THE HILL RIVER PROJECT

AND THE PROPOSED CONSERVATION RESERVE AT LESUEUR

A REPORT TO
THE ENVIRONMENTAL PROTECTION AUTHORITY
FROM
THE DEPARTMENT OF CONSERVATION AND
LAND MANAGEMENT

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FOREWORD

This publication is the Department of Conservation and Land Management's official report to the Environmental Protection Authority on the Hill River Project Environmental Review and Management Programme and Draft Environmental Impact Statement produced for Canning Resources and The Hill River Power Development Company.

This project, if approved, will be located within a proposed conservation reserve that has very high nature conservation values. Accordingly, my Department has a responsibility to review the ERMP and provide an assessment of its likely effects on the conservation of the flora and fauna of the area and on the landscape and recreational values of the proposed conservation reserve.

SYD SHEA
Executive Director
July, 1990

CONTENTS

FIGURES

TABLES

EXECUTIVE SUMMARY

1. BACKGROUND

The proposed conservation reserve at Lesueur of 27 493 ha is near Jurien Bay, some 220 km to the north of Perth. It has long been recognised as an area of outstanding flora conservation values, complex geological features and unusually rugged terrain in the subdued landforms of the northern kwongan region.

It has been recommended for reservation by botanists, the Australian Academy of Science, the Conservation Through Reserves Committee and the Environmental Protection Authority (EPA). These recommendations were endorsed by State Cabinet in 1976 and again in 1983, but the presence of coal deposits at the eastern end of the proposed conservation reserve has prevented reservation to the present day. The National Parks and Nature Conservation Authority recommended in 1989 that the Lesueur area be declared a national park.

In March 1989 Canning Resources Pty Ltd and The Hill River Power Development Company Pty Ltd submitted a Notice of Intent (NOI) to the EPA under the relevant provisions of the Environmental Protection Act. The NOI stated that the companies proposed to develop open cut coal mines and a power station to supply power to the State Energy Commission of Western Australia. About half the area proposed to be mined and the conceptual location of the power station were within the proposed conservation reserve. The EPA decided that the proposal should be subject to the highest level of evaluation, and required the companies to prepare an Environmental Review and Management Programme (ERMP).

The EPA sought from the Department of Conservation and Land Management (CALM) a detailed evaluation of the nature conservation, landscape and recreation values of the Lesueur area. This report was completed in August 1989 and was published as EPA Bulletin 424 (Burbidge *et al.* 1990). In May 1990 Canning Resources and The Hill River Power Development Company finalised their ERMP (which was compiled by consultants Dames and Moore) and this was released by the EPA for public comment until July 30, 1990. The CALM Report (EPA Bulletin 424) was released at the same time.

CALM decided to prepare a review of the ERMP for the EPA; this publication constitutes that submission.

The ERMP provides little information on the vegetation, flora or fauna of the proposed conservation reserve or on the vegetation, flora or fauna of nearby areas, nor does it provide an adequate regional context in which to make a reasonable assessment. The companies have commissioned studies by consultants on some aspects of these subjects. Many reports by consultants are referred to in the ERMP but these are unpublished and were not released with the ERMP. CALM obtained copies of relevant reports from the proponents to enable it properly to assess all available data.

The ERMP does not show the full extent of disturbance that will be caused by the proposed project. It gives an area of land that will be disturbed at some stage of the project life of 1 150 ha within the proposed conservation reserve, but this does not include the full area of disturbance since it ignores some construction outside this area, edge effects and other possible damage to vegetation such as from groundwater drawdown and air pollution. In order to assess better the possible impact of the proposed project, CALM developed a map based on ERMP Figure 7.4 plus a 100 m buffer strip around all cleared or flooded areas. The area of this 'impact zone' within the proposed conservation reserve is 1 474.5 ha. The figure of 100 m was chosen arbitrarily but is based on CALM's experience with long-term effects of disturbances on remnant vegetation in the wheatbelt and northern kwongan. We believe the width of the buffer strip to be conservative, especially since the mines have a projected life of 30 years.

2. VEGETATION

The high priority accorded to the establishment of a major conservation reserve in the Lesueur area is largely attributable to its unique floristic values. Within the proposed reserve are found high levels of species endemism, a high degree of species richness, and a very fine scale and hence complex mosaic of vegetation types. The proponents' regional analysis covering other conservation reserves in northern kwongan failed to locate most of the vegetation types found at Lesueur. Our analysis showed that the proposed development will have a severe direct impact on at least eleven of the 38 vegetation types so far defined. Nine of these communities are not known from outside the project area.

