knott (1991) and Jasinska (1990). These studies found abundant and diverse stygofauna communities occur in the root mats of overlying Tuart Woodlands and in the underground streams that intersect karst formations in the Yanchep National Park area.

An assessment of the subterranean fauna of Lots 201 and 202 Breakwater Drive was undertaken by Dr Brenton Knott (UWA Department of Zoology) and Neil Beckingham (Alan Tingay & Associates), refer to Appendix 3. The following information is summarised from this study.

Lots 201 and 202 Breakwater Drive lie to the north of Yanchep National Park. In contrast to Yanchep National Park, there is no direct exposure of surface water. Although subterranean aquifer water of the Gnangara Mound might reasonably by expected to have radial flow, ie. directly towards the Indian Ocean, local inhomogeneities of the geological strata combined with local topographic features may well result in some subterranean connectivity with the subterranean waters of Yanchep National Park. Consequently, an investigation was conducted to determine whether some of the Yanchep aquatic cavernicoles occurred in subterranean waters

under Lots 201/202. In and about Yanchep National Park are five caves with active epiphreatic streams, streams which typically occur at the boundary between the Tamala Limestone and the underlying Bassendean sands. Epiphreatic streams occur on the water table and form when the flow rate increases due to steep gradients in the water table. The epiphreatic streams are shallow (ca 11m depth from ground surface) and lined with tree root mats which constitute a reliable food source for subterranean creatures. This food supply, together with connection between many of the cave streams and surface water, are probably the two main factors for the diversity of aquatic cave dwelling animals at Yanchep, with 41 species in a 20m stretch of epiphreatic stream in Cabaret Cave (YN 30) (Jasinska *et al.*, 1996), and a total of 98 species (not including rotifers) from the five cave streams (Jasinska, E.J., 1997).

Jasinska (1997) identified five factors that control the development of tree root mats:

1. Presence of trees above caves. Root mats in Australia are related to a number of species of trees, including *Eucalyptus gomphocephala*, *Casuarina* spp., *Corymbia calophylla, Agonis flexuosa* and *Ficus* spp.

2. Cavernous rock with fissures or solution channels, ie. rock penetrable by roots.

3. Depth to cave waters of <30m, reflecting the limit to which tree roots can penetrate substrates.

4. Arid conditions in the cave atmosphere and soil above the cave for extended periods of the year.

5. Permanent streams or pools in caves.

With respect to the connections between surface and subterranean waters, Jasinska (1997) recognised six sources of the cavernicoles at Yanchep: (1) interstitial groundwater species, (2) aquatic epigean species representing burrow and other commensals, benthic and planktonic open water highly mobile forms and aquatic forms that move across land, (3) epigean (surface water dwelling) species with terrestrial adult stages and aquatic larvae, (5) subterranean open water forms, and (6) moist litter and wet-soil dwellers. The importance of surface waters at Yanchep, for example Loch McNess and Yonderup Lake serving as conduits for possible colonisation of the underworld in the area is therefore, readily apparent.

Although Lots 201 and 202 have been cleared partially, good stands of eucalypt remain; there are some karstic features although nowhere near as well developed as at Yanchep; investigations have shown the water table is to be quite deep (greater than 10m over the site); there is no evidence to support the presence of subterranean streams or pools; there is no surface water whatsoever. One, possibly two caves were noted. Access was possible to the bottom of one cave. There were few roots and none extended to near the bottom of the cave. The base of the case was moist and there was some evidence of limited surface flow, presumably from the rainfall of the 20 March 1999, there was no stream or root mats. Another possible cave was identified as a hole leading from the cavern which was investigated. No attempt was made to

explore this cavern given the unstable and dangerous nature of the sediments. Given the conditions, limited subterranean fauna would be expected.

A sampling program of subterranean water, both on and surrounding the site, was undertaken (Appendix 4). In addition a limited drilling program was attempted on the property to sample for stygofauna. The drilling program however, was abandoned due to the ground conditions encountered (refer to Appendix 4).

The water sampling program demonstrated that stygofauna in the area were in low number and of low diversity. It failed to locate any root mat habitat in the cave present on the site. The study detected the presence of two species of stygofauna in the area. The stygofauna detected appear not restricted to root mat habitats.

Potential Impacts

Any lowering of the water table as a result of development has the potential to deprive stygofauna of water or result in the destruction of the root mat habitat favoured by stygofauna (Jasinska *et al.*, 1996). Any changes to groundwater quality as a result of development (such as inputs of nutrients and pesticides) may impact on the stygofauna. The destruction of remnant Tuart Woodlands would potentially result in a destruction of habitat.

The low density nature of the development and separation distance from the area where abundant stygofauna have previously been located (adjacent to Loch McNess), results in the very limited potential for external influences on the stygofauna in Yanchep National Park (Knott, pers. comm.).

Proposed Management

In order that potential effects on the limited stygofauna assemblage are mitigated, the following measures will be undertaken to ensure preservation of habitat. The three remaining stands of trees and the majority of scattered native trees will be retained which will preserve the potential primary habitat of stygofauna. In addition, no development will be permitted on areas of land immediately above karstic structures unless approved by a suitably qualified geotechnical consultant.

In order to minimise the potential effect on stygofauna with respect to water quality, the proposed development will utilise ATUs or modified septic systems or small package treatment plants (for cluster developments) for effluent disposal. The minimum quality of the output effluent will be set in the Drainage, Nutrient and Water Management Plan. This plan will comply as a minimum with the requirements of protection of groundwater for a Priority 3 Groundwater Protection Zone and will need to take into account placement of drainage with respect to potential effects on stygofauna. With respect to nutrients added in the areas used for rural activities, this will also be managed in accordance with a comprehensive Drainage, Nutrient and Water Management Plan to be developed as outlined in Section 3.3.1. The plan will be developed in conjunction with the relevant Government authorities (W & RC, DEP). Effluent output and nutrient additions is likely to follow the Environmental

Protection Authorities Guidelines for "Protection of Aquatic Ecosystems" (EPA, 1993) with a factoring for the likely nutrient absorption abilities of the soil profile.

An assessment of the impact of drawdown on the shallow aquifer was undertaken by Aquaterra (1999). A discussion of this study is presented in Section 3.2.6 and the report is included as Appendix 4. The results of the study demonstrated that, even in the worst case scenario, drawdowns could be restricted to less than 0.5m in potential stygofauna areas as long as production bores were sited at least 200m from high risk karst areas (refer to Section 3.2.6). This level of drawdown is considered acceptable in the context of the results of the stygofauna assessment undertaken on the site. The assessment indicated that the stygofauna are not restricted to root mat communities and hence are mobile in the aquifer. Brenton Knott (UWA Zoology) has provided comment that drawdowns of 0.5m would not affect the stygofauna assemblage (Knott, pers comm.). Problems associated with minor drawdowns in water table (eg. 5cm) are related to the specific situation of root mat habitats in karst wetlands. It should also be noted that seasonal fluctuations in water table across the site are likely to be greater than 0.5 m.

Proposed Outcome

Management measures and planning controls will minimise any potential impacts on stygofauna by ensuring appropriate development occurs in the vicinity of areas where there is a significant potential for stygofauna to exist.

Proposed Scheme Provisions to Implement Management Strategy

The following Scheme Provisions are proposed to manage impacts associated with Stygofauna (also refer to Section 3.2.6):

Karst Landform

To protect karst the subdivider shall prepare a Karst Management Strategy, at LSP stage, to the requirements of council on the advice of DEP, WRC and a geotechnical consultant to avoid development over high risk karst subject to further assessment by a geotechnical engineer and environmental scientist.

Detailed investigations in accordance with the programs described in Table 1 (attached Section 4) will be undertaken to determine the presence of large karst structures within the building envelopes on the property. Development will not be approved in areas or close to any location where large karstic structures are known or suspected to be present unless deemed acceptable by a qualified geotechnical engineer and environmental scientist. Development will also only be permitted where investigations indicate that structures can be safely erected.

Appropriate geotechnical investigations will be required in the areas which have been identified as within the zone where karstic features may potentially occur. It is recognised that the completion of the geotechnical investigations, staged as necessary, will be required prior to subdivision approval being granted. Preliminary Ground Penetrating Radar Work will be undertaken at Local

Structure Plan stage. Detailed investigations, including drilling, will take place where necessary prior to subdivision application stage.

3.2.4 Specially Protected (Threatened) Fauna

EPA Objective

Protect Threatened Fauna and Priority species and their habitats, consistent with the provisions of the Wildlife Conservation Act, 1950.

Existing Environment

A vertebrate fauna survey of the Yanchep-Two Rocks area, including areas not contained within the Amendment area, was conducted in 1991. The survey results together with survey information from surrounding areas and an assessment of the regional significance of the fauna present in the area are detailed in Alan Tingay & Associates (1991). A summary of the results is provided below.

The survey involved an intensive and systematic trapping program, transect surveys, active searching, night spotlighting and opportunistic observations. Bird surveys were carried over a four day period in winter and spring. Nightspotting was conducted over ten nights during September and October. Opportunistic results were recorded throughout the survey periods.

The trapping program included the use of Elliott, pitfall (pvc pipe and bucket) and cage traps and equipment for trapping bats. Traps were operated for four nights in September and five in October 1991. Bats were sampled near the entrance of a cave on the property for a four night period in September. Weather conditions during the trapping period were generally fine and sunny with clear nights except for one day when rain was recorded.

The survey identified four sampling localities which were considered representative of the remaining native vegetation in the study area and included areas subject to System 6 recommendations. Seven site were selected within these sampling localities for intensive and systematic tapping. The location of the sampling locations and trapping sites are presented in Appendix 5 with the results of the survey.

The survey revealed a relatively diverse, but generally typical fauna for the region. A total of 3 amphibians, 24 reptiles, 63 native and 3 introduced birds, and 6 native and 5 introduced mammals were recorded during the survey. The reptile assemblage comprised 3 species of Gecko, 5 species of Legless Lizard, 2 species of Dragon, 12 species of Skinks and 2 snake species. The list of species detected during the survey period and within each of the sampling localities is presented in Appendix 5.

The frog species detected on the property are considered common and widespread throughout much of the south west region of Western Australia. In general the site provides only limited value for most frogs because of their requirement for surface water for breeding. Most reptiles detected during the survey were recorded in low

numbers. This finding may be partly as a result of the relatively cool weather experienced during the survey period.

All of the native mammals recorded in the survey appeared to occur in relatively small numbers at the time of the survey except perhaps the Western Grey Kangaroo which was more abundant. Single individuals of the Honey Possum and Common Dunnart were recorded at only one sampling location, and the Western Brush Wallaby was seen infrequently.

A comparison of the fauna present within the major habitats indicated the woodland habitats generally seemed to support a larger number of species and larger populations than heathlands. The composition of the fauna in the woodland and the heaths, overlapped to some extent, but was noticeably distinctive.

The diversity recorded is related to the range of different habitats that remain in the area despite use of much of the land for agricultural purposes. The main habitats are the tracts of remnant vegetation and remaining stands of Tuart trees on pastureland. This vegetation is restricted particularly to the near coastal zone, the north-eastern sector, and the eastern sector adjacent to Yanchep National Park. Under the MRS, most of this vegetation will be retained in "Parks and Recreation" reserves. Retention of these areas will protect a wide range of the locally important fauna habitats.

In a regional context the vertebrate fauna in the Yanchep-Two Rocks study area is similar to that found elsewhere in the region within National Parks and Conservation Reserves, particularly Yanchep National Park. This park supports a range of wetland and terrestrial fauna habitats of high quality which host a diversity of animal species. Equivalent, but more extensive and considerably less disturbed near coastal habitats also occur at Wilbinga immediately north of the Yanchep-Two Rocks study area. The vertebrate fauna that occurs in coastal and inland heath at Yanchep-Two Rocks is likely to be present at Wilbinga and almost certainly in larger numbers

The avifauna of the property was typical of the region however, the record of the Australian Bustard in considered unusual. Two species listed "in need of special protection" under provision of the Wildlife Conservation Act, 1950 were recorded. These comprise the Short-Billed Black Cockatoo (or Carnaby's Cockatoo) (Schedule 1) and the Peregrine Falcon (Schedule 4).

It is expected that these species may be occasional visitors to habitats within the Amendment area. The Short-billed Black-Cockatoo typically migrates to the coastal regions during non-breeding periods and feeds commonly in *Banksia* and Eucalypt woodlands, and *Dryandra* heath.

The Peregrine Falcon is uncommon, although widespread throughout much of Australia excluding the extremely dry areas. It shows habitat preference for areas near cliffs along coastlines, rivers and ranges and within woodlands along watercourses and around lakes. Nesting sites include ledges along cliffs, granite outcrops and quarries, hollow trees near wetlands and old nests of other large bird species. This species predominantly preys and feeds on other birds.

Both of these species have been recorded in surrounding areas including Wilbinga and Yanchep National Park, or are expected to occur in areas of suitable habitat. Additional species of gazetted fauna may also be present in less disturbed habitats in these areas.

Potential Impacts

The clearing of vegetation for development could potentially remove some habitats for species listed as threatened, but the impact is unlikely to be significant given the extent of areas proposed for Parks and Recreation or Regional Open Space in the region, the current disturbed condition of the land within the Amendment area and the retention of the three remaining significant stands of trees and the highly mobile nature of the avifauna.

Proposed Management

The management provisions for vegetation described in Sections 3.2.1 will provide for the protection of associated fauna habitats.

Proposed Outcome

Significant and representative areas of habitat suitable for the identified Specially Protected (Threatened) Fauna will be retained in Parks and Recreation areas adjacent to the Amendment area, which link and adjoin State Forest and Yanchep National Park.

Proposed Scheme Provisions to Implement Management Strategy

The proposed scheme provisions for vegetation described in Section 3.2.1 will provide for the protection of associated fauna habitats.

3.2.5 Karst Wetlands

EPA Objective

Maintain the integrity, functions and environmental values of karst wetlands.

Existing Environment

Karst wetlands are formed where groundwater intersects karst.

The term 'karst' is used to describe landscapes that are commonly characterised by closed depressions (sinkholes), subterranean drainage and both horizontal and vertical caves. The term is applied to a geomorphic province as a whole, and not just to the characteristic features of the terrain. Factors contributing to karstic formation are geologic, pedologic (soil), climatic, topographic, hydrologic, biologic and temporal. The features exhibited by any particular karst are the product of a complex interplay of these factors.

The term "karst wetlands" is referred to in the Wetland Classification System (Commonwealth of Australia, 1996) as "inland, subterranean karst wetlands". Following discussions with the DEP it is understood that 'karst wetlands' are areas where groundwater intersect karst phenomena that support a stygofauna assemblage (Stacey Harley, pers. comm.).

There are three main aquifers underlying the site, the Tamala Limestone, the Leederville Formation, and the Yarragadee Formation. The Tamala Limestone aquifer is the shallowest and most productive aquifer in the area. It also underlies the entire project site and it is this aquifer that karst wetlands could occur. Water in the superficial aquifer is derived from direct recharge over the site (ie infiltration) or flows from the Gnangara Mound to the east, which is itself recharged by winter rainfall.

An assessment of the subterranean fauna was undertaken by Dr Brenton Knott (UWA Department of Zoology) and Neil Beckingham (Alan Tingay & Associates). The assessment included assessment boreholes on and adjacent to the site and exploration of the cave. The results of the study are summarised in Section 3.2.3 and presented in Appendix 3.

The study demonstrated that stygofauna in the area were in low number and of low diversity. The study detected the presence of two species of stygofauna in the area. Dr Knott provided comment that in the Yanchep National Park the connection between many of the cave streams and surface water is likely to be a causal factor for the "karst wetlands" found in the Yanchep National Park (Appendix 4). Hence the absence of any surface water in the amendment area significantly decreases the likelihood of Karst Wetlands being present. In addition the absence of any root mat habitat in the cave on the site and the particular stygofauna species discovered in the study indicated that the probability of karst wetlands on the site is low.

Potential Impacts

Any lowering of the water table as a result of development has the potential to deprive stygofauna of water or result in the destruction of the root mat habitat favoured by stygofauna (Jasinska *et al.*, 1996). Any changes to groundwater quality as a result of development may impact on the stygofauna and karst wetlands. However, the results of the stygofauna assessment indicate that limited stygofauna assemblage on the site are not confined to root mat habitats and hence are less susceptible to groundwater changes to stygofauna which are restricted to the root mat habitat (Knott, pers. comm.).

Proposed Management

The management provisions for stygofauna and troglobitic fauna described in Section 3.2.3 will provide for the protection of stygofauna and the management of vegetation (section 3.2.1) will also protect karst wetlands (root mat habitats) if they occur on the site.

Proposed Outcome

Management resources and planning controls will minimise any potential impacts on karst wetlands (if they occur) both on-site and off-site by ensuring appropriate development occurs on the property.

Proposed Scheme Provisions to Implement Management Strategy

The following Scheme Provisions are proposed to manage issues related to karst wetlands (also refer to Section 3.2.3 and 3.3):

Karst Landform

To protect karst the subdivider shall prepare a Karst Management Strategy, at LSP stage, to the requirements of council on the advice of DEP, WRC and a geotechnical consultant to avoid development over high risk karst subject to further assessment by a geotechnical engineer and environmental scientist.

Detailed investigations in accordance with the programs described in Table 1 (attached Section 4) will be undertaken to determine the presence of large karst structures within the building envelopes on the property. Development will not be approved in areas or close to any location where large karstic structures are known or suspected to be present unless deemed acceptable by a qualified geotechnical engineer and environmental scientist. Development will also only be permitted where investigations indicate that structures can be safely erected.

Appropriate geotechnical investigations will be required in the areas which have been identified as within the zone where karstic features may potentially occur. It is recognised that the completion of the geotechnical investigations, staged as necessary, will be required prior to subdivision approval being granted. Preliminary Ground Penetrating Radar Work will be undertaken at Local Structure Plan stage. Detailed investigations, including drilling, will take place where necessary prior to subdivision application stage.

3.2.6 Groundwater Quantity

EPA Objective

Maintain the quantity of groundwater so that existing and potential uses, including ecosystem maintenance, are protected.

Existing Environment

There are three main aquifers underlying the site, the Tamala Limestone, the Leederville Formation, and the Yarragadee Formation. The Tamala Limestone aquifer is the shallowest and most productive aquifer in the area. It also underlies the entire project site. Water in the superficial aquifer is derived from direct recharge over the site (ie infiltration) or flows from the Gnangara Mound to the east, which is itself recharged by winter rainfall. The Gnangara Mound is a large mound of

groundwater underlying the Swan Coastal Plain to the east of the study area. In terms of subterranean release, the mound lies some 20m to 50m above the level of the water table in the Tamala Limestone aquifer.

Throughflow of groundwater to the coast in the Tamala Limestone was estimated (by WAWA, 1990) to be 365ML/yr/km width (i.e. roughly north-south width, parallel to groundwater level contours). This estimate was based on an assumed average aquifer transmissivity which WAWA (1990) believed was lower than is actually the case. The estimated throughflow used in this report, then, should be considered to be conservative. The hardness (calcium carbonate concentration) of the water in this aquifer is about 220mg/L, and the salinity (TDS) is about 400mg/L (Alan Tingay & Associates, and Peck, 1991). Salt from the ocean intrudes into deeper parts of the aquifer near the coast.

The Water Corporation currently extracts water from the superficial aquifer from 8 production bores in the Yanchep-Two Rocks area. In 1991/92, 668ML/yr was pumped from these bores for public supply (Davidson, 1995). The Water Corporation also plans to utilise ground water from the superficial aquifer for residential water supply purposes at some time in the future. It is proposed that an estimated 1,200ML/yr from each kilometre of the coastline will be withdrawn from the superficial aquifer. This is considerably greater than the predicted current through flow in this area of 365ML/year from each kilometre, although this estimate is considered conservative.

The Water Corporation however, expects on the basis of experience that there will be a significant increase of recharge to ground water as a result of urban development of the Two Rocks-Yanchep area (runoff from the roofs, roads and other impermeable surfaces). The Water Corporation expects that this artificial recharge of the superficial aquifer in the Yanchep-Two Rocks area will increase gradually to at least 30% of rainfall. The Corporation predicts that total abstraction of all of this recharge plus 70% of the existing through flow will be acceptable.

Assuming an average rainfall of 800mm/yr over the Yanchep-Two Rocks area (7000ha), recharge should amount of about 17,000ML/yr (Alan Tingay & Associates and Peck, 1991). Part of the existing through flow will be a result of recharge from this area, but the through flow estimate is considered to be conservative. Therefore, the amount of through flow available for withdrawal is about 70% of 365ML/yr per kilometre over 10km, or about 2,600ML/yr, and the total amount of ground water available is about 196,000ML/yr, or about 1,960ML/yr from each kilometre along a north-south line through the area.

As the Water Corporation proposes to pump about 1,200ML/yr from each kilometre in the Yanchep-Two Rocks area, a resource of about 760ML/yr from each kilometre could be withdrawn for other purposes.

It is recognised that there may be demands for water supplies for irrigation of public open space and new golf courses in the Yanchep-Two Rocks area. The Water Corporation has indicated preference that these demands are met by pumping from the superficial formation rather than deeper confined aquifers.

Potential Impacts

An assessment of hydrogeological issues associated with the Rural Community development was undertaken by Aquaterra (1999). The results of this study are presented in full in Appendix 6 and summarised below.

Demand

Precise water demand figures are not available at this time as the actual development layout has not been finalised. However, demands have been estimated for two development scenarios based on available generic Water Corporation and Agriculture WA information. The two broad development scenarios considered are:

- Scenario 1: 200 special rural residential lots evenly distributed over the study area or in numerous "clusters" with open natural bushland in between. This equates to 1200kL/d (peak demand), 860kL/d (average summer) and 360kL/d average demand); and

- Scenario 2: 200 special rural residential lots with approximately 100ha under "boutique" agriculture (vines, olives etc..). This equates to 5200kL/d (peak demand), 4860kL/d (average summer) and 2360kL/d (average annual assuming 6 months irrigation per year).

Impact on Pumping on Regional Groundwater

The groundwater throughflow beneath the development area is conservatively estimated to be around 2,000ML/yr (based on a regional throughflow of 365ML/yr/km over the 5.5km aquifer width of the development area). Potential additional recharge over the development area (assuming 30% of average rainfall over the 400ha site) is estimated to be some 960ML/yr. The predicted average annual demand (Scenario 2) is only 860ML/yr (or 2,360kL/d). Even if there were no recharge at all over the development area (worse case scenario), the predicted demand is only some 43% of the conservatively estimated groundwater throughflow. WAWA (1990) envisaged that abstraction of up to 70% of throughflow in an area would be acceptable.

In simple water balance terms then, the proportion of the water demand that is actually made up from groundwater throughflow will be somewhere between nil and 43%. In practice, however, groundwater pumping may be from bores located on the up-gradient side of the development area. As such, pumping would be initially balanced by throughflow from the east, with the reduction in throughflow being made up (if only partially) by any recharge on the site. The net effect on groundwater throughflow beneath the western (outflow) side of the site would be the net difference between inflow, pumping and additional recharge.

The worse case scenario would mean that some 43% of the groundwater throughflow beneath the development site would be intercepted by pumping. This represents 24% of the total groundwater throughflow beneath the broader Yanchep-Two Rocks area (estimated to be 3,650ML/yr - WAWA, 1990). WAWA also estimated that, when

taking into account additional recharge over the future Yanchep-Two Rocks urban development, there would remain some 760ML/yr/km width of aquifer for other purposes, after development of a WAWA groundwater supply system.

Impact of Pumping on Study Area

A simple lumped parameter analytical groundwater model was used by Aquaterra (1999) to assess the likely drawdown impacts of pumping from within the study area. For this exercise, conservative estimates of aquifer parameters and theoretical maximum pumping rates were adopted, so that the results are very conservative.

An aquifer transmissivity of 1000m^2/d and storativity of 20% were adopted and it was assumed that pumping would be from five bores spaced at roughly 1km intervals in a line perpendicular to the groundwater flow paths (ie. roughly north-south line). Drawdowns were predicted at two lines parallel to and located 200m and 500m from the line of the bores in the wellfield.

The predicted drawdowns after six months pumping at the peak maximum demand (of 5200kL/d) only marginally exceeded 0.5m at several points on the 200m line (at no point was the predicted drawdown greater than 0.6m). At 500m distance from the line of bores, predicted drawdowns were all less than 0.4m.

The predicted drawdowns after one years pumping at the annual average of 2360kL/d are all less than 0.4m on the 200m line.

That is, the results indicate that, even for worst case pumping and conservative aquifer parameters, drawdowns in excess of 0.5m should be restricted to an area immediately adjacent to (within around 200m of) the line of the wellfield.

Proposed Management

The Aquaterra (1999) assessment indicated that, even in the worst case, drawdowns could be restricted to less than 0.5m in potential stygofauna areas as long as production bores were sited at least 200m from high risk karst areas. Utilising the information gained through the Karst Assessment (Section 3.2.7), it would appear possible to locate the bores in a line parallel to (and at least 200m to the east of) the northwest-southeast trending boundary between the low risk and very low risk areas. Alternately the bores could be located along most of the northern margin and along the eastern margin of Lot 201, and along the northern two thirds of the eastern margin of Lot 202.

Another possible option would be to locate the bores along the western margin of the study area (ie. western margins of the ROS along East Park Drive) if this area was accessible. The bores would be located in higher transmissivity aquifer material than in the eastern part of the study area, and drawdowns due to pumping would be much lower than predicted in the above assessment. Confirmation of the best location and layout of the borefield will require more detailed site investigation and numerical groundwater modelling. This will be undertaken during detailed studies as part of the Drainage, Nutrient and Water Management Plan.

Proposed Outcome

From the assessment undertaken it is apparent that the Rural Community development's water requirements are such that significant drawdown effects to the superficial aquifer are not expected. Protection of stygofauna habitat will be achieved by locating the borefield not directly over high risk karst areas.

Proposed Scheme Provisions to Implement Management Strategy

The following Scheme Provisions are proposed to manage impacts associated with groundwater quantity:

Drainage, Nutrient and Water Management Plan

The subdivider shall prepare a Drainage, Nutrient and Water Management Plan, at LSP stage, to the requirements of council on the advice of DEP, WRC and Water Corporation to ensure:

- Groundwater extraction bores are located in areas where drawdowns will not impact on areas of karst or potentially significant stygofauna habitats. In all cases however, the borefield will be located at least 200m from high risk karst areas to avoid any potential impacts on stygofauna;
- The rate, quantity and quality of wastewater infiltrating the amendment area is maintained at levels compliant with the minimum requirements of the protection of a Priority 3 Groundwater Source Protection Area;
- Provision of details on the size and location of groundwater extraction bores and predictions of the area of impact of these bores;
- Agricultural activities do not adversely impact on karstic zones in terms of water quality and quantity;
- Best practice Water Sensitive Urban Design principles are incorporated to maximise on-site water infiltration generally;
- Provide measures to facilitate the removal of pollutants and nutrients.
- The habitat of stygofauna is protected in respect of nutrient and groundwater levels.
- The plan will require utilisation of nutrient attenuating sewage disposal mechanisms.
- Ensure effluent disposal areas are not sited over areas rated as high risk for karst phenomena.
- Include a requirement to submit a report demonstrating compliance with the criteria on the Plan.

- Include contingency plans in the event that the criteria are temporarily not achieved.

Karst Landform

To protect karst the subdivider shall prepare a Karst Management Strategy, at LSP stage, to the requirements of council on the advice of DEP, WRC and a geotechnical consultant to avoid development over high risk karst subject to further assessment by a geotechnical engineer and environmental scientist.

Detailed investigations in accordance with the programs described in Table 1 (attached Section 4) will be undertaken to determine the presence of large karst structures within the building envelopes on the property. Development will not be approved in areas or close to any location where large karstic structures are known or suspected to be present unless deemed acceptable by a qualified geotechnical engineer and environmental scientist. Development will also only be permitted where investigations indicate that structures can be safely erected.

Appropriate geotechnical investigations will be required in the areas which have been identified as within the zone where karstic features may potentially occur. It is recognised that the completion of the geotechnical investigations, staged as necessary, will be required prior to subdivision approval being granted. Preliminary Ground Penetrating Radar Work will be undertaken at Local Structure Plan stage. Detailed investigations, including drilling, will take place where necessary prior to subdivision application stage.

3.2.7 Karst

EPA Objective

Maintain the environmental, scientific, cultural and recreational values of karst landforms.

Existing Environment

The term 'karst' is used to describe landscapes that are commonly characterised by closed depressions (sinkholes), subterranean drainage and both horizontal and vertical caves. The term is applied to a geomorphic province as a whole, and not just to the characteristic features of the terrain. Factors contributing to karstic formation are geologic, pedologic (soil), climatic, topographic, hydrologic, biologic and temporal. The features exhibited by any particular karst are the product of a complex interplay of these factors.

Karst landscapes are formed principally by the selective chemical dissolution of limestone, or some other relatively soluble rock, by the percolation and flow of ground waters (as opposed to surface flows). The groundwater seeps along fractures and other zones of weakness gradually creating sizeable passages. As this dissolution generally takes place beneath the ground it is not necessary that solution caves have entrances to the surface. The solubility of limestone is much enhanced if the waters

contain dissolved carbon dioxide. Water moving through the atmosphere and soil scavenges this carbon dioxide becoming more acidic and thus more efficient at dissolving limestone. Studies in temperate climates suggests that two thirds or more of the total limestone solution takes place at the soil rock interface where waters percolate through the soil into the rock mass (Hamilton–Smith *et al.*, 1998).

A study of the geology and geomorphology of the area involving an interpretation of aerial photography, a review of previous studies in the region and thorough field mapping validation, identified two types of suspected karstic structures in the Yanchep region (Alan Tingay and Associates,1992a). The first type of karstic structures are observed on the surface and comprise small cavities, fissures and solution pipes. These are considered to be the result of rainwater falling onto the outcropping Tamala Limestone and dissolving portions of the rock on its way to the groundwater table. The small-scale structures observed on the surface are not necessarily restricted to any particular zone or location and are considered to be characteristic of the entire Tamala limestone formation and not indicative of a zone of karstic phenomena.

The second type of karstic structures are massive collapse features, considered to result from solution by groundwater at depth. Mapping of large-scale collapse features indicates that these are confined to an interdunal depression within the Tamala Limestone. This depression represents a probable zone of karstic activity (Figure 9). Two types of massive collapse structures, caves and dolines are present.

A cave of significant size is present on the south-western edge of Lot 202 as shown in Figure 9. This feature has resulted from the creation of a cavity at depth which has subsequently collapsed to produce a cave nearer the surface. The cave is elongate and at least 30m deep and probably connected to other cavities.

A number of dolines, or surface expressions of a collapse at depth, are present in the karstic zone. One of these is active and has increased in size over a number of years. Other undetected dolines may occur in remnant bushland within the suspected karstic zone. Dolines develop most often where there is a veneer of loose soil over collapsing limestone with the soil flowing into cavities at depth. Conversely, dolines may not be present in areas of bare limestone even though subterranean cavities may have developed.

Following consultation with both Ministry for Planning (MFP) and the Department of Environmental Protection (DEP) it was agreed that a further appraisal of the karst terrain on Lots 201 and 202 Breakwater Drive should be made in addition to studies previously undertaken (Alan Tingay & Associates, 1998b) to assist in assessing the rezoning application Amendment 837.

The methodology of the karst study was discussed with both MFP and DEP. The agreed karst study comprised:

- aerial photographic interpretation by a qualified geologist;

- ground proofing by an qualified geologist and a qualified geotechnical engineer; and

- ground survey with Ground Probing Radar (GPR) at specific locations under the direction of a qualified geologist.

The results of the mapping and GPR work have been simplified into a map showing areas with a high risk of karst, medium risk of karst, low risk of karst and very low risk of karst (Figure 9). This map will aid developers to determine the degree of further investigation required in specific areas of the property. It should be noted that due to the 'overview' nature of this study that the zones delineated in Map 2 are of a probable nature only, and it is possible that karst phenomena may be present in areas defined as low or very low risk.

The categories are based on the following:

i) High Risk of Karst - valley floors of interdunal depressions within an area regionally associated with karstic phenomena. Dolines and caves are associated with these areas. Areas of outcrop are also included in this category. GPR results indicate medium to high likelihood of karst.

ii) Medium Risk of Karst - valley sides at interdunal depressions in area regionally associated with karst. GPR results indicate low to medium likelihood of karst.

iii) Low Risk of Karst - land located in the area surrounding areas at high and medium risk of karst. GPR results and landform generally indicate low risk of karst, though the area in the regional expression of karstic scenery.

iv) Very Low Risk of Karst - landform indicates very low risks of karst, and located outside the zone regionally associated with the karst scenery. GPR results indicate generally low likelihood of karst.

The complete study results are presented in Alan Tingay & Associates (1998b) and in summary form in the "Proposed Management" Section below.
The study indicated that high risk areas are generally confined to the valley floor areas on the south-western areas of the site and that these areas are localised.

On the basis of the study (Alan Tingay & Associates, 1998b), it appears that it would be possible to develop a subdivision plan based on either a conventional layout or cluster development within the constraints imposed by the presence of karst provided adequate geotechnical studies are performed (Alan Tingay & Associates, 1998b).

Potential Impacts

The presence of large karstic structures at a site has major implications for the land use and development of that site. The karstic caprock may constrain development, due to the widespread small cavities associated with the leaching of the limestone by surface waters. Also, structures of considerable size, close to the surface, would have significant development implications, from a geotechnical viewpoint. These

constraints will be related to the depth of the karstic structures where they are evident. Active use of such sites may be inappropriate as there is a potential for collapse or subsidence.

Stormwater run-off could also potentially impact on karstic structures, if infiltration is concentrated over subsurface collapse structures and washing sand down into cavities. A cluster development, such as option 2, can concentrate stormwater runoff, requiring the construction of a sump, which could exacerbate problems if located over karst.

Proposed Management

Following discussions with Shire of Wanneroo, it was decided that prior to subdivision and during the development of the LSP (after the rezoning process) further geotechnical work will be undertaken to more clearly define the boundaries of high and medium risk of karst phenomena. The nature and scope of this work will be determined through discussion with the Shire of Wanneroo, the DEP and qualified geotechnical consultant. The outcome of this work will be an acceptable LSP with respect to the issue of karst.

At the subdivision stage detailed investigations (probably based on drilling and Ground Probing Radar) will be undertaken to determine the presence of large karst structures within the building envelopes on the property. Development will not be approved in areas or close to any location where large karstic structures are known or suspected to be present. Development will also only be permitted where there is a low risk of impact on karstic structures. The results of the 1996 geotechnical study associated with the Two Rocks-Yanchep Road (Coffey Partners International, 1996) and the work undertaken by Alan Tingay & Associate (1998b) indicate that the avoiding karst structures on the subject land is easily achievable.

The following recommendations are based on the results of the field mapping and GPR work and address the future geotechnical assessments required on a risk basis.

As a general recommendation the running of a GPR survey will be substantially more efficient than a program of drilling. Once final approvals have been made and the land subdivided it is recommended that as a general practice, subdivisions that include areas at risk be resurveyed on a more detailed basis and the subsequent geotechnical investigation target particular anomalies detected by the GPR.

Further processing and interpretation of the GPR data is recommended prior to the locating of specific drilling targets within the Medium and Low risk areas. Existing interpretation has been limited both by budget and time.

Any future geotechnical work may result in a reassessment of the risk rating within a particular area or subdivision based on the additional information.

High Risk

Both the field mapping and GPR data imply the presence of active karstic features both at and below the surface in areas identified as high risk. These features are likely

to be highly unstable and able to be activated without warning as has happened at one doline on the property (Alan Tingay & Associates, 1998b). Future development on such areas would not be recommended, including the incorporation of such zones into the site drainage system. If specifically required to confirm ground conditions at a particular point, Solid Flight Augering or an alternative drilling method may be used. Given that these areas are active, some restriction of access may be required. Comment on the nature of restrictions is beyond the scope of this investigation.

It should be noted that, whilst unlikely, there is always potential for collapse in areas of karstic phenomena hence drill sites should be chosen with due care.

Medium Risk and Low Risk

Field mapping and GPR data implied absence or limited karst phenomena in areas identified as medium to low risk. These areas are therefore likely to be stable. It is recommended that a geotechnical engineer is directly involved in the placement of building lots, and that following building lot selection a geotechnical assessment of each building lot is defined. This geotechnical assessment will involve the drilling of more than one hole per lot for medium risk and at least one hole per lot for the low risk, and specific GPR survey work as required. Should building envelopes be placed over identified GPR anomalies, then drilling using Solid Flight Augering or an alternative drilling method is recommended. The drilling will allow the delineation of the possible impact of a void feature on future development options for a particular area.

Very Low Risk

Field mapping and GPR data implied absence or very limited karst phenomena and this area is outside the zone of regional expression of karstic scenery. These areas are therefore, highly likely to be stable. It is recommended that a geotechnical engineer is directly involved in placement of building lots, and that following building lot selection a geotechnical assessment of each building lot is defined, in accordance with AS2870.1996. This geotechnical work may involve specific GPR survey work, test pitting and use of a sand penetrometer.

Proposed Outcome

The presence of karst on the subject land precludes traditional urban development. However, the proposed Rural Community development is well suited to an area with potential for karst. This is primarily due to the capacity to move building envelopes to the areas of no karst and avoid areas of karst or probable karst.

Proposed Scheme Provisions to Implement Management Strategy

The following Scheme Provisions are proposed to manage issues related to karst:

Karst Landform

To protect karst the subdivider shall prepare a Karst Management Strategy, at LSP stage, to the requirements of council on the advice of DEP, WRC and a geotechnical consultant to avoid development over high risk karst subject to further assessment by a geotechnical engineer and environmental scientist.

Detailed investigations in accordance with the programs described in Table 1 (attached Section 4) will be undertaken to determine the presence of large karst structures within the building envelopes on the property. Development will not be approved in areas or close to any location where large karstic structures are known or suspected to be present unless deemed acceptable by a qualified geotechnical engineer and environmental scientist. Development will also only be permitted where investigations indicate that structures can be safely erected.

Appropriate geotechnical investigations will be required in the areas which have been identified as within the zone where karstic features may potentially occur. It is recognised that the completion of the geotechnical investigations, staged as necessary, will be required prior to subdivision approval being granted. Preliminary Ground Penetrating Radar Work will be undertaken at Local Structure Plan stage. Detailed investigations, including drilling, will take place where necessary prior to subdivision application stage.

3.3 Pollution Management

3.3.1 Groundwater Quality

EPA Objective

Maintain or improve the quality of groundwater to ensure that existing and potential uses, including ecosystem maintenance are protected, consistent with the draft WA Guidelines for Fresh and Marine Waters (EPA, 1993) and the NHMRC/ARMCANZ Australian Drinking Water Guidelines - National Water Quality Management Strategy.

Existing Environment

The depth to the water table is relatively large in the location of the Rural Community site, with depths between 10m and 40m depending on topographic elevation. Drilling associated with the placement of Breakwater Drive (Coffey Partners, 1996) indicted the water table in between Lots 201 and 202 was generally deeper than 20m. In the south-eastern portion of the subject land, it was stated in Alan Tingay & Associates (1992a) that the water table rises to a depth of 3m below ground level, just inside the Regional Open Space (ROS) "greenbelt". However a recent drilling program in the

south-west corner of Lot 202 indicated water table depths of 11m and 10m in topographic lows (Appendix 4).

The direction of the groundwater flow in the region is moving away from the Gnangara Mound towards the ocean. The subject land is within a Priority 3 groundwater source protection area. The Water Corporation currently draws water from the superficial aquifer for public supply and proposes to continue this practice in the future. Chemical analysis of water from existing production bores indicates the concentration of potential contaminants is within the range recommended by the relevant guidelines for drinking water (Alan Tingay & Associates, 1992a).

A Priority 3 source protection area is the lowest category for source protection and requires that developers minimise the risks of water pollution "as far as practicable". Priority 3 protection areas are catchments where other land use values predominate over water protection in land planning and management. In these source protection areas it is recognised that there is some risk of long term contamination of groundwater as a result of urbanisation, and that there may be a need for higher water treatment costs in the future. With regard to the proposed Rural Community, the following minimum requirements for developers for Priority 3 areas are applicable:

- Ensure that septic tank densities and locations in non-urban areas comply with Water Corporation and Water & Rivers Commission recommendations.

- Restriction of disposal sites for polluting wastes (sites with suitable location, construction, and management to ensure no significant pollution can occur, may be acceptable).

Potential Impacts

Groundwater under the Swan Coastal Plain is vulnerable to contamination due to the unconfined sand aquifer which allows rapid infiltration of surface runoff. A number of potential sources of contamination are associated with the Rural Community. Relevant examples include fertiliser application, pesticide use, waste disposal leachate, leakage of fuel and other stored chemicals and road runoff. In addition, the keeping of horses has the potential to contribute to annual nutrient loads.

Development within the Rural Community has moderate potential to result in surface runoff or discharges that contain contaminants that may adversely affect water quality of the superficial aquifer.

Proposed Management

Nutrient and Drainage Management

The risk of contamination of the groundwater beneath the subject land will be minimised by adopting water sensitive urban design guidelines, the sewage disposal methodology outlined below, and developing a Drainage, Nutrient and Water Management Plan. The guidelines have the objective of managing the water balance, maintaining water quality and encouraging water conservation. The plan will be

developed in conjunction with the relevant Government authorities (W & RC, DEP). Effluent output and nutrient additions is likely to follow the Environmental Protection Authorities Guidelines for "Protection of Aquatic Ecosystems" (EPA, 1993) with a factoring for the likely nutrient absorption abilities of the soil profile.

Effluent Disposal

Inappropriate effluent disposal on the subject land has the largest potential to increase nutrient loads into the superficial aquifer and affect stygofauna. It is therefore essential that the effluent disposal of the subject land is managed carefully. The proposed Rural Community is not sewered and waste could either be removed to septic tanks, treated using ATUs, modified septics or small package treatment plants. In order to overcome the limitations of the subject land with respect to water pollution via subsurface drainage, ATUs or a modified septic system or a small package treatment plants will be used within the subdivision. This commitment exceeds that required by a Priority 3 source protection area.

ATUs are the most widely used on-site alternatives to septic tanks. The basic unit consists of an optional pre-settling chamber, and aeration compartment and a secondary settling chamber. Raw sewage flows into the ATU and is subjected to artificial aeration to cause the formation of activated sludge. After final settling, the clarified liquid is usually released into some form of absorption system. ATUs differ from septic systems in that they involve the use of oxygen to sustain biological activity during waste treatment.

ATUs are capable of removing substantial quantities of BOD from wastewater, which is the amount of oxygen consumed by micro-organisms in the decomposition of wastes and suspended solids. Some ATUs are also capable of significantly reducing the number of pathogenic organisms within effluent, and providing for the nitrification of ammonia and precipitation of phosphates.

To maintain a high level of treatment, a large biomass must be sustained within the aeration tank. This is usually achieved by the return of biomass to the process by the recycling of a proportion or all of the settled solids back into the aeration tank following the final step. The degree of treatment of wastes and disposal of clarified water, varies between manufacturers. Some examples are:

- Biomax C200 system. This system removes up to 40% of nitrogen but insignificant amounts of phosphorus. Phosphorus is generally removed through soil amendment in the disposal area, eg placement of red mud gypsum in the disposal area.

- Taylor Clearwater 90. Similar in operation to the Biomax C200 but capable of handling smaller volumes of effluent.

- Aquarius 250FB. This system undertakes chemical and biological treatment of wastewater. Phosphate is removed through chemical precipitation. Nitrogen is removed through denitrification.

Another option for on-site effluent disposal is a modified standard septic system. The Ecomax is a conventional anaerobic septic tank/dual leach drain system modified by the inclusion of a filter bed to the leach drain. The filter physically absorbs and chemically reacts with nutrients and pathogens contained with the wastewater. While the filter bed remains active, treated wastewater from an Ecomax septic tank is effectively free of nutrients.

If the clustered development design is undertaken then it is likely the treatment of sewage would be best suited to a small package treatment plant, rather than for example, individual ATUs. A small package treatment plant would be based on the principles of an ATU or amended septic and would be required to achieve comparable results in effluent quality.

Stormwater Systems

Water conservation will be the main objective during drainage design to ensure maximise recharge to the groundwater system. In general, this would involve the incorporation of swales and contour banks within table drains to disperse drainage flows on to the adjacent lot areas where there is no risk of ponding of flooding. There will be considerable opportunity for this within the sandy areas of the land where infiltration rates will be high.

For road drainage it is proposed to use lateral table drains, designed to cater for runoff from up to a 1 in 10 year storm, 72 hour, event. Small pipe culverts would be provided to divert these flows under intersections.

Runoff from the roads which are likely to flow to low points will be diverted to soakage sumps and basins located within drainage reserves. All sump and basin sites will be located so as to avoid karstic features. The Drainage Plan will need to assess the need for any additional measures required for treatment of stormwater such as soil amendment.

Keeping of Horses

The potential for nutrient input and export from the keeping of horses is to be controlled primarily by limiting the number of horses allowed per lot. A limit to a rate of one horse per lot is proposed.

Typical quantity and composition of wastes from mature horses as adopted by the Water & Rivers Commission are:

- Wet manure — 0.23% nitrogen (N)
0.08% phosphorus (P)
- Urine — 0.9% N
0.02% P
- Daily waste quantities for mature horses of 15kg wet manure and 15 litres of urine.

- Annual output of 62kg nitrogen and 6kg phosphorus per horse.

The soils of the Spearwood Dune System have moderate potential to adsorb phosphorus (Mcpharlin, *et al.,* 1990). Based on moderate Phosphorus Retention Indices and a maximum application from horses (assuming up to 200 horses) of 24kgN/ha/yr and 2kgP/ha/yr, it is considered that the nett export of nitrogen and phosphorus resulting from horse agistment is negligible.

In addition, no account has been made for uptake of nutrients by vegetation (likely to be in the order of at least 20%) or volatilisation of urine-nitrogen as ammonia. The loss of nitrogen following surface application of urine to sandy or (especially) alkaline soils has been widely reported. For example, Watson & Lapins (1969) recorded more than 50% of nitrogen was lost from urine deposited on sandy soils.

Provisions relating to management of horses will be stipulated in the Drainage, Water and Nutrient Management Plan relating to the protection of groundwater quality. The standard Shire of Wanneroo management practices with respect to the keeping of horses will of courses also apply.

Nutrient Management Associated with Viticulture and Horticulture Use

The preparation of a Drainage, Nutrient and Water Management Plan forms part of the proposed scheme provisions for the Rural Community. However, a preliminary desktop review of the impacts and management of horticulture on the site has been undertaken for the purpose of this study (Appendix 7).

The desktop study (Appendix 7) suggests Lots 201 and 202 Breakwater Drive contains soils of the Spearwood Dune System. Land capability information relating to Lots 201 and 202 is not categorical as to the suitability of the site for perennial horticultural pursuits such as orchards, vineyards and tree crops, but does indicate that the area is less suited to annual horticulture and grazing than it is to perennial horticultural pursuits. While the constraints to these land uses could be overcome by sound management practices, further site specific land capability investigations are appropriate to address this matter, and an undertaking in this regard is provided.

The property is located within a Priority 3 Groundwater Source Protection Area. Boutique agricultural land uses including perennial horticulture such as tree crops and vineyards are compatible land uses within a Priority 3 Groundwater Source Protection Area.

The Water & Rivers Commission has developed recommended maximum nutrient loadings for the protection of public water resources, based on the soil type upstream of the water resource, and the vulnerability of the receiving environment. The categories describe the site's ability to assimilate nutrients (Refer to Appendix 7). The amendment area is likely to fall within a B Vulnerability Category to protect the groundwater resource. This classification means the maximum permitted phosphorus and nitrogen loadings at the site are 20kg P/ha/year and 180Kg N/ha/year respectively. It is likely the nutrient loadings of a perennial horticultural enterprise would be less than the criteria specified (Appendix 6).

It is possible the vulnerability classification may change to a C classification should the results of a soil sampling program indicate the soils have a strong ability to retain phosphorus. In this case the maximum phosphorus and nitrogen loadings would be 50kg P/ha/year and 300kg N/ha/year respectively.

Proposed Outcome

The potential for any impact on groundwater quality and/ or stygofauna arising from development of the Amendment area will be minimised through specific provisions in the TPS amendment relating to water sensitive urban design and other control provisions specified above. The implementation of a Drainage, Nutrient and Water Management Plan at subsequent stages of the planning process in particular will assist in meeting the objectives of managing water balance, maintaining and enhancing water quality, promoting water conservation and protecting the habitat of stygofauna (Section 3.2.3).

Proposed Scheme Provisions to Implement Management Strategy

The following Scheme Provisions are proposed to managing impacts associated with groundwater quality:

Drainage, Nutrient and Water Management Plan

The subdivider shall prepare a Drainage, Nutrient and Water Management Plan, at LSP stage, to the requirements of council on the advice of DEP, WRC and Water Corporation to ensure:

- Groundwater extraction bores are located in areas where drawdowns will not impact on areas of karst or potentially significant stygofauna habitats. In all cases however, the borefield will be located at least 200m from high risk karst areas to avoid any potential impacts on stygofauna;
- The rate, quantity and quality of wastewater infiltrating the amendment area is maintained at levels compliant with the minimum requirements of the protection of a Priority 3 Groundwater Source Protection Area;
- Provision of details on the size and location of groundwater extraction bores and predictions of the area of impact of these bores;
- Agricultural activities do not adversely impact on karstic zones in terms of water quality and quantity;
- Best practice Water Sensitive Urban Design principles are incorporated to maximise on-site water infiltration generally;
- Provide measures to facilitate the removal of pollutants and nutrients.
- The habitat of stygofauna is protected in respect of nutrient and groundwater levels.

- The plan will require utilisation of nutrient attenuating, sewage disposal mechanisms.

- Ensure effluent disposal areas are not sited over areas rated as high risk for karst phenomena.

- Include a requirement to submit a report demonstrating compliance with the criteria on the Plan.

- Include contingency plans in the event that the criteria are temporarily not achieved.

Karst Landform

To protect karst the subdivider shall prepare a Karst Management Strategy, at LSP stage, to the requirements of council on the advice of DEP, WRC and a geotechnical consultant to avoid development over high risk karst subject to further assessment by a geotechnical engineer and environmental scientist.

Detailed investigations in accordance with the programs described in Table 1 (attached Section 4) will be undertaken to determine the presence of large karst structures within the building envelopes on the property. Development will not be approved in areas or close to any location where large karstic structures are known or suspected to be present unless deemed acceptable by a qualified geotechnical engineer and environmental scientist. Development will also only be permitted where investigations indicate that structures can be safely erected.

Appropriate geotechnical investigations will be required in the areas which have been identified as within the zone where karstic features may potentially occur. It is recognised that the completion of the geotechnical investigations, staged as necessary, will be required prior to subdivision approval being granted. Preliminary Ground Penetrating Radar Work will be undertaken at Local Structure Plan stage. Detailed investigations, including drilling, will take place where necessary prior to subdivision application stage.

Land Capability Assessment and Site Analysis

The subdivider will under take to the requirements of council, appropriate land capability analysis at LSP stage. This assessment will determine lot sizes and suitability for agriculture.

3.4 Social Surroundings

3.4.1 Aboriginal and Culture Heritage

EPA Objective

- Ensure that the proposal complies with the requirements of the Aboriginal Heritage Act, 1972; and

- Ensure that changes to the biological and physical environment resulting from the project do not adversely affect cultural associations within the area.

Existing Environment

Surveys for archaeological and ethnographic sites within the Yanchep-Two Rocks area were undertaken by Quartermaine (1991) and MacIntyre and Dobson (1991).

The archaeological survey involved an investigation of previous research in the area, a systematic field survey of the area, and recording of any archaeological material located. No archaeological sites were previously recorded within the study area. As a result of the survey one archaeological site was located approximately 1km north of the current Yanchep townsite and no sites were located in the subject land by this survey.

The ethnographic survey comprised a thorough review of the existing information, consultation with relevant Aboriginal persons and long term residents of the area, and site inspections. The survey revealed no recorded information of Aboriginal habitation or ceremonial activities within the Yanchep-Two Rocks area. A cave located within the subject land was identified by Mr K Colbung, Director of the Australian Institute of Aboriginal Studies (Canberra) as significant. The site includes a cave where, according to Mr Colbung, the crocodile slept overnight and was transformed into an Emu.

The knoll of the hill lies in a north south direction and forms the contour of the emu's body. The northern section represents the head, the southerly section the tail and the cave symbolises the heart.

The limestone capping and ridges represent the bones of the crocodile and the grass trees covering the knoll symbolise the emu's feathers.

The site is considered a mythological site within the meaning of the Aboriginal Heritage Act, 1972. No other Aboriginal or heritage sites were identified on the subject land.

Potential Impacts

If the cave site is not protected it could be damaged or destroyed from construction activities, domestic pets, livestock grazing or acts of vandalism.

Proposed Management

The identified site must be protected from interference and/or destruction which may be caused either through construction activities or from acts of vandalism.

Mr Colbung requested that the cave area be fenced to protect the cave site. He also asked that a reasonable amount of land surrounding the site be set aside to be used as public open space or parkland (Quartermaine, 1991). A buffer zone is proposed, as recommended in the "Report on a Survey for Aboriginal Sites" prepared by Gary Quartermaine (1991) which will contain this site in a 3ha reserve.

To ensure that the site is managed by the appropriate authorities it is proposed that this area be contained in a special reserve transferred to the Crown or a specific Aboriginal agency. Access and maintenance can therefore be properly controlled.

Proposed Outcome

Planning controls will minimise disturbance of the site.

Proposed Scheme Provisions to Implement Management Strategy

The following Scheme Provision is proposed to manage the potential impact associated with the Aboriginal Heritage site:

> **Aboriginal Heritage Management**
>
> In order to manage the potential impact associated with the Aboriginal Heritage Site, the subdivider will protect on a lot not less than 3ha, the identified heritage site and the area immediately surrounding the site will be fenced and sign posted, as appropriate.