We also considered the likely indirect impacts of the proposed mine and power station development on the vegetation of the region. The information provided in the ERMP is inadequate to allay serious concerns

about the acute and/or chronic effects of the various stack emissions on the vegetation over a wide area. Given the high biological significance of the area, the possibility of retrogressive succession occurring in the area is of considerable concern. The impacts of some trace elements in both air and water effluent have not been considered in the ERMP, nor have the effects of groundwater drawdown or changes in surface drainage been adequately dealt with.

The combined direct impacts and indirect effects of the proposed development on the vegetation of the region are likely to be very significant.

3. FLORA

The Hill River Project ERMP does not adequately address the EPA guidelines particularly in its assessment of the conservation status of, and impact on, Declared Rare Flora (DRF) and regional endemic taxa. Although the conservation status of DRF is briefly reviewed there is no reference to their security on existing or proposed reserves and there are insufficient data relating to the numbers of populations and individuals that are known to exist. The ERMP lists 48 "vulnerable taxa" which occur in the Lesueur area. These taxa, however, were not surveyed and consequently their distribution and conservation status, and impact of the project on them, has not been determined. There are also a further 56 regionally endemic taxa occurring in the project area which require some assessment of their conservation status. Populations of taxa at the limit of their range and relictual species have not been treated in the ERMP although they represent a genetic resource unique to the Lesueur area.

There is some discordance between the proponents' and CALM's assessment of the impact of the project on numbers of individuals of DRF, particularly for *Asterolasia drummondii* and *Hakea megalosperma*.

Although the ERMP proposes to re-establish DRF and other regional endemics found in the project area, the data and methodologies provided are insufficient to confidently predict the survival of many taxa proposed for re-introduction.

Cryptogams have not been considered by the proponents.

4. FAUNA

The ERMP does not adequately address the EPA guidelines and makes inadequate commitments for fauna conservation and rehabilitation. The vertebrate survey was limited in terms of seasons when sampling took place and because of this the ERMP makes unsupportable statements concerning animals' association with or dependence on particular habitats as well as the seasonality of habitat use. No surveys of terrestrial invertebrates were conducted and the ERMP makes unjustified statements about the difficulty and usefulness of such work as well as making unsupported assumptions concerning the relationships of invertebrates with vegetation types. Surveys of aquatic fauna were conducted at inappropriate times of the year, and consequently the ERMP makes unwarranted statements about the composition of the aquatic fauna. The ERMP contains no assessment of the conservation status of the aquatic fauna of the area. No surveys were conducted of the aquatic fauna of Cockleshell Gully, the largest catchment in the proposed conservation reserve, even though this catchment will be affected by the operation.

No surveys were made of the fauna of most of the proposed conservation reserve at Lesueur, nor of nearby conservation reserves, and no attempt was made by the proponents to assess the conservation status of the Lesueur fauna, particularly those occurring in the area to be mined or otherwise disturbed, in nearby conservation reserves.

The ERMP fails to recognise the importance of the whole Lesueur - Coomallo region for the survival of Carnaby's Black-Cockatoo and that the Cockatoo is important because it is implicated in the survival of *Banksia tricuspis*, a Declared Rare Flora species. It does not mention the cockatoo's need for fresh water sources (which must have shady trees around them), nor the possible effects of mining and water extraction in this context, although the Hill River and the Hill River Spring are highlighted as areas most likely to suffer from water table drawdown.

5. PHYTOPHTHORA AND OTHER FUNGAL PLANT DISEASES

Diseases caused by introduced and native fungi are part of the biological environment of native plant communities throughout south-western Australia. Any development requiring the large-scale modification of the natural environment must consider the impact that diseases have on susceptible plant communities and species and make a commitment to design appropriate disease management programs. These requirements have not been addressed in the ERMP for the Hill River Project. The proponents have only addressed the issue of dieback disease caused by *Phytophthora* species and no consideration has been given to other plant diseases that may occur in the area.

Dieback disease associated with *Phytophthora* species is briefly mentioned in the ERMP. Despite having acknowledged that the Lesueur area contains many susceptible and sensitive plant groups and that

there is potential for the spread of the disease, the proponents have failed to address vital issues relating to the potential impacts of the project. These issues are: an assessment of the hazard to susceptible vegetation, an appraisal of the risk of infestation and spread of the disease, and a commitment to disease management in terms of prevention and monitoring.

The risk of introduction of plant diseases during the 30 year time frame of the project is high. If introduced, *Phytophthora* species would have a high impact on the vegetation, causing local extinctions of many plant species and massive changes in species diversity.

6. LANDSCAPE, NATURE-BASED RECREATION AND TOURISM VALUES

Should the coal mines and power station project proceed, the natural character and scenic beauty of what are some of the most attractive landscapes within the northern kwongan will be severely degraded. The most scenic parts of the proposed conservation reserve at Lesueur would not be mined. However, there will be a significant impact on visual resource values if the mine goes ahead, as the area that will be mined is a supporting landscape and an important foreground to the eastern flank of the Gairdner Range. The viewsheds east and northeast from the Gairdner Range would also be affected and the coal-fired power station, with its 200 metre high stack, would be visible from a considerable distance, from both within and outside the reserve.