4. PROPOSED SCHEDULE TO TOWN PLANNING SCHEME TO INCORPORATE ENVIRONMENTAL CONDITIONS

1. The following clauses shall be inserted into the Shire of Wanneroo Town Planning Scheme No.1 Scheme Text:

5.13 Environmental Conditions

5.13.1 In accordance with Section 7AA of the Act, environmental conditions imposed by the Minister for the Environment on the Scheme or amendments to the Scheme and contained in Statements under Section 48F Environmental Protection Act, are incorporated into the Scheme by Schedule 13 of the Scheme.

5.13.2 Where appropriate, the environmental conditions are indicated on the Scheme Map by the Symbol EC to indicate that environmental conditions apply to the land.

5.13.3 The Council shall maintain a register of all the Statements published under Section 48F referred to in sub-clause 5.13.1 which shall be made available for public inspection at the offices of the Council.

Amendment No. (Gazettal Date)	Location of Land	Environmental Conditions
837 - X/X/199X	Lots 201 and 202 Breakwater Drive, Two Rocks	**1. Vegetation Management Plan** The subdivider shall prepare a Vegetation Management Plan at LSP stage, to ensure the long-term viability of remnant vegetation that may be affected directly or indirectly by development of the subject lots to the requirements of Council with the concurrence of the DEP and CALM. This plan shall include: 1.1 Description of vegetation and vegetation values. 1.2 Retention of significant areas of vegetation on the property. 1.3 Retention of mature trees and all three significant stands of trees except where utilities such as roads or construction of buildings is necessary or in those areas identified as prospective for small scale agricultural activities. 1.4 Isolation from the adjacent Parks and Recreation areas to the satisfaction of relevant State Agencies and will include opportunities for firebreaks, bridle paths and fencing as required. 1.5 Management arrangements for the keeping of horses which will address soil and vegetation protection. Restrictions on the keeping of horses to a rate of one horse per lot on conventional lots. In cluster subdivision, horses may only be kept on common land and not on individual lots. 1.6 Clear delineation of significant tree stands through use of dual use paths, roads and the like.

		1.7 Details on site maintenance arrangements - including weed control. 1.8 Allocation of responsibilities and identification of timing for the implementation of the Vegetation Management Plan.
		2. Drainage, Nutrient and Water Management Plan (Including for Protection of Stygofauna and Troglobitic Fauna) The subdivider shall prepare a Drainage, Nutrient and Water Management Plan, at LSP stage, to the requirements of council on the advice of DEP, WRC and Water Corporation to ensure: 2.1 groundwater extraction bores are located in areas where drawdowns will not impact on areas of karst or potentially significant stygofauna habitats. In all cases however, the borefield will be located at least 200m from high risk karst areas to avoid any potential impacts on stygofauna; 2.2 the rate, quantity and quality of wastewater infiltrating the amendment area is maintained at levels compliant with the minimum requirements of the protection of a Priority 3 Groundwater Source Protection Area; 2.3 provision of details on the size and location of groundwater extraction bores and predictions of the area of impact of these bores; 2.4 agricultural activities do not adversely impact on karstic zones in terms of water quality and quantity; 2.5 best practice Water Sensitive Urban Design principles are incorporated to maximise on-site water infiltration generally; 2.6 provide measures to facilitate the removal of pollutants and nutrients; and 2.7 the habitat of stygofauna is protected in respect of nutrient and groundwater levels. 2.8 The plan will require utilisation of nutrient attenuating sewage disposal mechanisms. 2.9 Ensure effluent disposal areas are not sited over areas rated as high risk for karst phenomena. 2.10 Include a requirement to submit a report demonstrating compliance with the criteria on the Plan. 2.11 Include contingency plans in the event that the criteria are temporarily not achieved.
		3. Karst Landform The subdivider shall prepare a Karst Management Strategy, at LSP stage, to the requirements of council on the advice of DEP, WRC and a geotechnical consultant to avoid development over high risk karst subject to further assessment by a geotechnical engineer and environmental scientist. Detailed investigations in accordance with Table 1 (attached) will be undertaken to determine the presence of large karst structures within the building envelopes on the property. Development will not be approved in areas or close to any location where large karstic structures are known or

		suspected to be present unless deemed acceptable by a qualified geotechnical engineer and environmental scientist. Development will also only be permitted where investigations indicate that structures can be safely erected. Appropriate geotechnical investigations will be required in the areas which have been identified as within the zone where karstic features may potentially occur. It is recognised that the completion of the geotechnical investigations, staged as necessary, will be required prior to subdivision approval being granted. Preliminary Ground Penetrating Radar Work will be undertaken at Local Structure Plan stage. Detailed investigations, including drilling, will take place where necessary prior to subdivision application stage.
		4. Aboriginal Heritage Management In order to manage the potential impact associated with the Aboriginal Heritage Site, the subdivider will protect on a lot not less than 3ha, the identified heritage site and the area immediately surrounding the site will be fenced and sign posted, as appropriate.
		5. Land Capability Assessment and Site Analysis The subdivider will under take to the requirements of council, appropriate land capability analysis at LSP stage. This assessment will determine lot sizes and suitability for agriculture.

TABLE 1

WORK SCHEDULE REQUIRED FOR SUBDIVISION OF LOTS 201 AND 202 BREAKWATER DRIVE WITH RESPECT TO KARST TERRAIN APPRAISAL

	Structure Plan Assessment Prior to Subdivision	Placement of Building Envelopes/Drainage Design for Proposed Subdivision			Building Envelope Assessment Prior to Building				
					Geotechnical Investigations for Foundation Assessment				
	A further geotechnical appraisal of the high and medium risk karst areas with respect to the draft LSP design **	Detailed interpretation of existing GPR data	Detailed geotechnical inspection target location, drilling and possible remediation	Geotechnical inspection and recommendations for additional geotechnical site assessment prior to building [1]	Further GPR as recommended from the geotechnical evaluation	Drilling >1 borehole to total depth of 15m	Drilling at least 1 borehole to a total depth of no more than 15m	Testing Pitting to 3m depth[2]	Perth Sand Penetrometer Testing to 750mm[3]
High	✓	✓	✓		Further work on high risk only if specifically required/remediation work				
Medium	✓	✓		✓	✓*	✓		✓	✓
Low		✓		✓	✓*		✓	✓	✓
Very Low		✓		✓	✓*			✓	✓

* On the basis of advice from the geotechnical assessment.

** Geotechnical works likely to involve mapping and GPR. Program to be developed in consultation with Shire of Wanneroo and a geotechnical engineer.

1. Following the geotechnical assessment a reappraisal of the work program for building envelope assessment with respect to the risk rating may be required.
2. Test Pitting is generally carried out by a backhoe and refilled after logging and sampling.
3. The Perth Sand Penetrometer is a hand held portable device used for measuring the compaction of soils.

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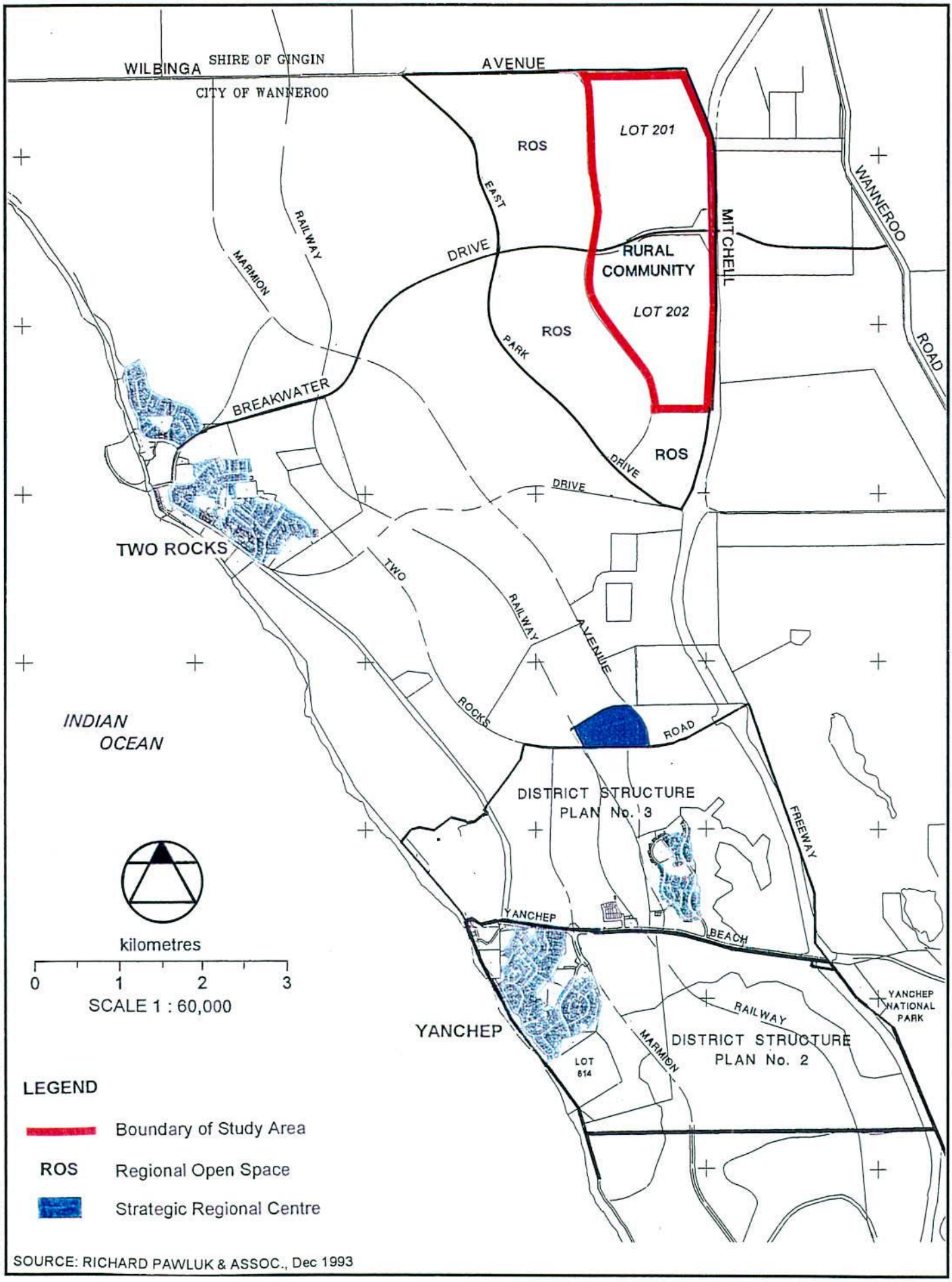
QUALITY ASSURANCE

As part of our Quality System, documents are checked then approved prior to distribution. Quality Assurance procedures require that the results of implementation of recommendations be validated against the intent of the recommendations. Alan Tingay & Associates is prepared to assist clients in assessing the outcomes of recommendations made in this report to establish whether those outcomes are in accordance with the objectives.

Document Reference:	99/12
Project Number:	99027
Draft:	Final
Checked:	Neil Beckingham
Approved:	N. Davies
Date:	1 June, 1999

FIGURES



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DRAWN: GLM 24-3-99
99027/99_12F1

SHIRE OF WANNEROO TOWN PLANNING SCHEME No1
AMMENDMENT 837 , YANCHEP - TWO ROCKS

LOCATION

FIGURE 1

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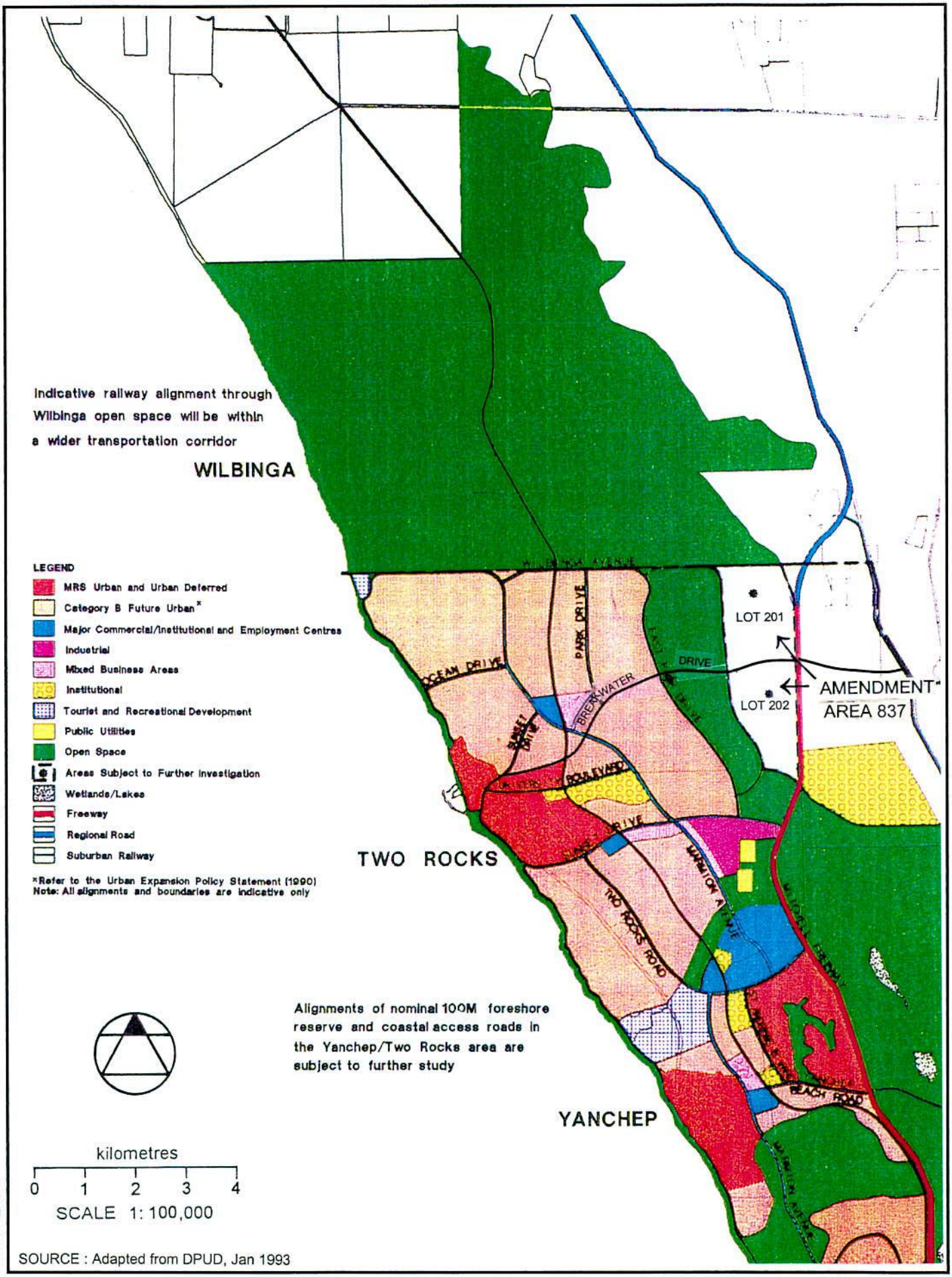

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SHIRE OF WANNEROO TOWN PLANNING SCHEME No1
AMMENDMENT 837 , YANCHEP - TWO ROCKS

YANCHEP STRUCTURE PLAN

FIGURE 2

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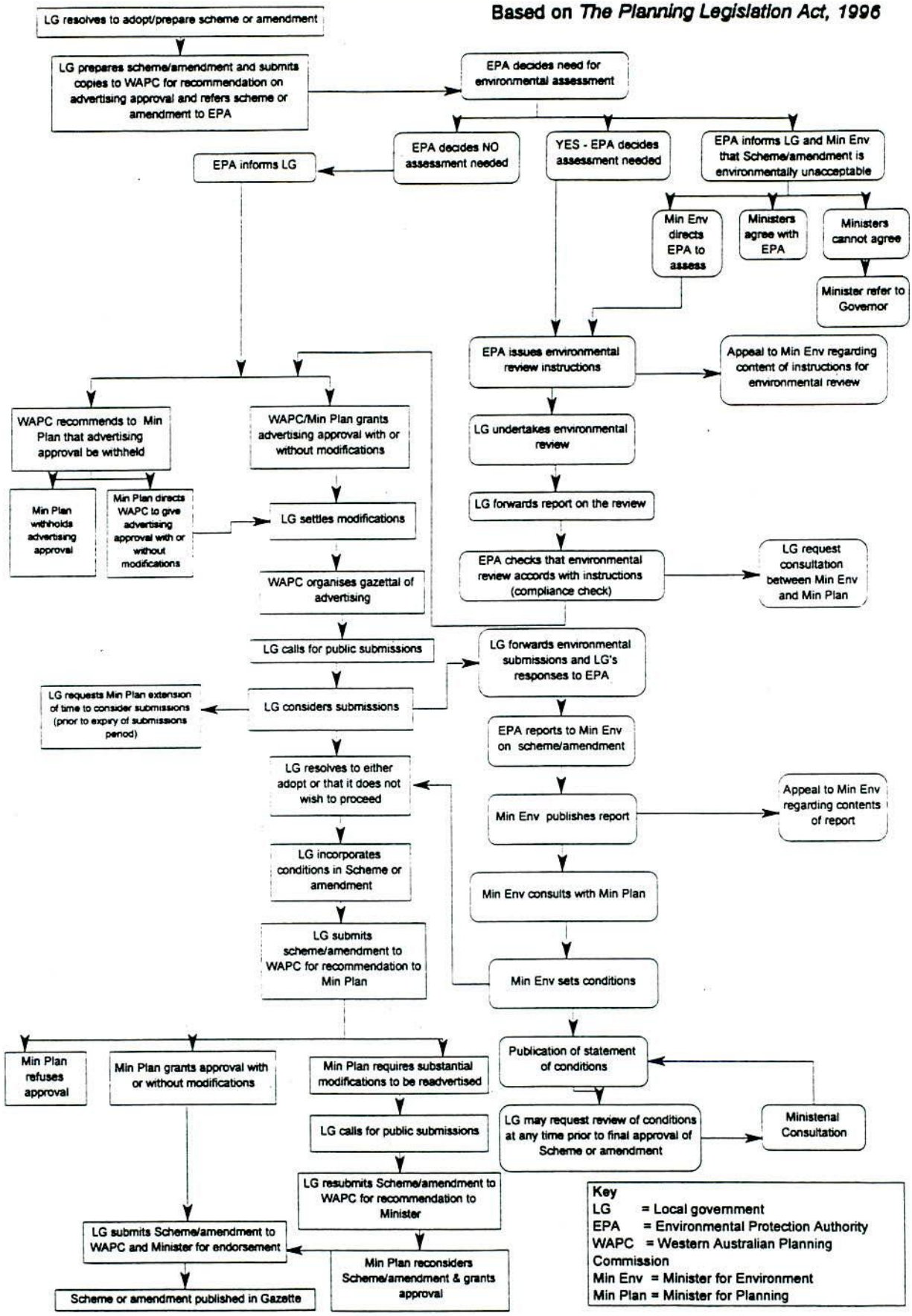
environmental scientists

Preparation & Environmental Assessment of Local Schemes & Amendments

Based on *The Planning Legislation Act, 1996*



SOURCE: WESTERN AUSTRALIAN PLANNING COMMISSION, 1996

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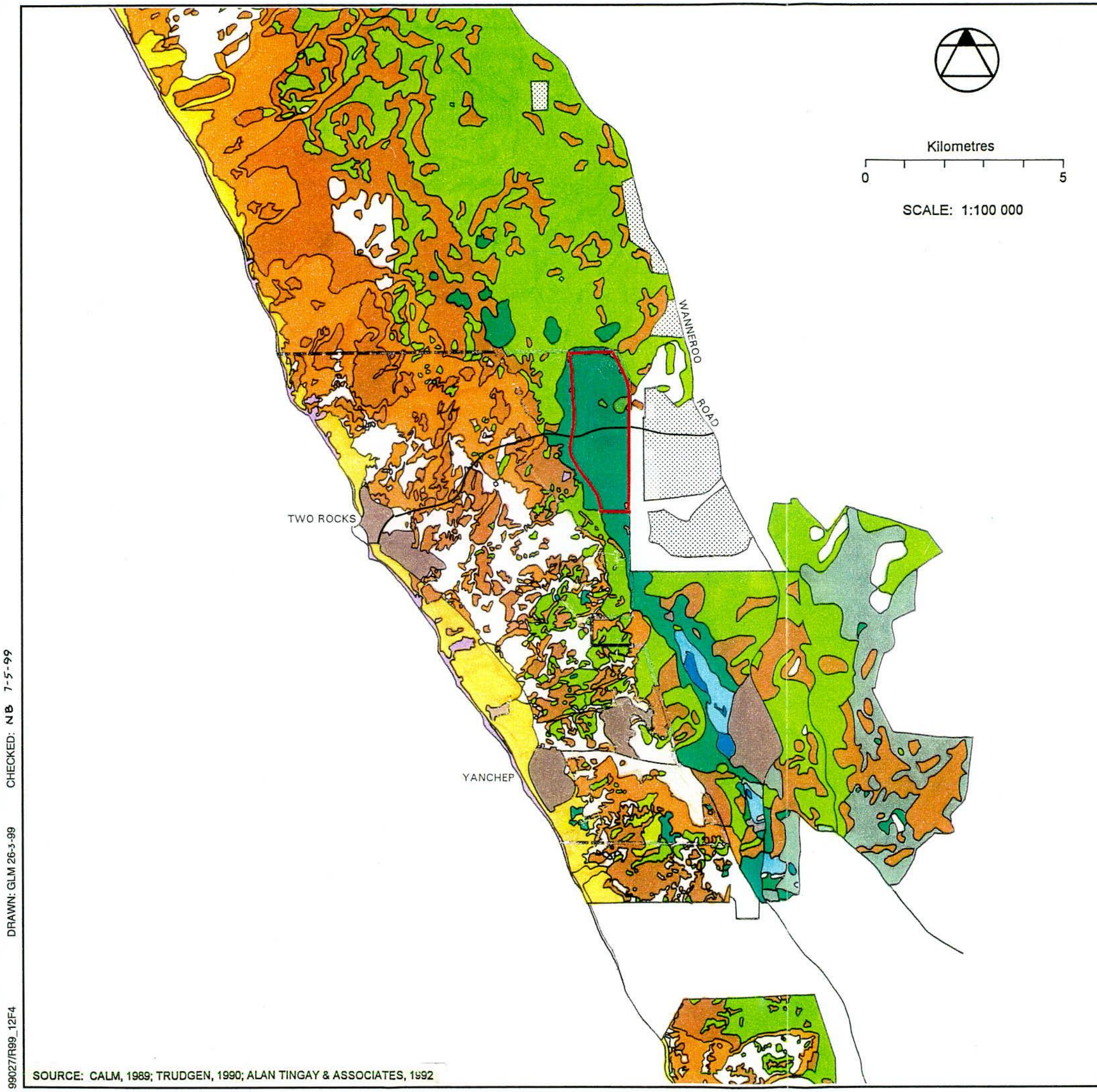
SHIRE OF WANNEROO TOWN PLANNING SCHEME No1
AMMENDMENT 837 - YANCHEP TWO ROCKS

ENVIRONMENTAL REVIEW PROCESS

FIGURE 3



Kilometres

0 5

SCALE: 1:100 000

LEGEND

- TUART WOODLAND
- JARRAH WOODLAND
- BANKSIA WOODLAND
- LIMESTONE HEATH
- INLAND DUNE HEATH
- COASTAL DUNE HEATH
- WETLAND VEGETATION
- OPEN WATER
- PASTURE
- BARE SAND
- PINE PLANTATION
- DEVELOPED AREA
- BOUNDARY OF AMENDMENT AREA 837

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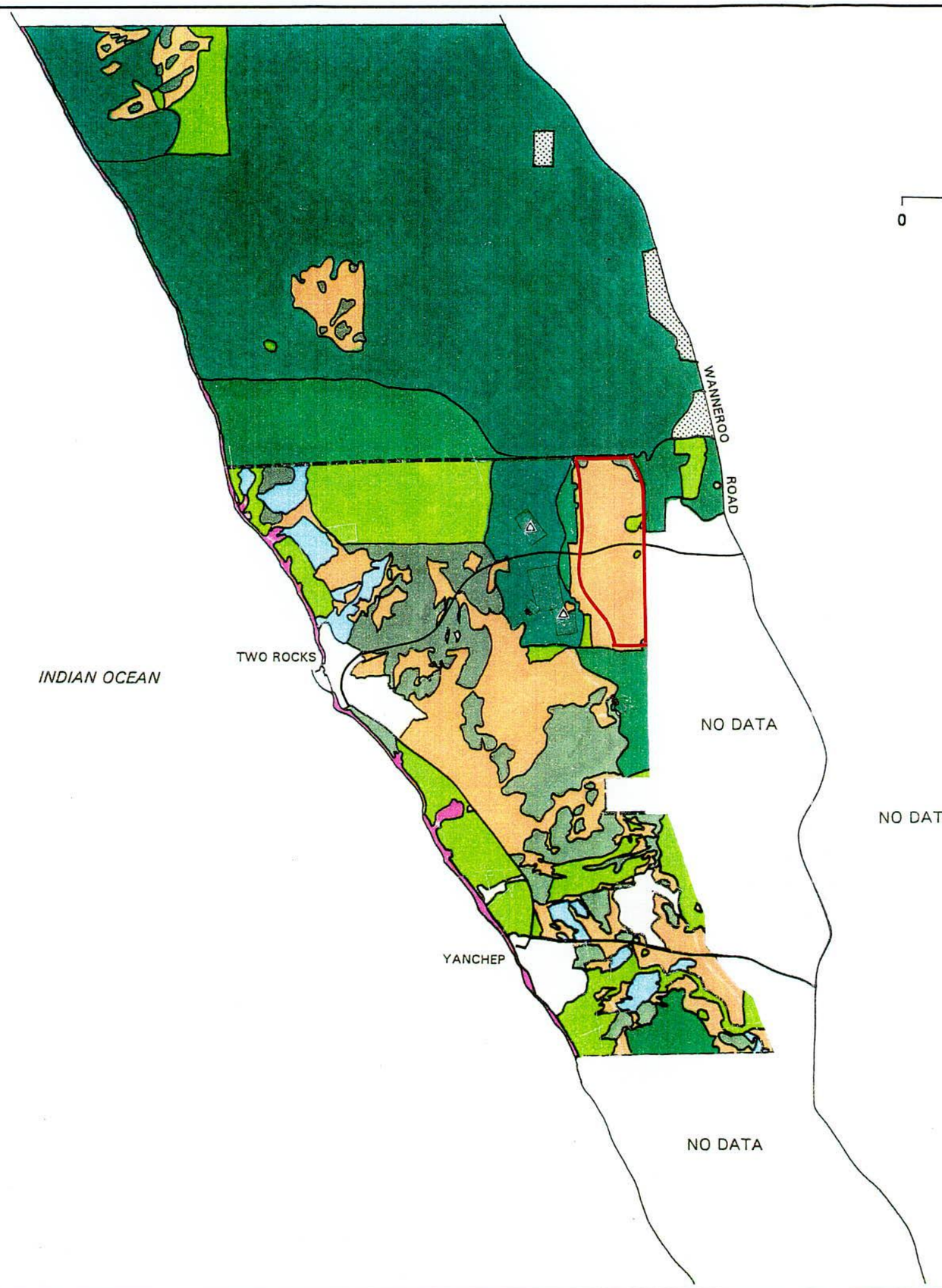
SHIRE OF WANNEROO
TOWN PLANNING SCHEME No1
AMENDMENT 837, YANCHEP - TWO ROCKS

REGIONAL VEGETATION COMMUNITIES

FIGURE 4

SOURCE: CALM, 1989; TRUDGEN, 1990; ALAN TINGAY & ASSOCIATES, 1992

99027/R99_12F4 DRAWN: GLM 26-3-99 CHECKED: NB 7-5-99



Kilometres

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SCALE: 1:100 000

LEGEND

- UNDISTURBED
- SLIGHTLY DISTURBED
- DISTURBED
- OBVIOUS DISTURBANCE
- SEVERELY DISTURBED
- DEGRADED
- BARE SAND
- DEVELOPED AREA
- LOCATION OF DECLARED RARE EUCALYPTS
- BOUNDARY OF AMENDMENT AREA 837

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SHIRE OF WANNEROO
TOWN PLANNING SCHEME No1
AMENDMENT 837, YANCHEP - TWO ROCKS

REGIONAL VEGETATION CONDITION

FIGURE 5

99027/R99_12F5 DRAWN: GLM 26-3-99 CHECKED: NB 7-5-99

WILBINGA CROWN LAND

CARABAN MPA C12

WANNEROO ROAD

STATE FOREST

M1

BREAKWATER DRIVE

TWO ROCKS

M3

M4

YANCHEP NATIONAL PARK

M2

YANCHEP BEACH ROAD

YANCHEP

INDIAN OCEAN

WANNEROO ROAD

SOURCE: MINISTRY FOR PLANNING

kilometres

0 1.0 2.0 3.0 4.0 5.0km

SCALE 1 : 100 000

AMENDMENT AREA 837

SYSTEM 6 AREAS

YANCHEP NATIONAL PARK

WILBINGA CROWN LAND

EXISTING AND PROPOSED CONSERVATION RESERVES AND PARKS & RECREATION AREAS UNDER MRS

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SHIRE OF WANNEROO
TOWN PLANNING SCHEME No1
AMENDMENT 837, YANCHEP - TWO ROCKS

EXISTING AND POTENTIAL CONSERVATION RESERVES& SYSTEM 6 AREAS IN THE YANCHEP REGION

FIGURE 6

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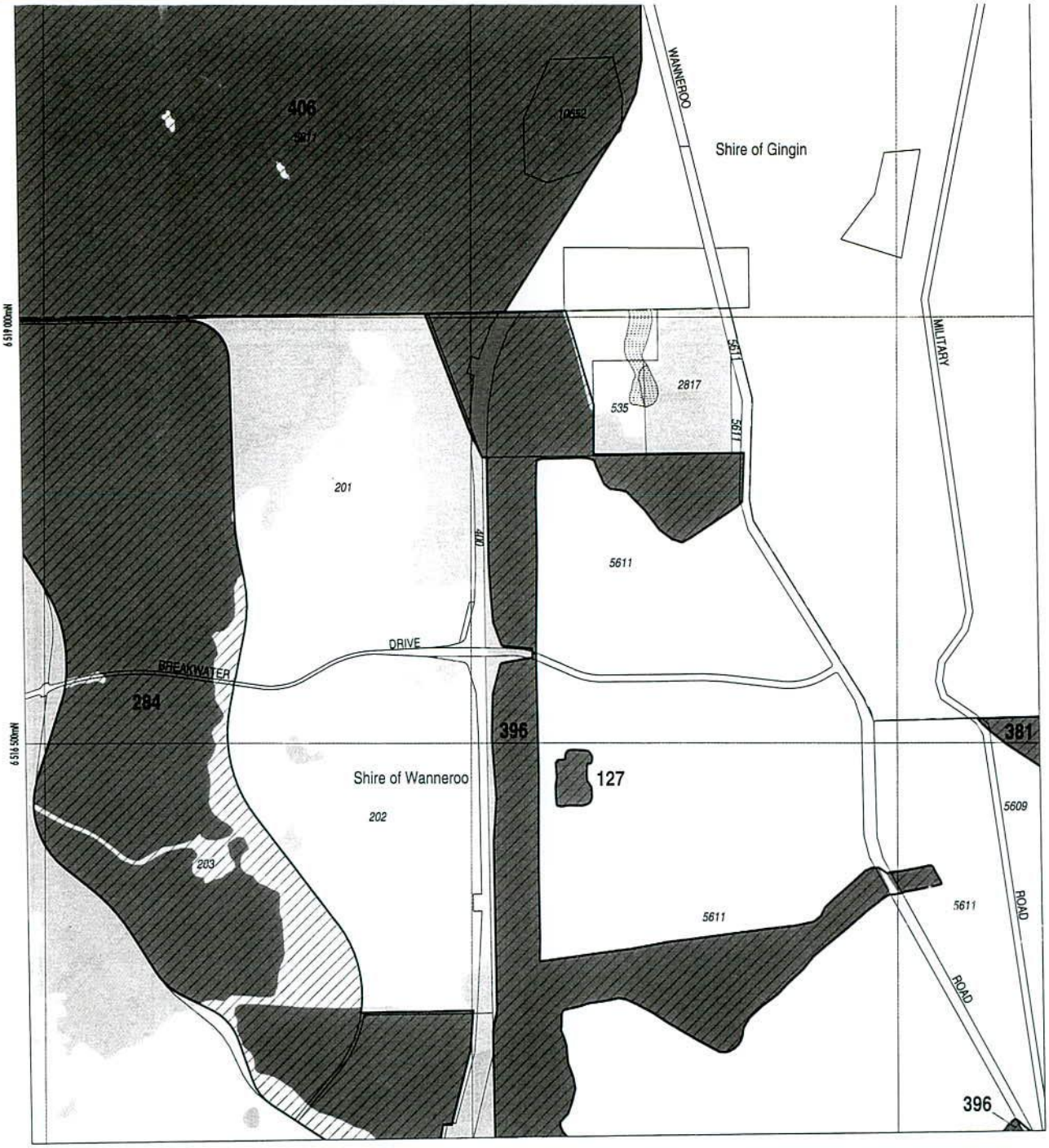
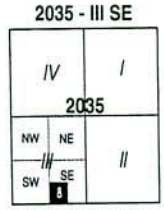


LEGEND

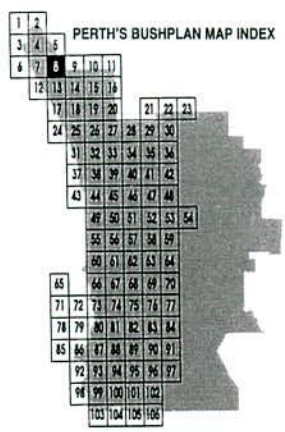
- 472 — Bushplan Sites With Regionally Significant Bushland
- Other Native Vegetation
- Conservation Category Wetlands
- Bushplan Sites With Some Existing Protection
- 696 — Lot Number, Location Number
- Channel Wetlands
- Local Government Boundary

2035 - III SE



1 : 25 000 AMG Reference Grid showing Perth's Bushplan Map Sheet Breakdown

PERTH'S BUSHPLAN MAP INDEX



N

SCALE

0 500 1000

Metres

Produced by Project Mapping Section
Land Information Branch, Ministry for Planning, Perth W.A. November 1998

ntw-map7//environ/bushplan//bushv2_8.dgn

Cadastral Data supplied by Department of Land Administration, W.A.

Wetlands Data supplied by Water and Rivers Commission

Native Vegetation Extent for Study Area supplied by Agriculture Western Australia

SOURCE: PERTH'S BUSHPLAN VOL2 PART C, 12/98 : Map 8

99027/99_12F DRAWN: GLM 4-4-99 CHECKED: NB 7-5-99

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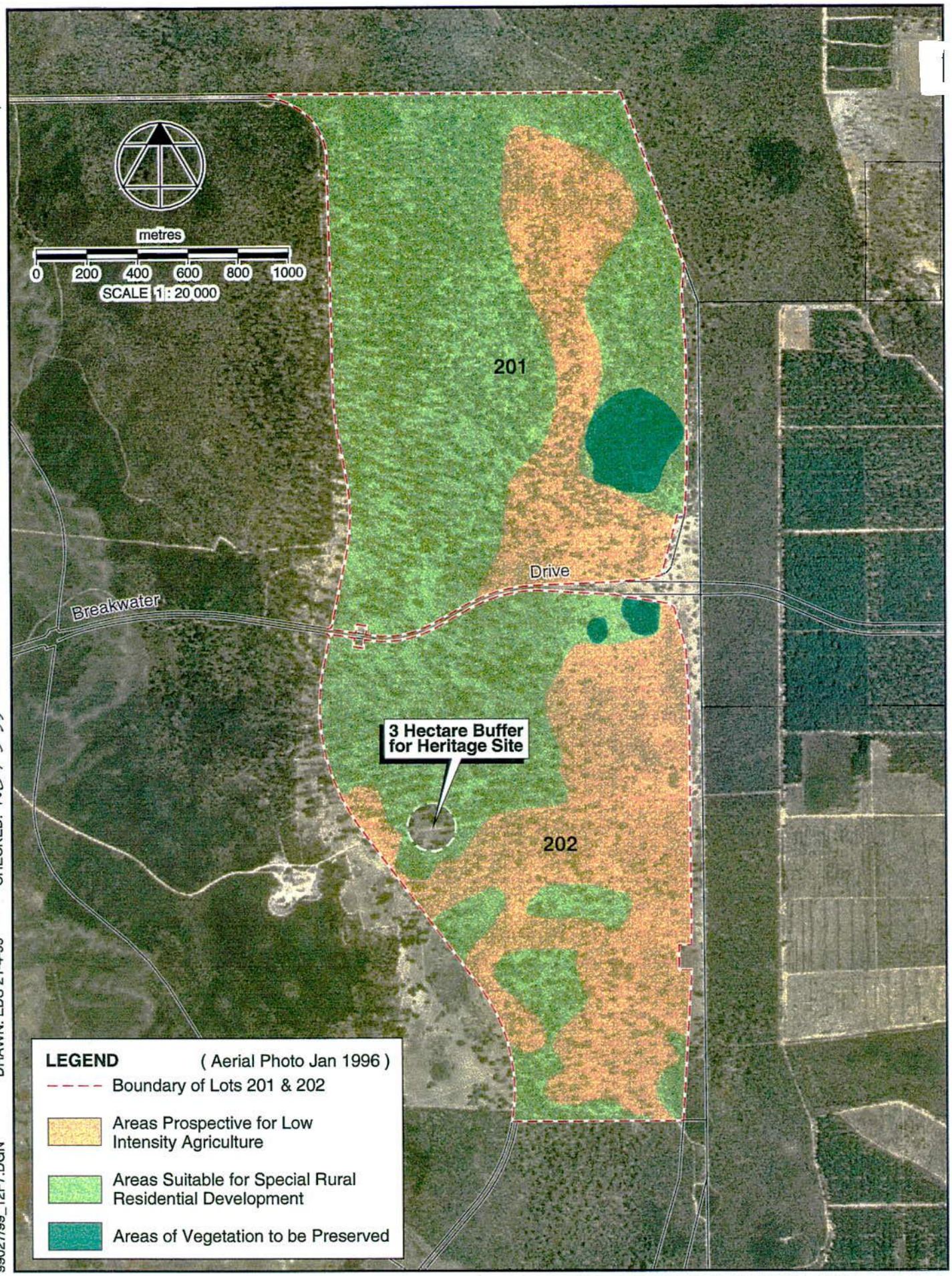
SHIRE OF WANNEROO TOWN PLANNING SCHEME No1
AMMENDMENT 837, YANCHEP - TWO ROCKS

BUSHPLAN SITE MAP

FIGURE 7



PRINTED: Thu 22 Apr 99

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SHIRE OF WANNEROO TOWN PLANNING SCHEME No1
AMMENDMENT 837, YANCHEP - TWO ROCKS

AREAS PROSPECTIVE FOR LOW INTENSITY AGRICULTURE

FIGURE 8

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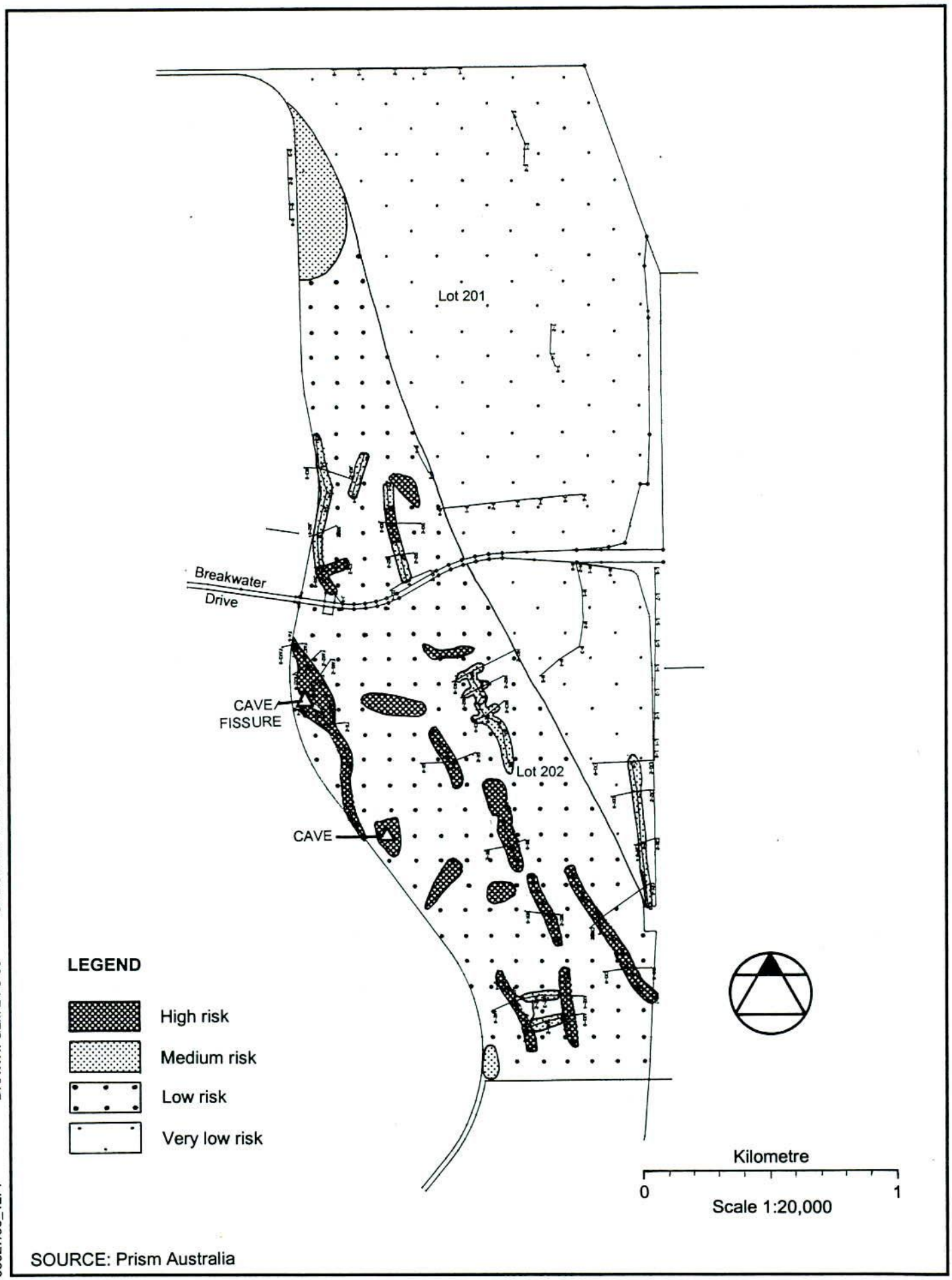

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SHIRE OF WANNEROO TOWN PLANNING SCHEME No1
AMMENDMENT 837 - YANCHEP TWO ROCKS

SUMMARY OF KARST PHENOMENA

FIGURE 9

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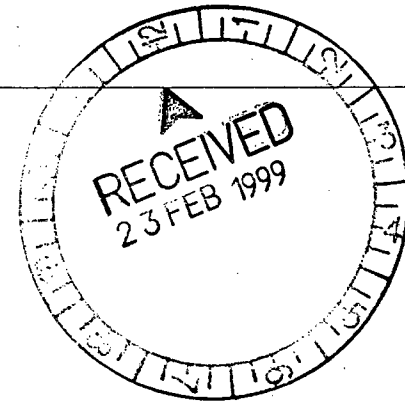
APPENDICES

APPENDIX 1

ENVIRONMENTAL REVIEW INSTRUCTIONS

Environmental Protection Authority



Alan Tingays and Associates
21 Howard St
PERTH WA 6000

Our Ref TP145/03
Enquiries Stacey Harley

Attention: Mr Neil Beckingham

SCHEME/AMD TITLE: **Shire of Wanneroo Town Planning Scheme 1 Amendment No 837 rezone from Rural to Rural Community**

SCHEME/AMD LOCATION: **Lots 201 and 202 Breakwater Drive**

LOCALITY: **Two Rocks**

Please find attached for your information the instructions specifying the scope and content of the environmental review document for the above amendment. These instructions, which have been forwarded to the responsible authority, are not yet final as they are subject to appeal to the Minister for the Environment under Section 100 of the EP Act.

Any appeals should be lodged in writing, accompanied by the $10.00 appeal fee, to:

Appeals Convenor

C/- Minister for the Environment

18th floor, Allendale Square

77 St Georges Tce

PERTH WA 6000

Appeals on these instructions must be received by the Appeals Convenor by 5:00 pm on 5 March 1999.

If there are no appeals you will be informed by the Department of Environmental Protection (DEP). The attached instructions would then become the final instructions.

In the event of there being appeals, there can be two outcomes:

a) The Minister may dismiss the appeals and would notify you accordingly. In this case the attached instructions would become the final instructions.

b) The Minister may uphold the appeals and would notify you accordingly. In this case the attached instructions would be modified and sent to you as the final instructions.

The environmental review document must be prepared in accordance with the final instructions. When this has been achieved, the document will be released for public review and you will be sent a copy.

Bernard Bowen

B K Bowen
CHAIRMAN

19 FEB 1999

Westralia Square, 141 St Georges Terrace, Perth, Western Australia 6000. Telephone: (08) 9222 7000. Facsimile: (08) 9222 7155.
Postal Address: PO Box K822, Perth, Western Australia 6842.

ENVIRONMENTAL ASSESSMENT OF PLANNING SCHEMES AND THEIR AMENDMENTS

SHIRE OF WANNEROO TOWN PLANNING SCHEME 1 AMENDMENT NO 837 REZONE FROM RURAL TO RURAL COMMUNITY, LOTS 201 AND 202 BREAKWATER DRIVE, TWO ROCKS

ENVIRONMENTAL REVIEW INSTRUCTIONS

1. Introduction

The Environmental Protection Act sets out that where a planning scheme, or an amendment to a scheme, is judged to have a significant environmental impact it will be subject to an assessment by the Environmental Protection Authority (EPA) under Section 48A of the Act. These schemes/amendments are being assessed because they raise significant environmental factors.

Where a scheme/amendment is subject to an assessment by the EPA, the responsible authority is required to produce an Environmental Review addressing the environmental factors relevant to the scheme/amendment. The EPA issues instructions for the scope and content of the Environmental Review. Below are the instructions for the above scheme/amendment.

The Environmental Review is then made publicly available with the scheme/amendment document to enable members of the public and relevant agencies to comment on the possible environmental impacts of the scheme/amendment. Additional information on the purpose and functions of environmental assessment of a scheme/amendment is given in Attachment 1.

The scheme that is the subject of this assessment is called Shire of Wanneroo Town Planning Scheme 1 Amendment No 837 rezone from Rural to Rural Community, Lots 201 and 202 Breakwater Drive, Two Rocks

A map showing the location of the amendment is shown as Attachment 2.

2. Instructions

2.1 Status of the instructions

The EPA, in its formulation of the instructions, endeavours to come to an agreement with the Responsible Authority and any other involved agency about the scope and content of the Environmental Review document. The Department of Environmental Protection (DEP) provides services and facilities for the EPA. In many cases the DEP will act for the EPA.

Other parties may also have a view about the contents of the instructions. To accommodate this additional input the instructions are subject to appeal to the Minister for the Environment.

Where an appeal is lodged and upheld the Chief Executive Officer will issue the final instructions, consistent with the appeal decision. Where no appeals are received or all appeals are dismissed, this document is the final instructions for the preparation of the Environmental Review.

2.2 General information

The fundamental requirements of the Environmental Review document are to:

a) describe the state of the environment affected by the scheme, indicating at least the scheme area and its immediate surroundings;

b) describe the purpose of any zoning or reservation;

c) identify those environmental factors which should be considered in relation not only to the scheme being assessed but also to later levels of planning, such as subdivision and development;

d) identify those environmental factors which require alternative procedures or processes to address any requirements for on-going long-term management;

e) for those environmental factors not relevant to the scheme being assessed, describe the process (approvals and the like) necessary to address those factors later, including likely referral to the EPA; and

f) for those factors relevant to the scheme being assessed, describe the extent to which the environment could be protected from both direct and indirect impacts, including:

- identifying the portions of the environment of highest conservation value and describing how the scheme plans to protect them;
- listing those land-uses that will be permitted without further environmental approval being required under proposed zoning;
- predicting the potential environmental impacts of these land uses;
- describing the scheme provisions which will allow management of those impacts to ensure the environment is protected to an acceptable level in the best manner possible; and
- identifying potential conflicts of land uses having environmental implications and how the environmental impacts are to be managed.

The Environmental Review document should consist of sections that deal with the above requirements. The recommended format for the Environmental Review document is enclosed as Attachment 3.

An important aspect of the environmental impact assessment process is the review by the public. The EPA wants to receive public input into the possible environmental impacts of this scheme and its implementation. To facilitate adequate public input, the Environmental Review should be made available as widely as possible and at a reasonable cost.

Attachment 4 contains:

1. a list of agencies and persons who should receive free copies of the Environmental Review (including EPA members);
2. a list of places where the Environmental Review should be made available for public viewing;
3. recommended cost of the Environmental Review; and
4. methods for advertising the availability of the Environmental Review.

2.3 Environmental factors relevant to this scheme and deferred environmental factors

The EPA, following consideration of the factors related to the scheme, is likely to identify some key factors which need to be given special attention and which should form the principal basis of the EPA assessment report to the Minister for the Environment. These key factors are termed the "environmental factors relevant to the scheme".

The EPA has also identified other environmental factors which it considers to be relevant to the scheme but are likely to be best addressed at a later level of planning. These factors are considered to be significant enough to warrant attention as part of the environmental review of this scheme to the extent that the Responsible Authority should show how these factors could be addressed at a later level of planning. These factors are called "deferred environmental factors". Note: no deferred factors have been identified for this amendment.

The EPA, in consultation with the Responsible Authority and the relevant agencies, has identified a list of factors likely to be found to be the "environmental factors relevant to the scheme" and those likely to be found to be "deferred environmental factors". This list is provided to assist with the preparation of the Environmental Review document, but during the course of the preparation of the document other factors may be found also to be relevant, and they should be included in the detailed discussion.

A copy of the form used to identify the environmental factors (the "filtering form") is included as Attachment 5.

2.4 General scope of the Environmental Review - Limit of the Environmental Review

The scheme amendment has been initiated to:

- Introduce a Rural Community zone;
- Rezone Lots 201 and 202 Breakwater Drive, Two Rocks from Rural to Rural Community.

2.5 Environmental factors relevant to the scheme

The EPA has identified some environmental factors which are relevant to the scheme area and should be addressed in the Environmental Review document. These factors are listed below (see Table 1).

Table 1: Environmental factors relevant to the scheme

CONTENT		SCOPE OF WORK	
Factors	**Site specific factor**	**Work required for the environmental review**	**Additional comments**
BIOPHYSICAL			
Terrestrial flora	Vegetation communities	Specify the possible indirect impacts that implementation of the Amendment may have on adjacent regionally significant remnant vegetation. Identify the significance of vegetation within the amendment area and potential impacts due to implementation of the proposed Amendment. Propose scheme provisions and discuss relevant strategies to minimise these impacts. In particular, discuss fire management.	Applies to the whole of the scheme area.
	Declared Rare and Priority Flora	Investigate for the presence of the Declared Rare and Priority Flora within the Amendment area. If there is a presence, identify how the population will be affected by implementation of the Amendment. Where necessary specify proposed scheme provisions and strategies for their protection.	Applies to the whole of the scheme area. *Eucalyptus argutifolia* is likely to occur in the Amendment area. A specific search should be undertaken for this species.
Terrestrial fauna	Stygofauna and troglobitic fauna	Determine the presence or absence of Stygofauna and troglobitic fauna. If stygofauna and/or troglobitic fauna are present document potential impacts and propose scheme provisions and strategies for their protection. Discuss the potential for known stygofauna and troglobitic fauna in Yanchep National Park to be impacted by implementation of the Amendment.	Applies to the whole of the scheme area.

Factors	Site specific factor	Work required for the environmental review	Additional comments
Terrestrial fauna	Specially Protected (Threatened) Fauna	Determine the probability of Specially Protected (Threatened) Fauna occurring within the scheme area. Discuss potential impacts from the implementation of the Amendment and how they will be addressed.	Applies to the whole of the scheme area.
Wetlands	Karst wetlands	Determine the presence or absence of karst wetlands in the amendment area. If there is a presence, assess the environmental value of the karst wetlands and determine the impact of implementation of the Amendment. Discuss potential implications for subterranean fauna, and propose scheme provisions and strategies to minimise any changes.	Applies to the whole of the scheme area. Karst wetlands are formed where groundwater intersects karst.
Groundwater	Groundwater quantity	A study of the groundwater hydrology should be undertaken to determine what variations in groundwater level may result from development of the Amendment area. Discuss potential implications for subterranean fauna, and propose scheme provisions and strategies to minimise groundwater level variations and impacts on subterranean fauna.	Applies to the whole of the scheme area.
Land	Karst	Identify areas of karstic formations within the amendment area. Identify the range of caves and other karst landforms in these areas. Discuss the potential impact that implementation of the Amendment may have on these formations. Discuss potential implications for subterranean fauna, and propose scheme provisions and strategies to minimise impacts.	Applies to the whole of the scheme area.
POLLUTION MANAGEMENT			
Water	Groundwater quality	Describe the groundwater hydrology of the area. Determine the nature and extent of potential impacts that development within the Amendment area may have on groundwater quality. Discuss the potential impact on subterranean fauna that may result. Propose scheme provisions and strategies to minimise any changes.	Applies to the whole of the scheme area.

Factors	Site specific factor	Work required for the environmental review	Additional comments
SOCIAL SURROUNDINGS			
Culture and Heritage	Aboriginal Culture and Heritage	Investigate into whether the Amendment area is of cultural or historical significance to indigenous people. If it is found to be of significance, identify how this will be addressed in liaison with relevant agencies.	Applies to the whole of the scheme area. Archaeological surveys and ethnographic consultations should be conducted with local Aboriginal communities. Any proposal which may impact upon a site with Aboriginal significance must be granted a permit from the Aboriginal Cultural Material Committee.

2.6 Deferred environmental factors

- None identified at this stage

Attachment 1

Information on the purposes and functions of the environmental assessment of schemes and their amendments

Purpose of the environmental assessment

The purpose of an environmental assessment is to ensure that the scheme takes proper account of the relevant environmental factors. To do this the EPA reports to the Minister for the Environment on the environmental factors relevant to the scheme, recommends environmental conditions under which the scheme may operate and provides other recommendations as it sees fit.

Functions of an Environmental Review

The primary function of the Environmental Review is to provide information about the environmental factors related to the proposed scheme to the EPA to enable it to evaluate the significant effect on the environment of the scheme and provide independent environmental advice to Government.

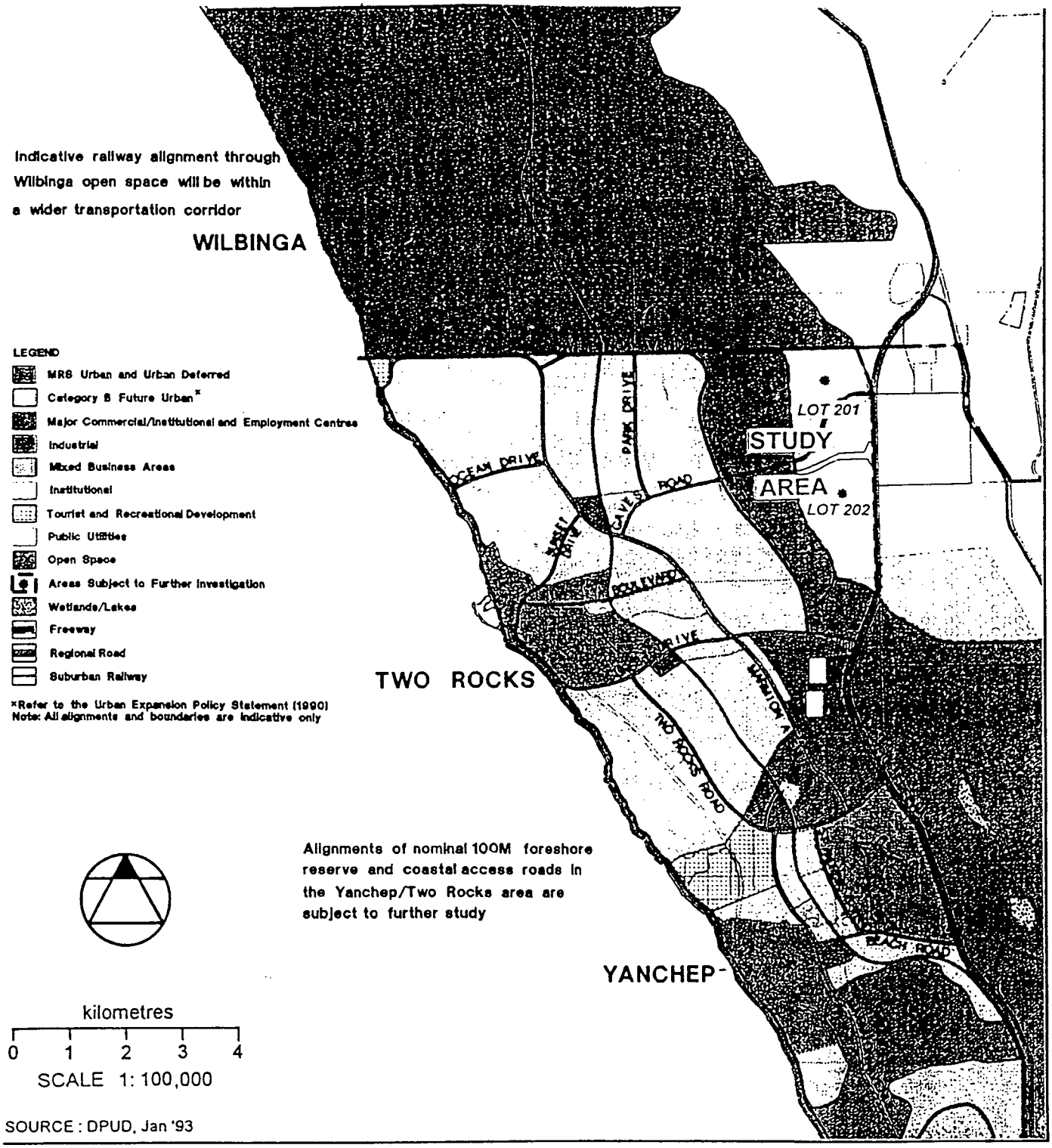
An additional function of the document is to clearly communicate details of the proposed scheme and its future implications to the public so that the EPA can obtain informed public comment on relevant environmental factors and their areas. Effective public information and involvement is an essential part of environmental impact assessment.

These instructions are issued to assist in identifying matters that should be addressed within the Environmental Review document. However, other relevant matters may arise during the preparation of the environmental review document and these should also be included.

The Environmental Review document will be made publicly available during the advertised period for the scheme and submissions from other agencies and the public will be sought. The Responsible Authority is required to forward submissions relating to the Environmental Review to the EPA and respond to the EPA on environmental factors or conditions and procedures which may apply should the proposal be implemented that are raised in those submissions. Based on the information in the Environmental Review document, the response to submissions and its own investigations the EPA will then report to the Minister for the Environment.

Attachment 2

Location of Scheme/amendment



AN TINGAY & ASSOCIATES

TWO ROCKS RURAL COMMUNITY
YANCHEP STRUCTURE PLAN

Attachment 3

Environmental Review Document Structure

The legislation requires that the Environmental Review Document be part of the amendment documentation. For our purposes it would be useful for it to be a separate volume, perhaps an appendix to the amendment document.

The following structure is suggested:

1. How to make a submission

- Include a standard sheet to guide the reader how to make a submission (format by DEP, yet to be determined).

2. Introduction

- Clarify who is the Responsible Authority.
- It is likely that the DEP will provide a standard paragraph or two to explain the background to the Environmental Review Document, in particular the process to date. eg the Environmental Review Document is prepared in accordance with S48A of the *Environmental Protection Act* 1986; the Environmental Review Document should be read in conjunction with the amendment document.
- Refer the reader to a process flow chart, probably from the Planning for People document, which could be Appendix A1.

3. Summary of Amendment

- Should include a brief description of scheme / amendment and its purpose.
- Cross reference to the amendment document, particularly the scheme text / provisions, wherever possible.
- Include a clear location map and any other figures to describe the amendment.

4. Environmental Factors Relevant to the Scheme

These factors will be specified by the EPA /DEP in the final instructions. Each factor should be addressed using the following format:

4.1 Environmental factor: wetlands

- Provide background on the current state of the environment.
- Discuss any polices relevant to the environmental factor.

Preliminary EPA objective / proposed alternative objective

- The EPA objectives for each environmental factor will be provided to the Responsible Authority following the issuing of the final instructions.

Potential impacts

- This section should outline the potential impacts that could result from the implementation of the scheme / amendment.

Proposed management

- How the scheme / amendment, provisions or zoning pattern address the impacts on environment.

- How scheme provisions will be implemented and how subsequent planning stages will address the impacts on the environment.

Proposed outcome

- Given the proposed management, can the EPA objective be met?
- On evaluation of the above (4.1.1 to 4.1.4) if it appears the EPA objective cannot be met this section provides the opportunity to offer an alternative objective and justify why the EPA should accept the alternative objective.

4.2 Environmental Factor eg terrestrial fauna

Preliminary EPA Objective / proposed alternative objective etc

5. Deferred Environmental Factors (if applicable)

- These will have been identified in the instructions
- Alternatively, the document may argue why an environmental factor relevant to the scheme, as determined by the EPA, is considered to be a deferred factor.
- This section should largely follow the same format as Section 4.

6. Summary of scheme provisions

- This Section should reiterate the proposed management of the environmental factors (from section 4).

7. References

8. Glossary (if necessary)

Appendices

A1 Flow chart of process

A2 Instructions and objectives

A3 Other information

Attachment 4

Availability of Environmental Review

1. Copies for distribution free of charge

Supplied to DEP:

- Library / Information Centre 9
- EPA members and Executive Officer 6
- Officers of the DEP (Perth) 5

Distributed by the responsible authority to:

Libraries

- J S Battye Library 3
- Joondalup Library 2
- Wanneroo Library 2
- Woodvale Library 2

Government departments

- Minister for Planning's Office 1
- Ministry for Planning 2
- Water and Rivers Commission 1
- CALM 2
- Water Corporation 1
- Aboriginal Affairs 1
- WA Museum 1

Other

- Conservation Council of WA 1
- University of WA 1
- Speleological Group of WA 1
- As Responsible Authority thinks fit .....

2. Recommended cost

In general, the Environmental Review document for Town Planning Schemes would be expected to be similar in length to Consultative Environmental Review (CER) documents, therefore the recommended cost for the document is $5 including postage - the same as recommended for proposals assessed at the level of CER.

Scheme Amendments for much larger proposed developments can be charged at $10 for the main document and $10 for appendices including postage - as recommended for proposals assessed at the level of Public Environmental Review or Environmental Review and Management Programme.

3. Advertising

The responsibility for advertising the release and availability of an Environmental Review resides with the responsible authority and is done at their expense under the following guidelines:

Format and content
The format and content of the advertisement should be approved by the DEP before appearing in the media. The advertisement should be compatible with the model advertisement below.

Size
As a guide, the size of the advertisement should be 2 newspaper columns (approximately 10 cm) wide by approximately 14 cm long. Dimensions less than these would be difficult to read.

Location

For Town Planning Schemes the approved advertisement should appear in the news section of the main local newspaper.

Model advertisement

Shire of Wanneroo Town Planning Scheme 1 Amendment 837

Environmental Review

(Public Review Period: date to date)

The Shire of Wanneroo have resolved to initiate Shire of Wanneroo Town Planning Scheme 1 Amendment 837 for the purposes of rezoning Lots 201 and 202 Breakwater Drive, Two Rocks from Rural to Rural Community.

An Environmental Review (ER) has been prepared by the Shire of Wanneroo to examine the environmental effects associated with the implementation of the proposed scheme/amendment, in accordance with Western Australian Government procedures. The ER describes the scheme/amendment, examines the likely environmental effects if implemented and the puts forward proposed environmental management procedures.

The Shire of Wanneroo has prepared a project summary which is available free of charge from (who and address).

Copies of the Environmental Review may be purchased for $5 from:

Shire of Wanneroo &/or Consultant
Address
Telephone: _____

Copies of the complete Environmental Review will be available for examination at:

- Department of Environmental Protection
  Library Information Centre
  8th Floor, Westralia Square
  141 St Georges Tce
  PERTH WA 6000
- Shire of Wanneroo Council Office
- Name of shire libraries

Submissions on this scheme/amendment are invited by (date). Please address your submission to:

Shire of Wanneroo
PO Box 21

JOONDALP WA 6919
Attention:

If you have any questions on how to make a submission, please ring the DEP project officer Stacey Harley on (08) 9222 7182, or Shire of Wanneroo on .....

APPENDIX 2

EXTRACTS FROM ALAN TINGAY & ASSOCIATES (1992b)

2. FLORA SURVEY

2.1 Methods

A list of the native species of the Yanchep property was compiled from observations and collections made along a series of foot and vehicle traverses carried out from September to November, 1991. These traverses covered the entire property but the southern section was extensively and severely burnt by a fire in January 1991 and therefore was not sampled in detail. Specimens which were difficult to identify in the field were collected, dried and pressed and later identified and verified at the Western Australian Herbarium.

Introduced species were recorded only if they occurred in areas of native vegetation.

As the Yanchep property was a likely habitat for one rare and one endangered *Eucalyptus* species a specialist botanist was contracted to search for these. His report is provided in Appendix 2.

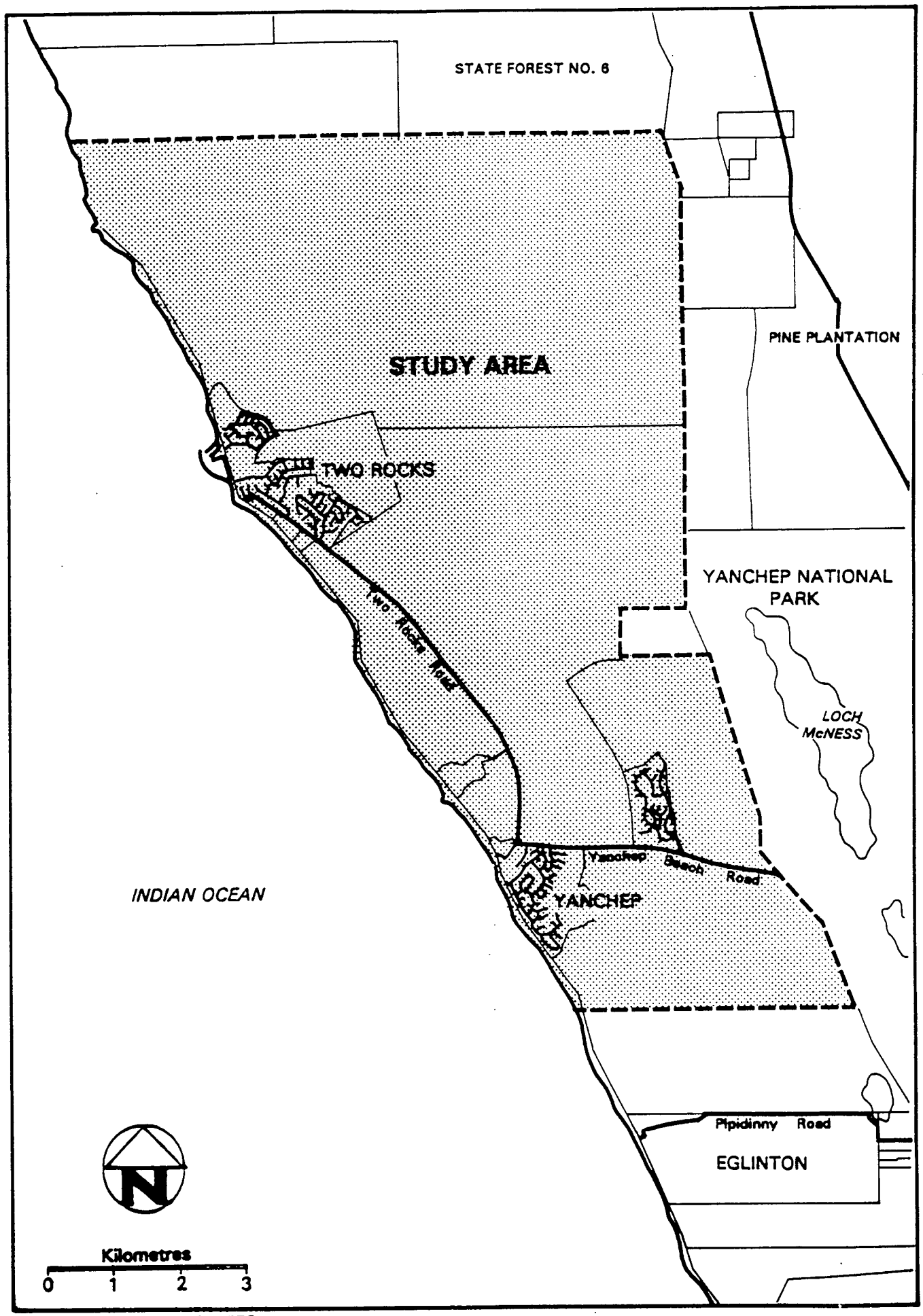
2.2 General Description

A total of 302 species were collected from the study area, including 248 native species and 54 introduced species (17.9% of the total). The complete list of species is presented in Appendix 1.

The 302 species are from 183 genera and 65 families. Dicotyledons comprise 228 species (75% of total), 135 genera (74%) and 50 families (77%) (Table 1). Thirty two families (49%) include only 1 or 2 species each. The most common Dicotyledon families are the Proteaceae, Myrtaceae, Asteraceae and Papilionaceae, all with 22 species. Considering native species only, the order is Proteaceae (22 species), Myrtaceae (20), Asteraceae (18) and Papilionaceae (18).

The families with the highest number of species in the Monocotyledonae are the Poaceae (20 species), Orchidaceae (11), Anthericaceae (7) and Cyperaceae (7). However, there are 14 introduced species of Poaceae. The order of Monocotyledon families, if only the native species are considered, is Orchidaceae (11), Cyperaceae (7), Haemodoraceae (6) and Poaceae (6).

The total of 248 native species is comparable with other areas of similar size in the region. For example 221 native species have been recorded to date from Wilbinga and Caraban MPA (10,000ha) and 166 native species from Breton Bay (7,000ha).



ALAN TINGAY & ASSOCIATES

LOCATION OF STUDY AREA

FIGURE 2

TABLE 1

PLANT FAMILIES AND THEIR NUMBER OF SPECIES REPRESENTED IN THE COLLECTION

( ) = number of non-native species

	Family	No. of Species
GYMNOPHYTA	Zamiaceae	1
MONOCOTYLEDONS	Poaceae	20 (14)
	Orchidaceae	11
	Cyperaceae	7
	Haemodoraceae	6
	Anthericaceae	5
	Restionaceae	5
	Iridaceae	4 (2)
	Daspyogonaceae	3
	Colchicaceae	2
	Asphodelaceae	2 (2)
	Xanthorrhoeaceae	2
	Centrolepidaceae	2
	Phormiaceae	1
	Juncaginaceae	1
DICOTYLEDONS	Proteaceae	22
	Myrtaceae	22 (2)
	Asteraceae	22 (5)
	Papilionaceae	22 (5)
	Epacridaceae	11
	Mimosaceae	10
	Goodeniaceae	9
	Apiaceae	8 (1)
	Brassicaceae	5 (4)
	Dilleniaceae	5
	Rhamnaceae	5
	Geraniaceae	5 (3)
	Stylidiaceae	5
	Aizoaceae	4 (2)
	Caryophyllaceae	4 (4)
	Thymeleaceae	4
	Santalaceae	4
	Casuarinaceae	3
	Lauraceae	3
	Droseraceae	3
	Crassulaceae	3 (1)

	Family	No. of Species
DICOTYLEDONS (continued)	Euphorbiaceae	3 (1)
	Sterculiaceae	3
	Solanaceae	3 (1)
	Polygonaceae	2 (2)
	Chenopodiaceae	2
	Amaranthaceae	2
	Portulacaceae	2
	Stackhousiaceae	2
	Sapindaceae	2
	Lamiaceae	2
	Myoporaceae	2
	Lobeliaceae	2
	Urticaceae	1
	Olacaceae	1
	Loranthaceae	1
	Gyrostemonaceae	1
	Phytolaccaceae	1 (1)
	Ranunculaceae	1
	Pittosporaceae	1
	Oxalidaceae	1 (1)
	Rutaceae	1
	Polygalaceae	1
	Violaceae	1
	Primulaceae	1 (1)
	Loganiaceae	1
	Scrophulariaceae	1 (1)
	Orobanchaceae	1 (1)
	Rubiaceae	1
	Campanulaceae	1

APPENDIX 3

VEGETATION CONDITION RATINGS

VEGETATION CONDITION RATINGS

U Undisturbed - No obvious signs of damage caused by the activities of man.

SD Slight Disturbance - Some slight signs of damage caused by the activities of man e.g. presence of non-aggressive weeds, vehicle tracks.

D Disturbed - Signs of damage caused by the activities of man including some impact on the vegetation structure such as caused by grazing, fire, logging. Non-aggressive weeds mainly, possibly with some more aggressive ones.

OD Obvious Disturbance - Obvious impacts of man such as grazing, partial clearing, frequent fires. Vegetation structure slightly altered but able to regenerate. More aggressive weeds such as Veltdgrass probably present.

SD Severe Disturbance - Severely impacted by grazing, fire or clearing with little scope of regeneration to normal structure. Usually with a number of weed species including aggressive species.

DE Degraded - Areas that are completely or almost completely without native species in the structure of the vegetation. Includes areas that are parkland cleared with their flora comprising weed or crop species with isolated native trees or shrubs.

APPENDIX 4

STYGOFAUNA ASSESSMENT SPECIALIST REPORT

The University of Western Australia

Dr Brenton Knott
Department of Zoology
Nedlands, Perth, Western Australia 6907
Facsimile: 61 8 9380 1029
Telephone: 61 8 9380 3970
E- mail: bknott@cyllene.uwa.edu.au

26 March 1999

Mr Neil Beckingham
Alan Tingay and Associates
21 Howard Street
PERTH WA 6000

Facsimile: 94813435

Dear Neil

***Re*: Subterranean Fauna, Lots 201 & 202 Breakwater Drive, Two Rocks**

I have pleasure in forwarding a brief report on our efforts to locate subterranean fauna, particularly stygofauna (obligate subterranean aquatic animals), on Lots 201 & 202 Breakwater Drive, Two Rocks. The area lies to the north of Yanchep National Park and lacks surface water drainage. Although subterranean aquifer water of the Gnangara Mound might reasonably be expected to have radial flow, i.e. directly towards the Indian Ocean, local inhomogeneities of the geological strata combined with local topographic features may well result in some subterranean connectivity with the subterranean waters of Yanchep. Consequently, an investigation was conducted to determine whether some of the Yanchep aquatic cavernicoles occurred in subterranean waters under Lots 201/202, the subject of this Report. In and about Yanchep National Park are five caves with active epiphreatic streams, streams which typically occur at the boundary between the Tamala Limestone and the underlying Bassendean sands. Epiphreatic streams occur on the water table and form when the flow rate increases due to steep gradients in the water table. The epiphreatic streams are shallow (ca 11 m deep) and lined with tree root mats which constitute a reliable food source for subterranean beasts. This food supply, together with connection between many of the cave streams and surface water, are probably the two main for the diversity of aquatic cave dwelling animals at Yanchep, with 41 species in a 20 m stretch of epiphreatic stream in Cabaret Cave (YN 30) (Jasinska, E. J., Knott, B. and A. J. McComb, 1996. Root mats in ground water: a fauna-rich cave habitat. *Journal of the North American Benthological Society* **15**: 508-519) and a total of 98 species (not including rotifers) from the 5 cave streams (Jasinska , E. J., 1997. Faunae of aquatic root mats in caves of southwestern Australia: origins and ecology. Unpublished PhD thesis, Department of Zoology, The University of Western Australia).

What factors control the development of tree root mats? Jasinska (1997) identified five, as follows:

1. Presence of trees above caves. Root mats in Australia are related to a number of species of trees, including *Eucalyptus gomphocephala*, *Casuarina* spp., *Corymbia calophylla*, *Agonis flexuosa* and *Ficus* spp.

2. Cavernous rock with fissures or solution channels, i.e. rock penetrable by roots.

3. Depth to cave waters of <30 m, reflecting the limit to which tree roots can penetrate substrates.

4. Arid conditions in the cave atmosphere and soil above the cave for extended periods of the year.

5. Permanent streams or pools in caves.

With respect to the connections between surface and subterranean waters, Jasinska (1997) recognised six sources of the cavernicoles at Yanchep: (1) interstitial groundwater species, (2) aquatic epigean species representing burrow and other commensals, benthic and planktonic open water highly mobile forms and aquatic forms that move across land, (3) epigean (surface water dwelling) species with terrestrial adult stages and aquatic larvae, (4) hypogean (subterranean water dwelling) species with terrestrial adult stages and aquatic larvae, (5) subterranean open water forms, and (6) moist litter and wet-soil dwellers. The importance of surface waters at Yanchep, for example Loch McNess and Yonderup Lake serving as conduits for possible colonisation of the underworld in the area is, therefore, readily apparent.

What conditions pertain throughout the area of Lots 201 and 202, Breakwater Drive, Two Rocks? Although the area has been cleared partially, good stands of eucalypt remain; there are some karstic features although nowhere near as well developed as at Yanchep; the water table seems to be quite deep; there is no evidence for the presence of subterranean streams or pools; there is no surface water whatsoever. One, possibly two caves were noted. We were able to get to the bottom of the cave of the one undisputed cave despite the unstable rock forms. There were very few roots and none extended to near the bottom of the cave. There was some cave decoration. Although the sediments at the bottom of the cave were moist and there was some evidence of limited surface flow, presumably from the rainfall of the preceding weekend, there was no stream or root mats. In the other possible cave, a hole leading into a cavern, no attempt was made to explore the site given the unstable and dangerous nature of the sediments. Given these conditions I would predict the presence of, at most, a limited subterranean fauna.

Quite extensive efforts were made (1) to get access to subterranean water, and (2) to sample for subterranean aquatic animals.

On Tuesday 16 March, 1999, we covered both lots looking for surface features which might indicate access to subterranean waters through caves and for topographic features which might indicate the presence of a subterranean stream. We identified three topographic points of low elevation to be drilled to see if an epiphreatic stream, even a root mat, might be intersected.

I was not present at the drilling on Saturday 20 March, 1999, but it was abandoned on the second attempt. The first bore reached water at 10 m in sand after boring through vuggy limestone. The second bore reached water at 11 m after going through caprock and sand.

On Tuesday 23 March, 1999, we revisited both lots and attempted to sample subterranean habitats through those access points already present, windmills and bores. A number of windmills were in disrepair and not functioning.

The following sites were sampled. Water was passed through a tower of sieves of size 1mm, 300 µm, 106 µm and all retentates of the two finer sieves returned to the laboratory. The volumes of water sampled from the windmill sites was 27 L, from the bores 5 - 6 L. Material retained on the 1 mm sieve was examined on site for fauna. The samples were kept cool and examined the following morning under a stereomicroscope at 6 - 50x magnifications. The specimens will be photographed next week and the photographs forwarded to you.

Site 1: Windmill, near end of limestone track, Lot 201. The pump was not working but the tank was *ca* quarter full and the water was pumped out making sure that the bottom sediments were disturbed. There was considerable organic material in the water, predominantly the skeletal remains of terrestrial insects. However, two calanoid copepods were found. I have not yet been able to identify them, but they clearly are interstitial by virtue of their small size (~600 μm) and lack of pigmentation. Interstitial copepods, possibly conspecific or at least congeneric, occur at Yanchep.

Site 2: Bore # 61710118, Lot 204. The water table was deep (> 20 m) and was sampled using your baler. Despite the locked cap on the bore, there was some organic material, predominantly the skeletal remains of terrestrial insects. However, two specimens of stygofauna were recovered, two crangonyctoid amphipods belonging to the same genus as that listed as Gen. Nov. in Jasinska (1997). Pending formal description of the Yanchep species, it is impossible to state whether the present two specimens are conspecific or congeneric.

Site 3: Windmill in lot west of 202. Again, this was sampled from the tank since the windmill was not pumping. Two live copepods (probably same as in Site 1) were found plus several ostracod shells.

Site 4: Windmill, Lot 202. Since the windmill was working, water from the pump lead was sampled directly. Only sand particles were found.

Site 5: Bore 61710027, immediately beyond the eastern boundary of Lot 202. Again the water table was deep, considerably deeper than in site 2 and was sampled using your baler. Some organic material, predominantly the skeletal remains of terrestrial insects but no subterranean fauna.

We have therefore demonstrated the presence of two species of stygofauna in the area. I think that this demonstrates that the methods used were successful, and the low numbers and low diversity are real and not a reflection of limited sampling technique. Of course, if larger volumes of water had been sampled, more specimens undoubtedly would have been found but a realistic compromise had to be made on time spent on sampling. Given the nature of the bores, I doubt whether we would have been able to extract significantly greater volumes of water.

The copepod and amphipod species have persisted despite some clearing of the surface woodland. Clearly, it is purely guess-work as to whether any species have been lost as a result of the partial clearing. However, given the depth to the water table at the sites with stygofauna, I doubt whether any impact of clearing would have reached the water table.

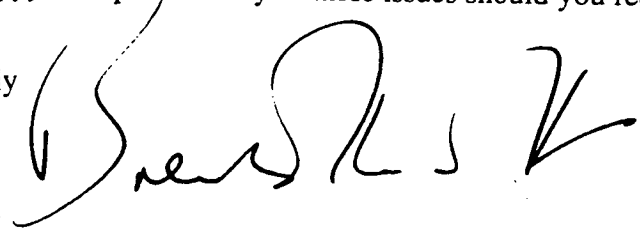
I think that with careful planning, the two most worrying impacts to guard against are

i the transfer of pollutants (excessive nutrient loads, petroleum-based substances, for example) from the surface to the groundwater.

ii the sudden lowering of the water table through heavy, local extraction, or of the Gnangara Mound generally.

I would be happy to expand on any of these issues should you require.

Yours sincerely



Brenton Knott

Alan Tingay
& Associates
environmental
scientists

12 April 1999 99026_005_nb

Mr Ben Styles
Tokyu Corporation
C/- Yanchep Sun City
Level 9 QV1 Building
250 St George's Terrace
PERTH WA 6000

Dear Ben,

RE: LIMITED DRILLING PROGRAM UNDERTAKEN FOR STYGOFAUNA ASSESSMENT ON LOTS 201 AND 202 BREAKWATER DRIVE, TWO ROCKS.

1. INTRODUCTION

The purpose of this letter is to detail the results of an attempted stygofauna sampling program utilising drilling in karst terrain on Lots 201 and 202 Breakwater Drive, Two Rocks. This work was commissioned by Tokyu Corporation and carried out on 20 March 1999.

The objective of the study was to provide new sampling points for stygofauna in karstic areas on the site. However, the drilling program was abandoned due to ground conditions encountered.

2. BACKGROUND

The issue of a stygofauna assessment for the site was a primary concern on the Environmental Protection Authority (EPA) and was raised as such on a meeting of 21 January 1999. It was indicated that the issue of stygofauna had been a factor for the EPA in setting a formal level of assessment for the proposed development.

The concept of a drill program was refined through conversations with Brenton Knott (UWA Zoology), Stacey Harley (DEP) and Bill Humphries (WA Museum).

It was decided to attempt to install five peizometers in areas prospective for stygofauna. In order to maximise the potential for sampling stygofauna the use of five millimetre slotted casing was selected. It was envisaged that casing would be required to be placed in cavernous limestone at the water table interface.

21 Howard Street, Perth 6000 Western Australia
Tel: (08) 9481 3434 Fax: (08) 9481 3435
E-mail: tingay@wantree.com.au

3. FIELD WORK

Field work consisted of drilling two boreholes using air core techniques. Drilling was carried out under the direction of a geologist from Alan Tingay & Associates. Borehole logs are attached. Both boreholes were not able to have peizometers installed due to the very friable nature of sands (holes collapsed upon withdrawal) and the impracticality of placing five millimeter screens in fine, grain size, sandy soils.

4. SITE CONDITIONS

4.1 Surface Conditions

The two drill holes were located in the south-western corner of Lot 202 where the RL's are lowest and the water table depth known to be the most shallow over the entire site. In addition both holes were sited over areas of karstic phenomena. TSA001 was sited at the bottom of a doline surrounding by isolated Tamala Limestone subcrop. TSA002 was sited just off an area of low lying Tamala Limestone outcrop, adjacent to several small collapse features (less than two metres in diameter and less than one metre deep) and nearby (less than fifty metres) to an active doline.

4.2 Subsurface Conditions

The following soil and rock units were identified:

UNIT	DESCRIPTION
Unit 1	Sand, very coarse to fine grained, grey to yellow orange (sands derived from Tamala Limestone)
Unit 2	Limestone/sandstone, fine to medium grained, light brown, includes calcrete, minor cavities.

5. ANALYSIS AND RECOMMENDATIONS

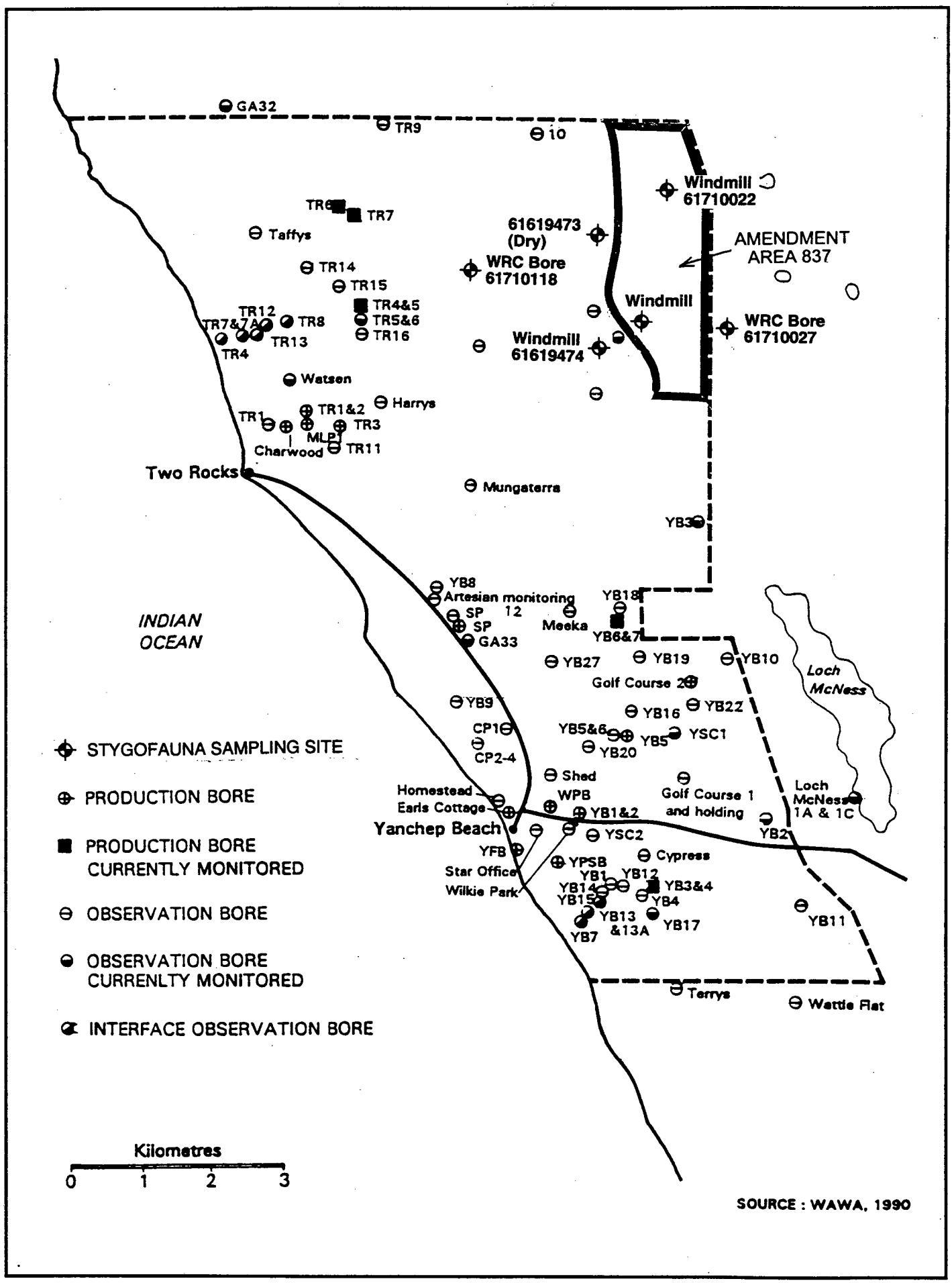
Discussions with DEP, UWA Zoology and the WA Museum indicated the optimum configuration of a borehole to sample for stygofauna would be five millimeter slotted casing located in cavernous Tamala Limestone at the water table interface. However, having drilled two holes in areas prospective areas for these conditions, the program was abandoned. This was due to the failure to locate suitable ground conditions and the realization in order to do so requires a very extensive drill program. Angus Davidson (Supervisor of Groundwater Resources, Water & Rivers Commission) agreed that in order to achieve an appropriate stratigraphy for stygofauna monitoring (cavernous limestone below the water table) potentially many exploration holes would be necessitated.

However, a sampling program was undertaken of the existing boreholes in and around the site. The methodology and results of this program are presented in the Environmental Review for Amendment 837, Shire of Wanneroo, Town Planning Scheme No. 1 (Alan Tingay & Associates, 1999). This sampling proved to be adequate for the purpose of stygofauna assessment and subsequently no further drilling is proposed. This decision is based on the adequacy of the sampling program already undertaken and the difficulty of accurately locating further monitoring bores specifically for stygofauna.

If you require any further information with respect to this issue please do not hesitate to contact me on (08) 9481 3434.

With regards

NEIL BECKINGHAM
Senior Environmental Scientist



99027/99_12F8 DRAWN: GLM 24-3-99 CHECKED: NB 7-5-99

SHIRE OF WANNEROO TOWN PLANNING SCHEME No1
AMMENDMENT 837, YANCHEP - TWO ROCKS

BOREHOLE LOCATIONS

APPENDIX 4 FIGURE 1

Alan Tingay & Associates
environmental scientists

ALAN TINGAY & ASSOCIATES

DRILL LOG

HOLE NO: **TSA 001**

Project:	**Tokyu Stygofauna Assessment**	*Client:*	**Tokyu Corporation**
Location:	Lot 202, Edge of Doline	*Job No:*	99027

Elevation:		m, AHD		*Logged By:*	Neil Beckingham
Coordinates:	N:		E:	*Checked By:*	
Excavator:				*Date:*	20/03/99

Depth (m)	Sample Type	Graphic Log	USCS Class	Description
5.0	Sand		SP	QUARTZ SAND - Grey to orange yellow, medium to fine grain size, moderately well sorted.
	Rock			CALCRETE - Cream to buff, fine to medium grain size, moderately well sorted, well rounded, fractured structure - voids to 5cm
10.0	Sand		SP	QUARTZ SAND - Brown to orange yellow, medium to coarse grain size. Moderately well sorted. ▽ Water table 11.0m.
15.0				
20.0	Sand		SP	QUARTZ SAND - brown,medium to coarse to very coarse, well rounded gravels and sand, poorly sorted.
25.0	Sand		SP	QUARTZ SAND - Yellow to orange, fine to medium grained, moderately well sorted.
30.0				EOH
35.0				

ALAN TINGAY & ASSOCIATES

DRILL LOG

HOLE NO: **TSA 002**

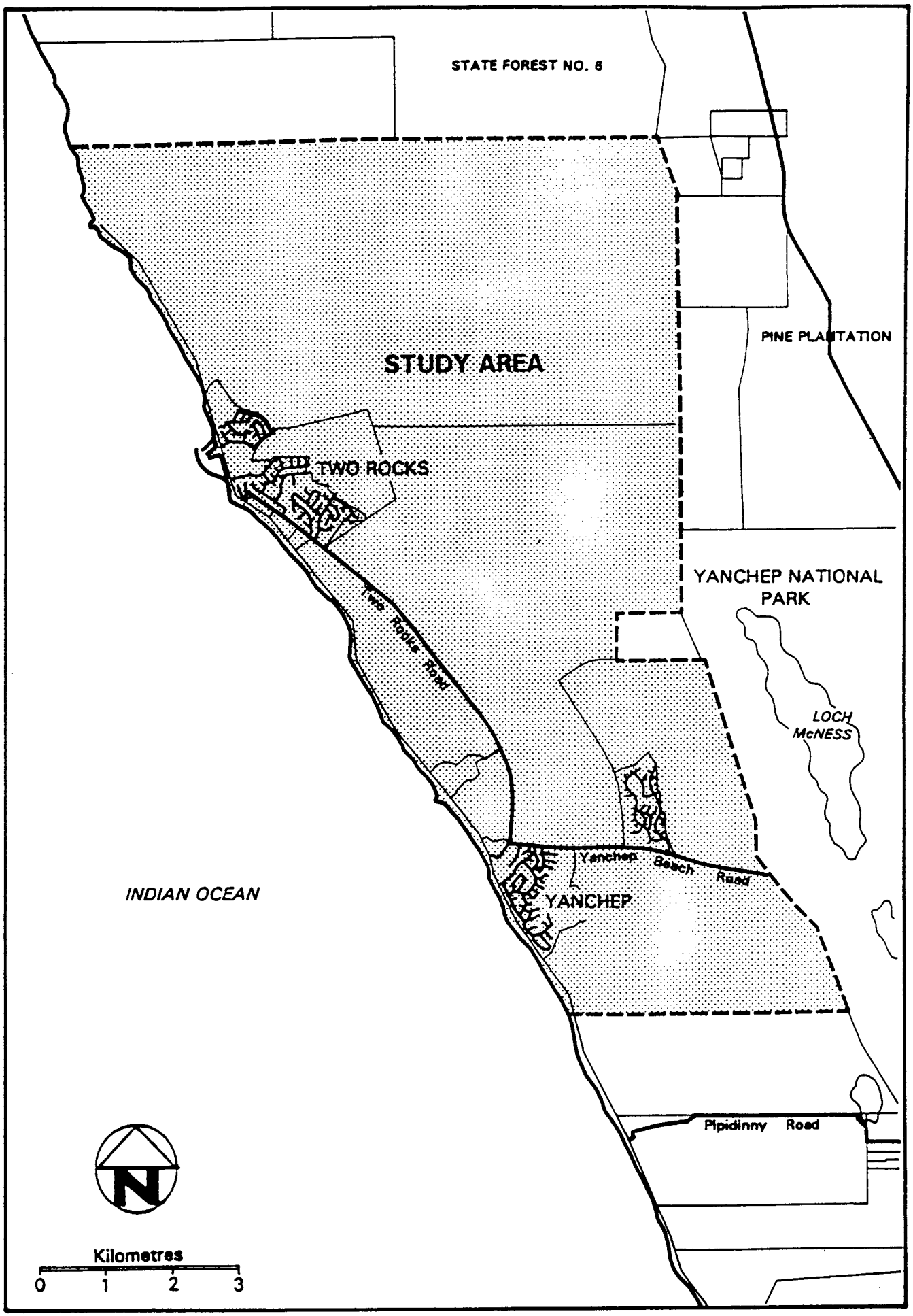
Project:	**Tokyu Stygofauna Assessment**	*Client:*	**Tokyu Corporation**
Location:	Lot 202, Edge of Doline	*Job No:*	99027

Elevation:	m, AHD	*Logged By:*	Neil Beckingham
Coordinates:	N: E:	*Checked By:*	
Excavator:		*Date:*	20/03/99

Depth (m)	Sample Type	Graphic Log	USCS Class	Description
	Rock			CALCAREOUS QUARTZ SANDSTONE - White, fine to medium grain size, moderately well sorted, well rounded.
				VOID 1.9-2.1m
	Rock			
5.0				VOID 4.0-4.65m
	Rock			CALCAREOUS QUARTZ SANDSTONE - White, fine to medium grain size, moderately well sorted, well rounded, well indurated.
10.0				▽ Water Table 10.2m
	SAND		SP	QUARTZ SAND - Grey to orange yellow, medium to fine grain size, moderately to poorly sorted.
15.0				
20.0				
25.0				
				EOH
30.0				
35.0				

APPENDIX 5

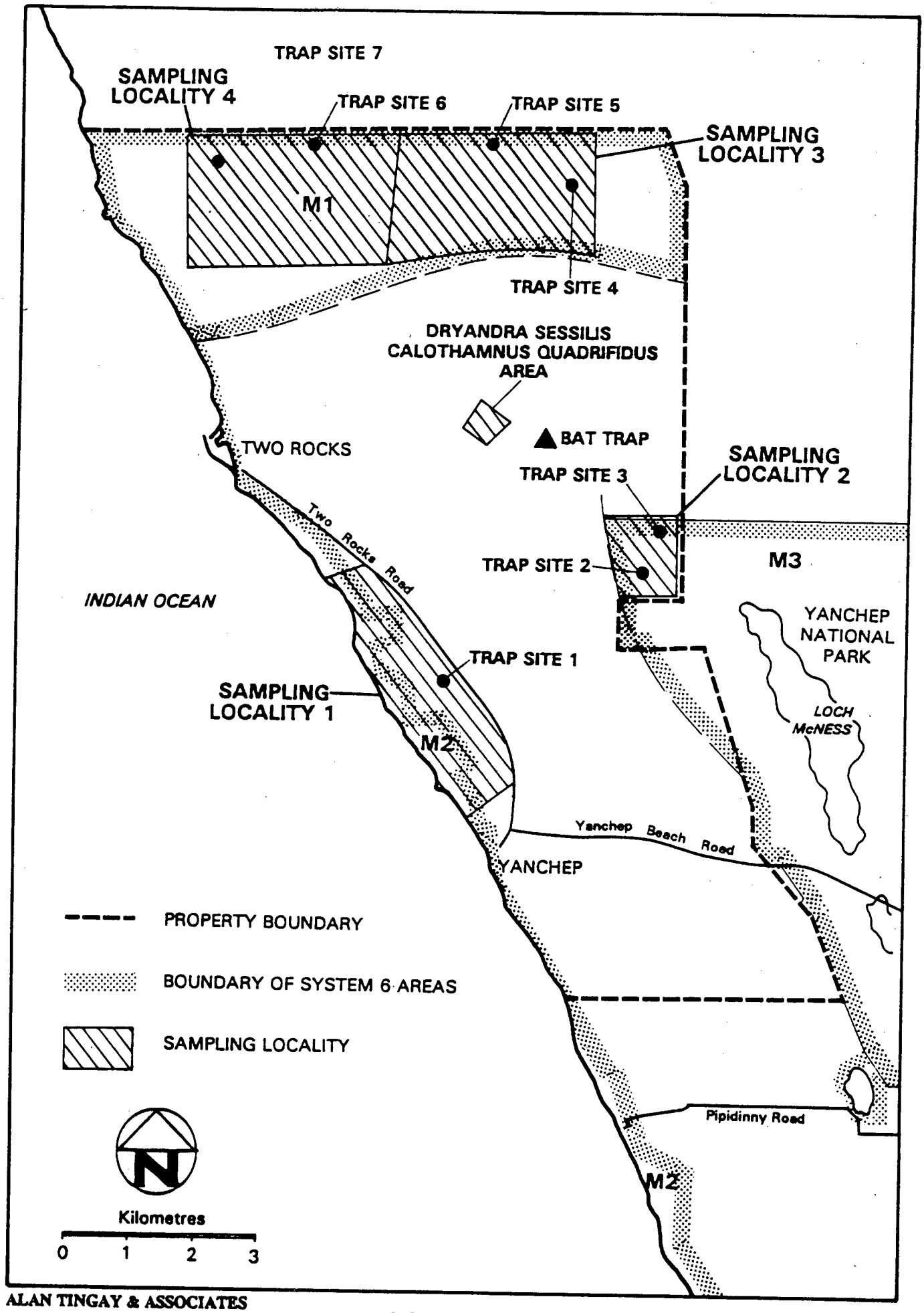
FAUNA SPECIES LIST EXTRACTED FROM ALAN TINGAY & ASSOCIATES (1991)



ALAN TINGAY & ASSOCIATES

LOCATION OF STUDY AREA

FIGURE 1



ALAN TINGAY & ASSOCIATES

LOCATION OF FAUNA SAMPLING AREAS AND TRAP SITES

FIGURE 2

OBSERVED FAUNA ON YANCHEP PROPERTY

KEY:

A-HABITAT TYPE

1. Property as a whole

2. Coastal Heath (systematically surveyed)

3. Inland Heath (systematically surveyed)

4. *Banksia* Woodland (systematically surveyed)

5. Tuart *Eucalyptus gomphocephela* Woodland (systematically surveyed)

6. Other (opportunistic survey only includes pasture)

B. STATUS

* Observed during survey

\# Rare or otherwise in need of special protection (Wildlife Conservation Act, 1990)

(o) Introduced species

Numbers refer to maximum number of individuals seen during survey (numbers not shown for opportunistic sightings)

Amphibian & Reptile Species						
Habitat Type	**1**	**2**	**3**	**4**	**5**	**6**
LEPTODACTYLIDAE/FROGS						
Heleioporus eyrei	*			2	3	
Limnodynastes dorsalis	*	1		1	1	
Myobatrachus gouldii	*			2	2	
Total Number of Species	**3**	**1**		**3**	**3**	
GEKKONIDAE/GECKOS						
Crenadactylus o. ocellatus	*				2	
Diplodactylus spinigerus	*	1				
Phyllodactylus m. marmoratus	*			3	2	
PYGOPOGIAE/LEGLESS LIZARDS						
Apraisia repens	*	1				
Delma fraseri	*		1	1		
D. grayii	*			1		
Lialis burtonis	*				1	
Pletholax g. gracilis	*	1				
AGAMIDAE/DRAGON LIZARDS						
Pogona m. minor	*	1		1		
Tympanocryptis a. adelaidensis	*			2		
SCINCIDAE/SKINKS						
Cryptoblepharus plagiocephalus	*			1	2	*
Ctenotus fallens	*	1		1		
C. lesueurii	*			1		
Egernia kingii	*	1				
Hemiergis quadrilineata	*	1	1	1	3	
Lerista elegans	*	2	2	1	2	
L. praepedita	*				1	
Menetia greyii	*		6	1	1	
Morethia obscura	*			1	1	
M. lineoocellata	*		1		1	
Tiliqua occipitalis	*					*
T. r. rugosa	*	2	4	2	2	*
ELAPIDAE/ELAPID SNAKES						
Pseudonaja a. affinis	*	1	1			
Vermicella bimaculata	*			1		
Total Number of Species	24	10	7	12	11	3

Bird Species						
Habitat Type	**1**	**2**	**3**	**4**	**5**	**6**
DROMAIIDAE						
Dromaius novaehollandiae/Emu	*		1	1	1	*
ANATIDAE						
Tadorna tadornoides/Australian Shelduck	*				5	
ACCIPITRIDAE						
Elanus notatus/Black-shouldered Kite	*		1			
Lophoictinia isura/Square-tailed Kite	*		1			
Aquila audax/Wedge-tailed Eagle	*		1	1		
Hieraaetus morphnoides/Little Eagle	*	1	1			
FALCONIDAE						
Falco peregrinus/Peregrine Falcon #	*		*			
F. longipennis/Australian Hobby	*			1	1	
F. cenchroides/Australian Kestrel	*	1	2			
OTIDIDAE						
Ardeotis australis/Australian Bustard	*		1			
LARIDAE						
Larus novaehollandiae/Silver Gull	*	1				
COLUMBIDAE						
Colomba livia/Feral Pigeon (o)	*	12	1			
Streptopelia chinesis/Spotted Turtle-Dove (o)	*					*
Streptopelia senegalensis/Laughing Turtle-Dove (o)	*	6		1		
Phaps chalcoptera/Common Bronzewing	*				1	
CACATUIDAE						
Calyptorhynchus funereus latirostris/						
Carnaby's Black Cockatoo #	*		1	10	4	
Cacatua roseicapilla/Galah	*	5		7	12	*
C. sanguinea/Little Corella	*					*
PLATYCERCIDAE						
Barnardius zonarius/Port Lincoln Ringneck	*			5	19	*
Neophema elegans/Elegant Parrot	*				*	
CUCULIDAE						
Cuculus pallidus/Pallid Cuckoo	*			1	2	
C.pyrrhophanus/Fan Tailed Cuckoo	*	1			3	
Chrysococcyx basalis/Horsfield's Bronze Cuckoo	*	1	1	1	2	
C.lucidus/Shining Bronze Cuckoo	*			1	2	
STRIGIDAE						
Ninox novaeseelandiae/Southern Boobook	*				2	
PODARGIDAE						
Podargus strigoides/Tawny Frogmouth	*			2		
ALCEDINIDAE						
Dacelo novaeguineae/Laughing Kookaburra (o)	*			1	1	
Halcyon sancta/Sacred Kingfisher	*		1			*
MEROPIDAE						
Merops ornatus/Rainbow Bee-eater	*			2		
HIRUNDINIDAE						
Cheramoeca leucosternum/White-backed Swallow	*	1	1			
Hirundo neoxena/Welcome Swallow	*	4	1			
Cecropis nigricans/Tree Martin	*	18	1			
MOTACILLIDAE						
Anthus novaeseelandiae/Richard's Pipit	*	1				*

Bird Species						
Habitat Type	**1**	**2**	**3**	**4**	**5**	**6**
CAMPEPHAGIDAE						
Coracina novaehollandiae/Black-faced Cuckoo-shrike	*		2	3	3	
MUSCICAPIDAE						
Petroica multicolor/Scarlet Robin	*			3	6	
Melanodryas cucullata/Hooded Robin	*			1		
Pachycephala rufiventris/Rufous Whistler	*			3	3	
Colluricincla harmonica/Grey Shrike-thrush	*			1	5	
Rhipidura fuliginosa/Grey Fantail	*	3		2	5	
R. leucophrys/Willie Wagtail	*	1	1	1		
MALURIDAE						
Malurus splendens/Splendid Fairy-wren	*	1	8	5	18	
M. leucopterus/White-winged Fairy-wren	*	4				
ACANTHIZIDAE						
Sericornis frontalis/White-browed Scrubwren	*	22				
Smicrornis brevirostris/Weebill	*				1	*
Gerygone fusca/Western Gerygone	*	2		4	12	*
Acanthiza apicalis/Inland Thornbill	*	1			1	
A. inornata/Western Thornbill	*			5	4	
A. chrysorrhoa/Yellow-rumped Thornbill	*				5	
MELIPHAGIDAE						
Anthochaera carunculata/Red Wattlebird	*	6	4	10	6	*
A. chrysoptera/Little Wattlebird	*	1	1	6	14	
Lichenostomus virescens/Singing Honeyeater	*	12	1	7	2	
L. ornatus/Yellow-plumed Honeyeater	*				*	
Melithreptus lunatus/White-naped Honeyeater	*				*	
Lichmera indistincta/Brown Honeyeater	*	7	15	32	21	
Phylidonyris novaehollandiae/New Holland Honeyeater	*			2	3	
P. nigra/White-cheeked Honeyeater	*	3	5	11		
P. melanops/Tawny-crowned Honeyeater	*		12			
Acanthorhynchus superciliousus/Western Spinebill	*			1	4	
PARDALOTIDAE						
Pardalotus punctatus/Spotted Pardalote	*				4	
P. striatus/Striated Pardalote	*			1	8	
ZOSTEROPIDAE						
Zosterops lateralis/Silvereye	*	4	4	4		
GRALLINDAE						
Grallina cyanoleuca/Australian Magpie-lark	*			1	1	
ARTAMIDAE						
Artamus cinereus/Black-faced Woodswallow	*		7			*
CRACTICIDAE						
Cracticus torquatus/Grey Butcherbird	*	5	3	1	1	
Gymnorhina tibicen/Australian Magpie	*	3	2	5	7	*
CORVIDAE						
Corvus coronoides/Australian Raven	*	6	6	4	6	*
Total Number of Species	66	28	29	38	37	13
Total Number of Native Birds	63	26	28	37	37	12

Mammal Species						
Habitat Type	**1**	**2**	**3**	**4**	**5**	**6**
DASYURIDAE						
Sminthopsis griseoventer/Common Dunnart	*		1			
TARSIPEDIDAE						
Tarsipes rostratus/Honey Possum	*		1			
MACROPODIDAE						
Macropus irma/Western Brush Wallaby	*			*	*	
M. fuliginosus/Western Grey Kangaroo	*		11	16	8	*
VESPERTILIONIDAE						
Eptesicus regulus/King River Eptesicus	*				1	*
MURIDAE						
Mus musculus/House Mouse (o)	*	6		4	2	
Rattus fuscipes/Bush Rat	*	3				
Rattus rattus/Black Rat (o)	*	2				
LEPORIDAE						
Oryctolagus cuniculus/Rabbit (o)	*	1	*	*	*	*
CANIDAE						
Vulpes vulpes/Fox (o)	*	1	*	*		*
FELIDAE						
Felis catus/Feral Cat (o)	*	*		1		*
Total Number of Species	11	5	6	6	4	5
Total Native Mammals	6	1	3	2	3	2

FAUNA FOUND IN SYSTEM 6 AREAS ON YANCHEP PROPERTY

KEY:

A. SYSTEM 6 AREA

1. M2 Coastal Strip between Yanchep and Two Rocks (Coastal Heath)

2. M3 Yanchep National Park area (Banksia and Tuart Woodland)

3. M1 Two Rocks Open Space (Banksia and Tuart Woodland)

4. M1 Two Rocks Open Space (Mainly Heath)

B. STATUS

* Observed during survey

\# Rare or otherwise in need of special protection

(o) Introduced species

@ Observed during survey but not in System 6 Areas

Amphibian & Reptile Species				
System 6 Area	1	2	3	4
LEPTODACTYLIDAE/FROGS				
Heleioporus eyrei		*		
Limnodynastes dorsalis	*	*	*	
Myobatrachus gouldii		*	*	
Total Number of Species	1	3	2	0
GEKKONIDAE/GECKOS				
Crenadactylus o. ocellatus			*	
Diplodactylus spinigerus	*			
Phyllodactylus m. marmoratus		*	*	
PYGOPOGIAE/LEGLESS LIZARDS				
Apraisia repens @				
Delma fraseri				*
D. grayii			*	
Lialis burtonis		*	*	
Pletholax g. gracilis	*			
AGAMIDAE/DRAGON LIZARDS				
Pogona m. minor	*		*	
Tympanocryptis a. adelaidensis			*	
SCINCIDAE/SKINKS				
Cryptoblepharus plagiocephalus		*	*	
Ctenotus fallens	*	*		
C. lesueurii		*		
Egernia kingii @				
Hemiergis quadrilineata	*	*	*	
Lerista elegans	*		*	*
L. praepedita @				
Menetia greyii			*	*
Morethia obscura		*	*	
M. lineoocellata			*	*
Tiliqua occipitalis @				
T. r. rugosa	*	*	*	*
ELAPIDAE/ELAPID SNAKES				
Pseudonaja a. affinis	*			*
Vermicella bimaculata			*	
Total Number of Species	8	8	14	6

Bird Species				
System 6 Area	1	2	3	4
DROMAIIDAE				
Dromaius novaehollandiae/Emu		*	*	*
ANTATIDAE				
Tadorna tadornoides/Australian Shelduck		*		
ACCIPITRIDAE				
Elanus notatus/Black-shouldered Kite				*
Loproictinia isura/Square-tailed Kite @				
Aquila audax/Wedge-tailed Eagle		*		*
Hieraaetus morphnoides/Little Eagle				*
FALCONIDAE				
Falco peregrinus/Peregrine Falcon # @				
F. longipennis/Australian Hobby			*	*
F. cenchroides/Australian Kestrel	*			*
OTIDIDAE				
Ardeotis australis/Australian Bustard				*
LARIDAE				
Larus novaehollandiae/Silver Gull	*			
COLUMBIDAE				
Columba livia/Feral Pigeon (o)	*			*
Streptopelia chinensis/Spotted Turtle Dove (o) @				
Streptopelia senegalnesis/Laughing Turtle-Dove (o)	*	*		*
Phaps chalcoptera/Common Bronzewing		*		
CACATUIDAE				
Calyptorhynchus funereus latirostris/				
Carnaby's Black Cockatoo #		*	*	*
Cacatua roseicapilla/Galah	*	*	*	
C. sanguinea/Little Corella @				
PLATYCERCIDAE				
Barnardius zonarius/Port Lincoln Ringneck		*	*	*
Neophema elegans/Elegant Parrot @				
CUCULIDAE				
Cuculus pallidus/Pallid Cuckoo	*	*		*
C. pyrrhophanus/Fan-tailed Cuckoo	*		*	
Chrysococcyx basalis/Horsfield's Bronze-Cuckoo	*	*	*	*
C. lucidus/Shining Bronze-Cuckoo		*	*	*
STRIGIDAE				
Ninox novaeseelandiae/Southern Boobook		*		
PODARGIDAE				
Podargus strigoides/Tawny Frogmouth		*	*	
ALCEDINIDAE				
Dacelo novaeguineae/Laughing Kookaburra (o)		*	*	*
Halcyon sancta/Sacred Kingfisher @				
MEROPIDAE				
Merops ornatus/Rainbow Bee-eater	*	*		
HIRUNDINIDAE				
Cheramoeca leucosternum/White-backed Swallow	*			*
Hirundo noexena/Welcome Swallow	*			*
Cecropis nigricans/Tree Martin	*			*
MOTACILLIDAE				
Anthus novaeseelandiae/Richard's Pipit				*
CAMPEHAGIDAE				
Coracina novaehollandiae/Black-faced Cuckoo-shrike		*	*	*

Bird Species				
System 6 Area	1	2	3	4
MUSCICAPIDAE				
Petroica multicolor/Scarlet Robin		*	*	
Melanodryas cucullata/Hooded Robin			*	
P. rufiventris/Rufous Whistler	*	*	*	*
Colluricincla harmonica/Grey Shrike-thrush		*	*	*
Rhipidura fuliginosa/Grey Fantail	*	*	*	*
R. leucophrys/Willie Wagtail	*	*		*
MALURIDAE				
Malurus splendens/Splendid Fairy-wren	*	*	*	*
M. leucopterus/White-winged Fairy-wren	*			*
ACANTHIZIDAE				
Sericornis frontalis/White-browed Scrubwren	*			*
Smicornis brevirostris/Weebill		*	*	
Gerygone fusca/Western Gerygone	*	*	*	*
Acanthiza apicalis/Inland Thornbill	*	*		
A. inornata/Western Thornbill		*	*	*
A. chrysorrhoa/Yellow-rumped Thornbill		*	*	
MELIPHAGIDAE				
Anthochaera carunculata/Red Wattlebird	*	*	*	*
A. chrysoptera/Little Wattlebird	*	*	*	*
Lichenostomus virescens/Singing Honeyeater	*	*	*	*
L. ornatus/Yellow-plumed Honeyeater @				
Melithreptus lunatus/White-naped Honeyeater @				
Lichmera indistincta/Brown Honeyeater	*	*	*	*
Phylidonyris novaehollandiae/New Holland Honeyeater		*	*	*
P. nigra/White-cheeked Honeyeater	*	*	*	*
P. melanops/Tawny-crowned Honeyeater				*
Acanthorhynchus superciliousus/Western Spinebill		*	*	
PARDALOTIDAE				
Pardalotus punctatus/Spotted Pardalote		*		
P. striatus/Striated Pardalote		*	*	
ZOSTEROPIDAE				
Zosterops lateralis/Silvereye	*		*	*
GRALLINDAE				
Grallina cyanoleuca/Australian Magpie-lark		*		
ARTAMIDAE				
Artamus cinereus/Black-faced Woodswallow				*
CRACTICIDAE				
Cracticus torquatus/Grey Butcherbird	*	*	*	*
Gymnorhina tibicen/Australian Magpie	*	*	*	*
CORVIDAE				
Corvus coronoides/Australian Raven	*	*	*	*
Total Number of Species	29	40	33	41
Total Number of Native Species	27	38	32	38

Mammal Species				
System 6 Area	**1**	**2**	**3**	**4**
DASYURIDAE				
Sminthopsis griseoventer/Common Dunnart				*
TARSIPEDIDAE				
Tarsipes rostratus/Honey Possum				*
MACROPODIDAE				
Macropus irma/Western Brush Wallaby		*		*
M. fuliginosus/Western Grey Kangaroo		*	*	*
VESPERTILIONIDAE				
Eptesicus regulus/King River Eptesicus @				
MURIDAE				
Mus musculus/House Mouse (o)	*	*	*	
Rattus fuscipes/Bush Rat	*			
Rattus rattus/Black Rat (o) @				
LEPORIDAE				
Oryctolagus cuniculus/Rabbit (o)	*	*	*	*
CANIDAE				
Vulpes vulpes/Fox (o)	*		*	*
FELIDAE				
Felis catus/Feral Cat (o)	*		*	
Total Number of Species	5	4	5	6
Total Number of Native Species	1	2	1	4

FAUNA FOUND ON YANCHEP PROPERTY AND NEARBY REGIONS

KEY:

A. REGION

1. Yanchep property (based on present vertebrate fauna survey by Alan Tingay & Associates, 1991).

2. Eglinton (based on fauna assessment by Ninox Wildlife Consulting, 1990).

3. Breton Bay (based on fauna assessment by Ninox Wildlife Consulting, 1991).

4. Wilbinga (based on a fauna assessment by Ninox Wildlife Consulting, 1991).

5. Yanchep National Park (based on the following:

   - o Burbidge & Rolfe, pers.comm. 1991 - CALM Fauna Survey of Yanchep National Park 1987-1988 (unpublished)

   - o Shannon, pers.comm. 1991 - Bird banding studies in Yanchep National Park 1981-1991 (unpublished).

   - o RAOU sightings database for Yanchep National Park, 1987-1989 (unpublished).

B. STATUS

* Observed or trapped during survey.
Note: Only land birds have been included on the lists. Seabirds, waders and waterbirds have been omitted to allow meaningful comparisons of regions.

\# Rare or otherwise in need of special protection

(o) Introduced species

Amphibian & Reptile Species					
Region	**1**	**2**	**3**	**4**	**5**
LEPTODACTYLIDAE/FROGS					
Heleioporus eyrei	*				*
Limnodynastes dorsalis	*				*
Litoria adelaidensis					*
L. moorei					*
Myobatrachus gouldii	*				*
Ranidella sp					*
Total Number of Species	**3**	**0**	**0**	**0**	**6**
GEKKONIDAE/GECKOS					
Crenadactylus o. ocellatus	*				*
Diplodactylus polyophthalmus					*
D. spinigerus	*				*
Phyllodactylus m. marmoratus	*			*	*
Underwoodisaurus millii				*	
PYGOPOGIAE/LEGLESS LIZARDS					
Apraisia repens	*			*	*
Delma fraseri	*				*
D. grayii	*				*
Lialis burtonis	*				*
Pletholax g. gracilis	*				*
Pygopus lepidopodus				*	*
AGAMIDAE/DRAGON LIZARDS					
Pogona m. minor	*	*	*	*	*
Tympanocryptis a. adelaidensis	*		*	*	*
SCINCIDAE/SKINKS					
Cryptoblepharus plagiocephalus	*			*	*
Ctenotus fallens	*	*	*		*
C. lesueurii	*				*
Egernia kingii	*				
E. napoleonis		*		*	*
Hemiergis quadrilineata	*	*	*	*	*
Leiolopisma trilineatum					*
Lerista elegans	*		*	*	*
L. lineopunctulata			*	*	*
L. praepedita	*	*	*	*	*
Menetia greyii	*			*	*
Morethia lineoocellata	*		*		*
M. obscura	*			*	*
Omolepida branchialis			*	*	*
Tiliqua occipitalis	*	*			
T. r. rugosa	*	*	*	*	*
VARNIDAE/MONITORS					
Varanus gouldii					*
TYPHLOPIDAE/BLIND SNAKES					
Ramphotyphlops australis			*		*

Amphibian & Reptile Species					
Region	1	2	3	4	5
ELAPIDAE/ELAPID SNAKES					
Demansia psammophis reticulata			•		
Notechis curtus			•		
Pseudonaja a.affinis	•				•
Rhinoplocephalus gouldii			•		•
Vermicella bertholdi		•		•	
V. bimaculata	•				
V. calonotos #					•
V. semifasciata				•	
Total Number of Species	24	8	14	18	31

Bird Species					
Region	1	2	3	4	5
DROMAIIDAE					
Dromaius novaehollandiae/Emu	*		*	*	*
ANATIDAE					
Tadorna tadornoides/Australian Shelduck	*				*
ACCIPITRIDAE					
Elanus notatus/Black-shouldered Kite	*			*	*
Haliastur sphenurus					*
Accipter fasciatus/Brown Goshawk				*	*
A. cirrhocephalus					*
Lophoictinia isura/Square-tailed Kite	*				*
Aquila audax/Wedge-tailed Eagle	*		*	*	*
Hieraaetus morphnoides/Little Eagle	*		*	*	*
Circus aeruginosus/Marsh Harrier			*		*
FALCONIDAE					
Falco longipennis/Australian Hobby	*				*
F. berigora/Brown Falcon			*	*	*
F. cenchroides/Australian Kestrel	*	*	*	*	*
TURNICIDAE					
Turnix varia/Painted Button-quail			*		
Turnix velox/Little Button Quail					*
OTIDIDAE					
Ardeotis australis/Australian Bustard	*				
CHARADRIIDAE					
Vanellus tricolor/Banded Lapwing					*
LARIDAE	*				
Larus novaehollandiae/Silver Gull	*		*		
COLUMBIDAE					
Columba livia/Feral Pigeon (o)	*				*
Streptopelia chinesis/Spotted Turtle-Dove (o)	*				*
S. senegalensis/Laughing Turtle-Dove (o)	*				*
Phaps chalcoptera/Common Bronzewing	*	*	*		*
Ocyphaps lophotes/Crested Pigeon			*		
CACATUIDAE					
Calyptorhynchus funereus latirostris/					
Carnaby's Black Cockatoo #	*			*	*
Cacatua roseicapilla/Galah	*		*	*	*
C. sanguinea/Little Corella	*				*
LORIIDAE					
Glossopsitta prophyrocephala/Purple-crowned Lorikeet					*
PLATYCERCIDAE					
Purpureicephalus spurius/Red-capped Parrot					*
Barnardius zonarius/Port Lincoln Ringneck	*	*	*	*	*
Neophema elegans/Elegant Parrot	*				*
CUCULIDAE					
Cuculus pallidus/Pallid Cuckoo	*			*	*
C. pyrrhophanus/Fan-tailed Cuckoo	*			*	*
Chrysococcyx basalis/Horsfield's Bronze-Cuckoo	*		*	*	*
C. lucidus/Shining Bronze-Cuckoo	*		*	*	*
STRIGIDAE					
Ninox novaeseelandiae/Southern Boobook	*				*

Bird Species					
Region	1	2	3	4	5
PODARGIDAE					
Podargus strigoides/Tawny Frogmouth	*				*
AEGOTHELIDAE					
Aegotheles cristatus/Australian Owlet Nightjar					*
APODIDAE					
Apus pacificus/Fork-tailed Swift					*
ALCEDINIDAE					
Dacelo novaeguineae/Laughing Kookaburra (o)	*	*		*	*
Halcyon sancta/Sacred Kingfisher	*				*
MEROPIDAE					
Merops ornatus/Rainbow Bee-eater	*	*		*	*
HIRUNDINIDAE					
Cheramoeca leucosternum/White-backed Swallow	*	*	*	*	*
Hirundo neoxena/Welcome Swallow	*	*	*	*	*
Cecropis nigricans/Tree Martin	*				*
MOTACILLIDAE					
Anthus novaeseelandiae/Richard's Pipit	*	*	*	*	*
CAMPEPHAGIDAE					
Coracina novaehollandiae/Black-faced Cuckoo-shrike	*		*	*	*
Lalage sueurii/White-winged Triller					*
MUSCICAPIDAE					
Petroica multicolor/Scarlet Robin	*			*	*
P. goodenovii/Red-capped Robin					*
Melanodryas cucullata/Hooded Robin	*				
Eopsaltria georgiana/White-breasted Robin			*		
Pachycephala pectoralis/Golden Whistler					*
P. rufiventris/Rufous Whistler	*	*	*	*	*
Colluricincla harmonica/Grey Shrike-thrush	*		*	*	*
Rhipidura fuliginosa/Grey Fantail	*	*	*	*	*
R. leucophrys/Willie Wagtail	*	*	*	*	*
SYLVIIDAE					
Cinclorhamphus mathewsi/Rufous Songlark		*			
C. cruralis/Brown Songlark			*		
MALURIDAE					
Malurus splendens/Splendid Fairy-wren	*	*	*	*	*
M. lamberti/Variegated Fairy-wren		*	*		*
M. leucopterus/White-winged Fairy-wren	*	*	*	*	*
Stipiturus malachurus/Southern Emu-wren					*
ACANTHIZIDAE					
Sericornis frontalis/White-browed Scrubwren	*	*	*		*
Smicrornis brevirostris/Weebill	*			*	*
Gerygone fusca/Western Gerygone	*	*	*	*	*
Acanthiza apicalis/Inland Thornbill	*	*	*	*	*
A. inornata/Western Thornbill	*			*	*
A. chrysorrhoa/Yellow-rumped Thornbill	*	*		*	*

Bird Species					
Region	1	2	3	4	5
NEOSITTIDAE					
Daphoenositta chrysoptera/Varied Sittella					*
CLIMACTERIDAE					
Climacteris rufa/Rufous Treecreeper					*
MELIPHAGIDAE					
Anthochaera carunculata/Red Wattlebird	*	*	*	*	*
A. chrysoptera/Little Wattlebird	*	*	*		*
Manorina flavigula/Yellow-throated Miner			*	*	*
Lichenostomus virescens/Singing Honeyeater	*	*	*	*	*
L. ornatus/Yellow-plumed Honeyeater	*				
Melithreptus lunatus/White-naped Honeyeater	*				*
Lichmera indistincta/Brown Honeyeater	*	*	*	*	*
Phylidonyris novaehollandiae/New Holland Honeyeater	*	*		*	*
P. nigra/White-cheeked Honeyeater	*	*	*		*
P. melanops/Tawny-crowned Honeyeater	*	*	*	*	*
Acanthorhynchus superciliosus/Western Spinebill	*	*	*	*	*
EPHTHIANURIDAE					
Ephthianura tricolor/Crimson Chat					*
E. albifrons/White-fronted Chat					*
DICAEIDAE					
Dicaeum hirundinaceum/Mistletoebird					*
PARDALOTIDAE					
Pardalotus punctatus/Spotted Pardalote	*		*		*
P. striatus/Striated Pardalote	*			*	*
ZOSTEROPIDAE					
Zosterops lateralis/Silvereye	*	*	*	*	*
GRALLINIDAE					
Grallina cyancoleuca/Australian Magpie-lark	*		*		*
ARTAMIDAE					
Artamus cinereus/Black-faced Woodswallow	*		*		*
A. cyanopterus/Dusky Woodswallow					*
CRACTICIDAE					
Cracticus torquatus/Grey Butcherbird	*	*	*	*	*
Cracticus nigrogularis/Pied Butcherbird				*	
Gymnorhina tibicen/Australian Magpie	*	*	*	*	*
CORVIDAE					
Corvus coronoides/Australian Raven	*	*	*	*	*
Total Number of Species	64	31	45	45	84
Total Number of Native Species	60	30	44	44	80

Mammal Species					
Region	**1**	**2**	**3**	**4**	**5**
MACROPODIDAE					
Macropus fuliginosus/Western Grey Kangaroo	*	*	*	*	*
M. irma/Western Brush Wallaby	*				*
TARSIPEDIDAE					
Tarsipes rostratus/Honey Possum	*				*
PERAMELIDAE					
Isoodon obesulus/Southern Brown Bandicoot #					*
DASYURIDAE					
Smithopsis griseoventer/Common Dunnart	*				
MURIDAE					
Hydromys chrysogaster/Water Rat					*
Mus musculus/House Mouse (o)	*	*			*
Rattus fuscipes/Bush Rat	*				*
Rattus rattus/Black Rat (o)	*				*
MOLOSSIDAE					
Tadarida australis/White-striped Mastiff-bat					*
VESPERTILIONIDAE					
Nyctophilus major/Greater Long-eared Bat					*
N. geoffroyi/Lesser Long-eared Bat					*
Chalinobus gouldii/Gould's Wattled Bat					*
Eptesicus regulus/King River Eptesicus	*				
CANIDAE					
Canis familiaris/Dog (o)					*
Vulpes vulpes/Fox (o)	*	*	*	*	*
FELIDAE					
Felis catus/Feral Cat (o)	*				*
LEPORIDAE					
Oryctolagus cuniculus/Rabbit (o)	*	*	*	*	*
BOVIDAE					
Capra hircus/Feral Goat (o)			*		
TACHYGLOSSIDAE					
Tachyglossus aculeatus/Short-beaked Echidna					*
Total Number of Species	**11**	**4**	**4**	**3**	**17**
Total Number of Native Species	**6**	**1**	**1**	**1**	**11**

APPENDIX 6

GROUNDWATER EXTRACTION SPECIAL REPORT

aquaterra

22 Bowman Street, South Perth
Western Australia, 6151
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Fax: (08) 9368 4055

22 March 1999

Alan Tingay & Associates
21 Howard Street
PERTH WA 6000

Attention: Neil Beckingham

Dear Neil,

Re: Rural Community Development (Lots 210 and 202 Breakwater Drive, Two Rocks) Hydrogeological Issues

Further to your letter of 15 March 1999 and telephone calls with yourself and Noel Davies, we are pleased to present the following brief report on our assessment of the hydrogeological issues that you raised in relation to the above development.

We understand that the critical issue is the likely drawdowns of groundwater levels as a result of water supply pumping particularly with respect to the potential impacts on stygofauna. These have been reported to be present in shallow karst features in the subsurface limestones in the Yanchep-Two Rocks area. We also understand that there are no definitive data on what magnitudes of drawdown would pose a threat to the stygofauna. For the purposes of this assessment (as discussed) we have adopted a target drawdown (below prevailing groundwater levels) of 0.5m as the preferred maximum. This is similar to the magnitude of normal seasonal water table fluctuations.

We also make comment on potential wellfield layouts with respect to relative drawdown impacts and also with respect to potential pollution issues.

1. BACKGROUND

Background hydrogeological conditions for the Yanchep-Two Rocks area are well documented in a report by Alan Tingay & Associates and Peck (1991) which formed part of the Yanchep Structure Plan. This was also the source reference for more recent Environmental Review by Alan Tingay & Associates (1998) which covered all of the proposed development except the small area of Lots 201 and 202 Breakwater Drive. Relevant summary points include the following:

- Groundwater flows from the east (Gnangara Mound) towards the coast.
- Aquifer transmissivity in the shallow (Superficials Formation) aquifer ranges from around 1000 to over 20,000m^2/d, with the lower values occurring mostly along the eastern (upgradient) margin of the site. An average transmissivity of around 5,000m^2/d was adopted for the area, although it was recognised that the actual average may be significantly higher.
- Groundwater throughflow in the area, under natural conditions, was conservatively estimated to be around 365ML/yr per km length of coastline (or width of groundwater flowpath).
- As a result of increased runoff from roofs, roads etc., in situ recharge to the shallow aquifer should increase to around 30% of rainfall. Based on an average rainfall of 800mm/yr and an area of 7,000ha for the main Yanchep-Two Rocks area, this would result in around 17,000ML/yr recharge (or around 1,700ML/yr per km width of aquifer).

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- WAWA (now the Water Corporation) accepts that the safe yield of the aquifer system is 70% of the throughflow from upgradient (ie. from the east) plus all of the additional recharge resulting from roof/road runoff. That is, some 1960ML/yr per km width of aquifer.
- Water Corporation plans to pump up to the equivalent of 1,200ML/yr/km from the shallow aquifer to support the demands of the overall Yanchep-Two Rocks development. The proposed wellfield will be installed along a 7km line parallel to and about 1.5km inland from the coast extending from just south of Two Rocks to just south of Yanchep.

There has been no specific investigation of the hydrogeology of the proposed extension to the overall development (the "study area"). That is Lots 201 and 202, Breakwater Drive and associated "buffer" open spaces (referred to as ROS- "regional open spaces"). However, based on the information in the above reports, the following preliminary conclusions have been drawn:

- The width of the aquifer (perpendicular to groundwater flow paths) in the study area is around 5.5km and therefore the groundwater throughflow is likely to be around 2,000ML/yr (or more).
- The area for residential/rural development is around 400ha and therefore the additional recharge due to development is likely to be around 960ML/yr.
- Groundwater level contours within the study area are closely spaced reflecting lower aquifer transmissivity than in the near coastal strip. Based on hydraulic gradients measured from plans in the above reports (and assuming no substantial changes to groundwater flow rates), it is estimated that the aquifer transmissivity in the northern/northeastern part of the study area is around a quarter of the average (say 1,000 to 1,500m^2/d). In the southern part of the study area, where contours are more widely spaced, the transmissivity is estimated to be around a half the average (say 2,000 to 3,000m^2/d). Along the western margin of the study area where the contours flatten out, the transmissivity is probably about the average (5,000m^2/d).

Recent work carried out in the Alkimos-Eglinton study area (by Alan Tingay & Associates and Woodward-Clyde, 1997), located immediately to the south of Yanchep, provides additional information on recharge rates which might apply to developed areas. This investigation included numerical modelling of the impacts of development and groundwater pumping on groundwater levels and wetlands. Model calibration required in-situ recharge rates in excess of 30% for residential lots, pasture, market gardens and golf courses. Therefore, the 960ML/yr additional recharge estimated above is probably conservative.

2. IMPACT OF WATER CORPORATION PUMPING

Water Corporation's proposed pumping of around 12,000ML/yr from the shallow aquifer (equivalent to 1,200ML/yr/km of the total Yanchep-Two Rocks area) is substantially less than the total estimated available resource of 1960ML/yr/km.

While there have been no detailed hydrogeological investigations (with quantitative drawdown predictions) in the Yanchep-Two Rocks area, the results of the Alkimos-Eglinton area do provide good indications of likely overall impacts. The hydrogeological setting at Alkimos-Eglinton is very similar to that at Yanchep-Two Rocks. The proposed Water Corporation (and other) pumping was mostly to be from a wellfield aligned parallel to and 1.5km from the coast, similar to Yanchep-Two Rocks. Proposed pumping rates were equivalent to around 1,400ML/yr/km, and therefore also similar (if marginally higher) to that proposed for Yanchep-Two Rocks.

The modelling predicted that steady state groundwater level drawdowns (as a result of pumping) over most of the model area (ie. excluding areas immediately adjacent to the production bores) would be in the range 0.05 to 0.15m. Predicted drawdowns along the eastern part of the model (equivalent area to the study area) were all less than 0.1m. Similar (or slightly less) drawdowns would be expected in the Yanchep-Two Rocks area.

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3. IMPACT OF PUMPING IN THE STUDY AREA

3.1 Demand

Precise water demand figures are not available at this time as the actual development layout has not been finalised. However, we have estimated demands for two development scenarios based on available generic Water Corporation and Agriculture WA information.
The two broad development scenarios considered are:

- Scenario 1: 200 special rural residential lots evenly distributed over the study area or in numerous "clusters" with open natural bushland in between.
- Scenario 2: 200 special rural residential lots with approximately 100ha under "boutique" agriculture (vines, olives etc).

WAWA (now Water Corporation) figures for the water demand for special rural residential lots (based on 120% of normal residential demands) are 1.8kL/d (annual average), 4.3kL/d (average summer) 5.4kL/d (average peak summer week) and 6kL/d (peak day). Agriculture WA figures for irrigation demand for both olives and vines (but not table grape vines) are around 4mm/d (or 40kL/d/ha) for four to six months of the year.

Likely demands then will be in the order of:

- Scenario 1: 1,200kL/d (peak demand), 860kL/d (average summer) and 360kL/d (average demand).
- Scenario 2: 5,200kL/d (peak demand), 4,860kL/d (average summer) and 2,360kL/d (average annual assuming 6 months irrigation per year).

3.2 Impact of Pumping on Regional Groundwater

The regional groundwater throughflow is conservatively estimated to be around 2,000ML/yr and the additional recharge due to development is conservatively estimated to be some 960ML/yr.

The predicted average annual demand is only 2,360kL/d, or around 860ML/yr, and such a supply could potentially be made up from the additional recharge alone, with little to no impact on throughflow.

3.3 Impact of Pumping on Study Area

A simple lumped parameter analytical groundwater model was used to assess the likely drawdown impacts of pumping from within the study area. For this exercise, conservative estimates of aquifer parameters and theoretical maximum pumping rates were adopted, so that the results are very conservative.

An aquifer transmissivity of 1000m^2/d and storativity of 20% were adopted and it was assumed that pumping would be from five bores spaced at roughly 1km intervals in a line perpendicular to the groundwater flow paths (ie. roughly north-south line). Drawdowns were predicted at two lines parallel to and located 200m and 500m from the line of the bores in the wellfield.

The predicted drawdowns after six months pumping at the peak maximum demand (of 5,200kL/d) only marginally exceeded 0.5m at several points on the 200m line (at no point was the predicted drawdown greater than 0.6m). At 500m distance from the line of bores, predicted drawdowns were all less than 0.4m.

The predicted drawdowns after one years pumping at the annual average of 2,360kL/d are all less than 0.4m on the 200m line.

That is, the results indicate that, even for worst case pumping and conservative aquifer parameters, drawdowns in excess of 0.5m should be restricted to an area immediately adjacent to (within

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around 200m of) the line of the wellfield. These results are consistent with the results of previous numerical modelling work carried out in the area just south of Yanchep-Two Rocks.

4. COMMENTS ON WELLFIELD LAYOUTS

4.1 Drawdown Management

The above assessment indicates that, even in the worst case, drawdowns could be restricted to less than 0.5m in potential stygofauna areas as long as production bores were sited at least 200m from high risk karst areas. From the plan provided (Figure 2: Summary of Karst phenomena Risk) we have reviewed, it would appear possible to locate the bores in a line parallel to (and at least 200m to the east of) the northwest-southeast trending boundary between the low risk and very low risk areas. Alternately the bores could be located along most of the northern margin and along the eastern margin of Lot 201, and along the northern two thirds of the eastern margin of Lot 202.

Another possible option would be to locate the bores along the western margin of the study area (ie. western margins of the ROS along East Park Drive) if this area was accessible. The bores would be located in higher transmissivity aquifer material than in the eastern part of the study area, and drawdowns due to pumping would be much lower than predicted in the above assessment.

4.2 Groundwater Quality

While the general effluent and landuse management practices outlined in the Environmental Assessment for the study area (Alan Tingay & Associates, 1998) should reduce the potential for groundwater contamination, we make the following comments:

- Bores on the eastern margin (up-hydraulic gradient side) of the study area are less likely to be affected than those on the western (down gradient) side.
- The "capture zones" of individual production bores will be dependent on local aquifer properties and pumping rates. However, they are not likely to be very large and so it might be possible to locate bores within several hundred metres or so (laterally with respect to groundwater flow paths) from effluent disposal areas and/or animal stabling areas. Bores should not be sited directly down gradient of these facilities.

We trust that the above assessment and presentation of conclusions are sufficient for your current needs. We must stress that the assessment is only of a preliminary nature and based on many assumed and averaged figures. More reliable predictions of drawdowns would require more site specific data and more detailed modelling. However, we believe we have used conservative estimates and so that we are confident that the impacts of pumping will be small (less than 0.5m).

If you have any enquiries regarding this assessment, or any other aspect of the overall study, please don't hesitate to call us.

Yours sincerely,
Aquaterra

Jon Hall
Principal Hydrogeologist (Director)

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APPENDIX 7

NUTRIENT MANAGEMENT PLAN SPECIALIST REPORT

SHIRE OF WANNEROO

RURAL COMMUNITY DEVELOPMENT LOTS 201 AND 202 BREAKWATER DRIVE, TWO ROCKS

POTENTIAL FOR BOUTIQUE AGRICULTURAL LAND USE

ALAN TINGAY & ASSOCIATES
AND
SOIL MANAGEMENT CONSULTANTS PTY LTD

APRIL 1999

REPORT NO: 99/30

TABLE OF CONTENTS

1. INTRODUCTION

Boutique agricultural ventures such as vineyards or tree crops may be incorporated within the Rural Community Development proposed for Lots 201 and 202 Breakwater Drive, Two Rocks.

This report provides a desktop review of the suitability of the site for such a land use. The soil properties and the location of the site within a Groundwater Protection Area will impact on the land use and the management practices adopted within the study area. This report briefly reviews the relevant site characteristics and environmental criteria and makes recommendations regarding the proposed management of possible land uses. It is stressed the report is preliminary in nature. A further assessment should be undertaken when more details of the proposed boutique agricultural land use are available.

2. SITE ATTRIBUTES

2.1 Geology and Soils

The property is located within the Perth Basin, a geological formation containing Phanerozoic rocks of sedimentary origin. Within the property soils are developed on the Tamala Limestone (Spearwood Dune System). The Tamala Limestone is an aeolian calcarenite composed of foraminiferal and molluscan skeletal fragments with variable amounts of quartz sand. It is light to yellowish brown in colour (Alan Tingay & Associates, 1998).

The Spearwood Dune System is a series of parallel ridges and depressions composed of Pleistocence aeolian limestone and quartz sand. The Spearwood Dune System is frequently associated with karst topography. In the Yanchep-Two Rocks area, the Spearwood Dune System is defined by a series of shore parallel ridges and depressions that extend in a north-east to south-west direction across the site.

Quartz sands derived from the weathering of the Tamala Limestone cover much of the property and can be up to 20m thick in the 'hollows' between highs in the Tamala Limestone. The occasional outcrop of Tamala Limestone is also observed in the subject area (Figure 1) (Alan Tingay & Associates, 1992).

The Karrakatta and Cottesloe Associations are soils of the Spearwood Dune System. Throughout the literature, the Karrakatta soils are defined as comprising deep yellow sands over limestone, and are divided into yellow and grey soil phases. Cottesloe soils are defined as consisting of exposed limestone, or shallow brown sands over limestone (Semeniuk & Glassford, 1989). Both soils types occur on the property.

The soils of the Spearwood Dune System are infertile but retain applied phosphate due to the presence of iron or aluminium oxides in the soil which 'fix' phosphorus. In contrast nitrogen is rapidly leached from the soils due to rapid conversion of NH_4 to NO_3; the low carbon content and excessive irrigation. They support market gardens at Wanneroo and Spearwood, as well as pine plantations such as those at Gnangara. Yanchep and Myalup, and irrigated lucerne such as that west of Harvey. The shallow sands to the west within the Spearwood Dune System are deficient in phosphorus, potassium, copper and zinc but they contain plenty of water at shallow depths which is used for irrigation. The deep sands to the east drain freely and can be too dry for agricultural purposes.

Yellow Karrakatta sands are generally very deep soils with at least 10m to groundwater. While the Phosphorus Retention Index (PRI) of the top metre of soil is usually about 3-4, the PRI increases considerably with depth. For example, samples taken at Guilderton at depths of 2-7m had PRIs of 16-26 (McPharlin et al., 1990). The average profile PRI of deep yellow Karrakatta sand at Two Rocks is therefore likely to be greater than 10.

The yellow Cottesloe sands and the orange Spearwood sands that overlie limestone also have very good phosphorus retention properties, with average PRI profiles of 10 or greater. The PRI of the top metre is usually 5-10, increasing with depth. Samples

of Cottesloe sand subsoils taken at a depth of 1.5-2m at 6 sites on the Swan Coastal Plain between Mandurah and Guilderton had PRIs of 9-15, with a mean of 12 (Chemistry Centre WA and Soil Management Consultants Pty Ltd, unpublished reports).

The considerable capacity of Cottesloe and Spearwood sands to retain fertiliser phosphate has been demonstrated by investigations of several soil profiles at Medina Vegetable Research Station (McPharlin et al.,1990). This research showed that after twenty five years of vegetable production with average application rates of phosphorus of about 350-450kg/ha per year, virtually all the residual phosphorus was retained in the top 1-1.5m of soil profile above the limestone layer.

2.2 Groundwater

The hydrogeology and water resource development of the Yanchep Two Rocks region is described in specialist reports by Alan Tingay & Associates and Peck (1991) and Aquaterra (1999). The depth to groundwater in the proposed Rural Community Development ranges between 10m and 40m (Alan Tingay & Associates and Peck, 1991), with a recent drilling program in the south-west corner of the Lot 202 indicated water table depths of 10m and 11m in topographic lows.

The direction of the groundwater flow is moving away from the Gnangara Mound towards the ocean. The subject land is within a Priority 3 Groundwater Source Protection Area. The Water Corporation currently draws water from the superficial aquifer in the Yanchep/Two Rocks region for public supply and proposes to continue this practice in the future. Chemical analysis of water from existing production bores indicates the concentration of potential contaminants is within the range recommended by the relevant guidelines for drinking water.

A Priority 3 source protection area is the lowest category for source protection and requires only that developers minimise the risks of water pollution "as far as practicable". Priority 3 protection areas are catchments where other land use values predominate over water protection in land planning and management. In these source protection areas it is recognised that there is some risk of long term contamination of groundwater as a result of urbanisation, and that there may be a need for higher water treatment costs in the future. Protection of Priority 3 areas is generally achieved through management guidelines, rather than restrictions on land use.

3. LAND CAPABILITY OF SPEARWOOD SANDS

Land capability is a term used to express the ability of land to support a particular type of use without causing permanent damage (Austin and Cocks, 1978).

A five class system, which focuses on land use limitations and risks of land (and water) degradation, is used by the Department of Agriculture to express land capability (Tables 1, 2). Land capability classes indicate the degree of severity of physical limitations to a particular land use together with the level of management needed to contain any subsequent land degradation. Capability subclasses indicate the nature of the limitations (Table 2).

TABLE 1
LAND CAPABILITY CLASSES

Capability Class	General Description
I	Very high capability for the proposed activity or use. Very few physical limitations present which are easily overcome. Risk of land degradation is negligible.
II	High capability. Some physical limitations affecting either productive land use or risk of land degradation. Limitations overcome by careful planning.
III	Fair capability. Moderate physical limitations significantly affecting productive land use or risk of land degradation. Careful planning an conservation measures required.
IV	Low capability. High degree of physical limitations significantly affecting productive land use or risk of land degradation. Careful planning and conservation measures required.
V	Very low capability. Severity of physical limitations is such that its use is usually prohibitive in terms of either development costs or the associated risk of land degradation.

TABLE 2
LAND CAPABILITY SUB-CLASSES

Capability Sub-Class	Land Quality Limiting Proposed Land Use	Capability Sub-Class	Land Quality Limiting Proposed Land Use
a	Soil absorption ability	n	Nutrient retention ability
b	Foundation soundness	o	Water pollution risk by overland flow
c	Slope instability risk	p	Microbial purification ability
d	Subsoil water retention ability	q	Groundwater quality
e	Water erosion risk	r	Rooting conditions
f	Flood risk	s	Water pollution risk by subsurface drainage
g	Groundwater availability		
h	Dam site construction suitability	t	Topsoil nutrient retention ability
i	Waterlogging/inundation risk	v	Wave erosion risk
j	Surface water availability	w	Wind erosion risk
k	Soil workability	x	Ease of excavation
l	Nutrient availability	y	Salinity Risk
m	Moisture availability		

Boutique agricultural land uses may take the form of:

- grazing stock;
- annual horticulture e.g. vegetables or market gardens of shallow rooted species where soil is cultivated at least once a year and fertilised regularly;
- perennial horticulture e.g. orchids, vineyards or the tree crops of deep rooted species where soil is only cultivated at the initial planting, but regularly fertilised.

The requirements for a particular land use such as a boutique agricultural land use are determined by considering the effect the land use will have on the land, and the effect the attributes of the land will have on the land use. The land use requirements for boutique agricultural activities are shown in Table 3.

TABLE 3
LAND USE REQUIREMENTS FOR AGRICULTURAL LAND USES

	Essential	Desirable
Conservation Requirements	Land should not be susceptible to an erosion risk which will prohibit its sustained use or cause off-site effects detrimental to adjacent land users or the community. Leaching of nutrients from the use of fertilisers should not pollute ground or surface water resources.	
Development/ Management Requirements		Areas be sufficiently free of waterlogging or inundation to provide easy access and on-site trafficability. Where cultivation is required, the soils should be easily worked.
Productivity Requirements (for agricultural activities)	Areas used for irrigated agriculture should have a sufficient supply of suitable quality water from a groundwater, surface stream or farm dam supply, and the land should not be strongly susceptible to salinity.	Areas used for grazing or horticultural activities have favourable conditions with respect to: • soil nutrient availability • soil moisture availability • development of plant root system.

(after Wells, 1989)

The capability of the soils of the Spearwood Dune System found at Lots 201 and 202 Breakwater Drive for boutique agricultural uses (as identified in Wells, 1988) is shown in Table 4.

TABLE 4

LAND CAPACITY OF SPEARWOOD SANDS

Agriculture			Water Supply
Grazing	**General Annual Horticulture**	**Perennial Horticulture**	**Irrigation Water Supply**
III - IV m,w	III - IV w,k,t	II	II B

k	soil workability	II	high capability
m	moisture available	III	fair capability
t	topsoil nutrient retention ability	IV	low capability
w	wind erosion risk		
B	groundwater bore best option		

This information suggests that the area is well suited to perennial horticulture pursuits such as vineyards, orchards or tree crops but is less suited to grazing or annual horticulture due to constraints posed by the risk of wind erosion and the 'workability' of the soil. It also indicates that the site has a high capability for groundwater for irrigation, as demonstrated by the report prepared by Aquaterra (1999).

However, other land capability information (e.g. as presented in the WAPC's Metropolitan Rural Planning Policy Atlas Maps, and in a report prepared for the City of Wanneroo by the Department of Agriculture) suggests a lower capability for boutique agricultural uses as envisaged. Further site specific land capability investigations would, therefore, be considered appropriate.

4. LAND USE COMPATIBILITY WITH PUBLIC DRINKING WATER SOURCE AREAS

The Water & Rivers Commission has developed tables to provide guidance on the compatibility of various land uses within the public drinking water source areas. The tables serve as a guide and therefore allow some flexibility. Possible land uses listed within the Water & Rivers Commission Land Use Compatibility Tables that may be considered as part of a boutique agricultural land use for a Priority 3 groundwater protection area are shown in Table 5.

TABLE 5
LAND USE COMPATIBILITY WITH PUBLIC DRINKING WATER SOURCE AREA

AGRICULTURE - ANIMALS

Land Use	Priority 3
Apiaries	Restricted
Aquaculture e.g. marron farms, fish farms, algae culture	Restricted
Dairy Farming	Restricted
Feedlots	Restricted
Livestock grazing (extensive)	Compatible
Livestock grazing (intensive)	Restricted [5]
Piggeries	Incompatible
Poultry farming (housed)	Restricted
Stables	Compatible
Stockholding and saleyards	Restricted [3]

AGRICULTURE - PLANTS

Land Use	Priority 3
Broad acre cropping i.e. non-irrigated	Compatible
Floriculture (extensive)	Compatible
Floriculture (intensive)	Restricted
Field horticulture	Restricted
Hydroponic horticulture	Restricted
Orchards	Compatible
Potted Nurseries	Compatible
Silviculture (tree farming)	Compatible
Turf Farms	Restricted
Viticulture (wine & table grapes)	Compatible

PROCESSING OF ANIMALS/ANIMAL PRODUCTS

Land Use	Priority 3
Abattoirs	Incompatible
Cheese/butter factories	Restricted [4]
Food processing	Restricted [1]
Tanneries	Incompatible
Wool scours	Incompatible

PROCESSING OF PLANTS/PLANT PRODUCTS

Land Use	Priority 3
Breweries	Restricted [4]
Composting/soil blending (commercial)	Restricted
Vegetable/food processing	Restricted [2]
Wineries	Restricted

SPORT AND RECREATION

Land Use	Priority 3
Equestrian centres	Compatible

Definitions:

Compatible: the land use is compatible with the management objectives of the priority classification

Incompatible: the land use is incompatible with the management objectives of the priority classification

Restricted: the land use may be compatible with the management objectives of the priority classification, with appropriate site management practices

Notes in Table:

1. Restrictions on the use of fuel and chemicals apply.

2. Must be connected to deep sewerage, where practical, or otherwise to an approved waste disposal system that meets water quality protection objectives.

3. May be permitted if this use is incidental to the overall land use in the area and consistent with planning strategies.

4. Restrictions apply to siting of effluent disposal systems in areas with poor land capability and a shallow depth to groundwater.

5. Restrictions apply to stocking levels.

Source: extracted from Land Use Compatibility in Public Drinking Source Areas, Water Quality Protection Note. Water & Rivers Commission, 1999.

Thus potential boutique agricultural activities such as extensive livestock grazing, stables and equestrian centres, non-irrigated cropping, orchards, potted nursery, tree farming and viticulture are compatible with the management objectives of a Priority 3 Groundwater Source Protection Area. Other activities such as field horticulture, hydroponic horticulture and cheese factories may be compatible, with appropriate management practices.

5. VULNERABILITY CATEGORY

The Water & Rivers Commission has developed recommended maximum nutrient loadings for the protection of public water resources, based on the soil type upstream of the water resource, and the vulnerability of the receiving environment, as shown in Table 6. The four categories describe the site's ability to assimilate nutrients.

TABLE 6
RECOMMENDED MAXIMUM NUTRIENT LOADINGS BASED ON SOIL TYPES UPSTREAM OF WATER RESROUCES AND THE VULNERABILITY OF THE RECEIVING ENVIRONMENT

Vulnerability Category	Soil Description	Maximum Phosphorus Loading (kg/ha/yr)	Maximum Nitrogen Loading (kg/ha/yr)
A	Coarse sandy soils/gravels draining to surface waters with moderate/high eutrophication risk	10	140
B	Coarse sandy soils/gravels draining to waters with a low risk of eutrophication	20	180
C	Loams/clay soils (PRI>10) draining to waters with a moderate/high eutrophication risk	50	300
D	Loams/clay soils (PRI>10) draining to waters with a low risk of eutrophication	120	480

Notes:
- Applies to all nutrient sources, both natural and artificial
- PRI means Phosphorus Retention Index

Source: Rachael Millier, Water & Rivers Commission, 1999

Given its location within a Priority 3 Groundwater Protection Area and the presence of soils of the Spearwood Dune System, Lots 201 and 202 Breakwater Drive, Two Rocks would most likely be assigned a 'B' vulnerability category classification. The maximum phosphorus loading per year would therefore be 20kgP/ha/yr while the maximum nitrogen loading would be 180kgN/ha/yr.

However, it is possible the site may receive a 'D' classification should the results of a soil-sampling program indicate the soil at the site has a strong ability to retain phosphorus (PRI>10). Given the high phosphate retention abilities of the yellow Karrakatta sands and the Cottesloe/Spearwood sands on the Swan Coastal Plain, PRI values greater than 10 would be expected for the subject area. In this case the site would receive a 'D' classification and the maximum phosphorus loading would be 50kgP/ha/yr while the maximum nitrogen loading would be 300kgN/ha/yr.

6. FERTILISER REQUIREMENTS AND MANAGEMENT PRACTICES FOR BOUTIQUE AGRICULTURE

The level of fertiliser input will depend on the agricultural activity, with grazing and perennial horticulture requiring the lowest inputs and turf and vegetable production the highest inputs.

6.1 Phosphorus

Within several years of development Karrakatta and Cottesloe sands will develop available P that can be utilised by a following crop, thus allowing a considerable reduction in the required rate of fertiliser P. Soil testing is an essential tool for determining the optimum maintenance rate of fertiliser P to achieve the desired crop yield and quality. Crops will initially require applications of fertiliser P between 30-50kg/ha (grazing) and 200-400kg/ha (vegetables) for the first few years on new land. Subsequently soil testing is used to maintain the concentration of available P (soil test P) at between 15-25mg/kg (grazing) and 50-100mg/kg (vegetables). These concentrations will require maintenance applications of fertiliser P at rates of 12-15kg/ha (grazing) and 30-50kg/ha (vegetables).

Given that crop removal of phosphorus will be about 10kg/ha for grazing or hay crops and about 25kg/ha for vegetable crops, residential fertiliser P should be no more than 5kg/ha per year for grazing enterprises and 30kg/ha per year for two vegetable crops. Requirements for perennial horticulture and turf production will be between these extremes. Thus, provided soil testing is used as part of fertiliser P management, the maximum annual P loadings will be very much less than the limit of 120kg/ha per year for the Water & Rivers Commission vulnerability category D soils.

6.2 Nitrogen

Average annual application rates of Nitrogen vary from nil for grazing to 1250kg/ha/year for two vegetable crops. The crops of most concern for potential losses of nitrate-N are turf production and vegetables. Problems have been exacerbated in the past by the use of high rates of poultry manure prior to planting, inefficient irrigation systems and uneven broadcast applications of fertiliser N.

Raw poultry manure will not be available for use in the near future, and replacement composts should have better slow release N properties. New turf or vegetable enterprises would be expected to adopt improved practices for irrigation and fertigation that will result in significant increases in the efficiency of water and fertiliser N use. For example, summer potatoes grown on Spearwood sand with trickle fertigation achieved maximum yields at 350kg N/ha, with nearly 50% of the N removed in the tubers (Hegney et al., 1997). This is a significant improvement over the average fertiliser N application rate of 900kg /ha/crop for potatoes grown on the Swan Coastal Plain.

Turf production could be expected to achieve even greater reductions in residual (potentially leachable) fertiliser N with the use of fertigation and efficient irrigation systems due to the permanent root system of turf, lower rates of irrigation and the lower N requirement compared with vegetables.

Soil testing is of little value in the management of fertiliser N. However, tissue testing (leaf petioles or blades) for vegetable and perennial crops and grass clippings analysis for turf are very useful for assessing the level of supply of fertiliser N, especially where fertigation is used to provide N in frequent small applications, and should be part of any crop management at Lots 201 and 202 Breakwater Drive. Provided tissue testing (or grass clipping analysis) is part of the fertiliser N management, the maximum N loadings are expected to be much less than the 480kg/ha/yr limit for Water & Rivers Commission vulnerability category D soils.

7. DISCUSSION AND CONCLUSION

Lots 201 and 202 Breakwater Drive contains soils of the Spearwood Dune System. These soils are well suited to perennial horticultural pursuits such as orchards, vineyards and tree crops, having a high land capability rating for perennial horticulture. The area is less suited to annual horticulture and grazing. However, the constraints to these land uses can be overcome by sound management practices.

The property is located within a Priority 3 Groundwater Source Protection Area. Boutique agricultural land uses including perennial horticulture such as tree crops and vineyards are compatible land uses within a Priority 3 Groundwater Source Protection Area.

The study area is likely to fall within a B Vulnerability Category to protect the groundwater resource. This classification means the maximum permitted phosphorus and nitrogen loadings at the site are 20kgP/ha/year and 180kgN/ha/year respectively. It is likely that the nutrient loadings of a perennial horticultural enterprise would be less than the criteria specified. It is however, possible the vulnerability classification may change to a D classification should the results of a soil sampling program indicate the soils have a strong ability to retain phosphorus. In this case the maximum phosphorus and nitrogen loadings would be 50kgP/ha/year and 300kgN/ha/year respectively.

This study has been based on a desktop assessment of the properties of the soils of the Spearwood Dune system. It is recommended that a detailed soil sampling program be undertaken at Lots 201 and 202 Breakwater Drive prior to the commencement of any boutique agricultural land use to confirm the desktop results detailed above. It is also recommended that a Nutrient and Drainage Management Plan be prepared for the proposed activity at the detailed design phase. The Nutrient and Drainage Plan should follow the best practice guidelines developed by the Water and Rivers Commission to protect the State's water resources.

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LOT 201

LOT 202

TWO ROCKS

INDIAN

OCEAN

YANCHEP

Wanneroo

Road

Kilometres

0 1 2

SCALE 1 : 50, 000

Alan Tingay & Associates

environmental scientists

99027/R99_12App7F1 DRAWN: KR 14-4-99 CHECKED: NB 7-5-99

LEGEND

DESCRIPTION	GEOLOGICAL UNIT	
CALCAREOUS SAND - white, fine grained sub-rounded quartz and shell debris.	Safety Bay Sand (mobile dunes)	HOLOCENE
CALCAREOUS SAND - weakly cemented in places, of eolian origin.	Safety Bay Sand	HOLOCENE
QUARTZ SAND - pale and olive yellow, medium to coarse grained, moderately sorted.	Sand derived from Tamala Limestone	PLEISTOCENE
LIMESTONE - pale yellowish brown, weakly cemented, friable, medium grained, sub-rounded quartz and shell debris, of eolian origin.	Tamala Limestone	PLEISTOCENE
LIMESTONE - as above, abundant karstic phenomena.	Tamala Limestone	PLEISTOCENE

BOUNDARY OF AMENDMENT AREA 837

COASTAL HEADLANDS & WAVECUT PLATFORMS OF TAMALA LIMESTONE

CAVE

DOLINE

QUARRY

SHIRE OF WANNEROO
TOWN PLANNING SCHEME No1
AMENDMENT 837, YANCHEP - TWO ROCKS

GEOLOGY MAP OF YANCHEP PROPERTY

APPENDIX 7 - FIGURE 1