The project would also significantly impact on those recreationists, tourists and residents who value the relatively pristine natural environment of the Lesueur area which presently exists. In particular, outdoor recreation activities such as bushwalking, nature study and sightseeing, which are dependent on the region's natural values, would suffer the most.

The ERMP fails to adequately address these issues and does not provide sufficient information on which to arrive at informed conclusions. The ERMP also fails to identify important 'non-use' values associated with the region's unspoilt character.

7. REHABILITATION

Information contained in the ERMP is insufficient for assessment of the likely success of rehabilitation after mining and de-commissioning of the power station. The proponents have not detailed their rehabilitation program; instead they propose to produce a management plan prior to commencement of mining. Many of the general statements that are made in the ERMP and inconsistencies between formal commitments and stated rehabilitation objectives suggest a very superficial understanding of the complexities involved in rehabilitation. The proponents suggest that experiences gained in the Lesueur area and at Eneabba provide the basis for successful reconstruction / reclamation programs. However, this work has not yet been shown to be successful; furthermore there are significant differences between the types of disturbance at those sites and that proposed for Lesueur in the ERMP. It is concluded that reconstruction or reclamation is not achievable within a human life-time, but that revegetation with a limited range of native plant species may be.

8. CONCLUSIONS

We and our colleagues have previously reported on the nature conservation, landscape and recreation values of the proposed conservation reserve at Lesueur. This report should be read in conjunction with that earlier one.

We conclude that vegetation, flora and fauna of the proposed Lesueur conservation reserve is of world significance and its values are not duplicated elsewhere. It is clear that the proposed mines and power station would impact significantly on the nature conservation, landscape and recreation values of the proposed reserve. Further, the ERMP has not demonstrated that its own rehabilitation aims can be met and there are serious doubts that anything but a simple vegetation can be established on the overburden dumps. The landforms of the area will be greatly modified and will not be returned to their original contours. The risk of introduction of plant diseases during the 30 year time frame of the project is high. Over 90% of the vegetation in the eastern end of the proposed conservation reserve at Lesueur is rated as high or medium hazard to *Phytophthora* and, if introduced, *Phytophthora* would have a high impact on the vegetation, causing local extinctions of many plant species, as well as reducing success of rehabilitation.

The ERMP for the Hill River Project does not adequately comply with the EPA's guidelines in significant respects and has major shortcomings. Some of these could be overcome if further studies were made or if parts of the ERMP were re-written. However, we believe that, even if major shortcomings were overcome, the proposed project would still have significant detrimental effects on the nature conservation, landscape and recreation values of the proposed conservation reserve at Lesueur.

Given the nature of its charter, CALM is likely to conclude that many mining developments within existing or proposed conservation reserves would be environmentally unacceptable. There are also occasions when environmental and aesthetic values may not be unduly disturbed by mining. In such cases CALM may not oppose the project. However, in the

case of the Hill River Project, CALM concludes there will be major impacts on an area of the very highest conservation values. If the project goes ahead, it would be to the significant detriment of nature conservation and of the proposed conservation reserve.

We conclude that, from a nature conservation, landscape and recreation point of view, the project is environmentally unacceptable.

Chapter 1

INTRODUCTION

by Andrew A Burbidge

Department of Conservation and Land Management, Western Australian Wildlife Research Centre, P.O. Box 51, Wanneroo, W.A. 6065.

Abstract

The proposed conservation reserve at Lesueur of 27 493 ha is near Jurien Bay, some 220 km to the north of Perth. It has been recommended for reservation by botanists, the Australian Academy of Science, the Conservation Through Reserves Committee and the Environmental Protection Authority (EPA). These recommendations were endorsed by State Cabinet in 1976 and again in 1983, but the presence of coal deposits at the eastern end of the proposed conservation reserve has prevented reservation to the present day. The National Parks and Nature Conservation Authority recommended in 1989 that the Lesueur Area be declared a national park.

In March 1989 Canning Resources Pty Ltd and The Hill River Power Development Company Pty Ltd submitted a Notice of Intent (NOI) to the EPA which stated that the companies proposed to develop open cut coal mines and a power station within the proposed conservation reserve. The EPA decided that the proposal should be subject to the highest level of evaluation, and required the companies to prepare an Environmental Review and Management Programme (ERMP).

The EPA sought from the Department of Conservation and Land Management (CALM) a detailed evaluation of the nature conservation, landscape and recreation values of the Lesueur Area. This report was published as EPA Bulletin 424 (Burbidge et al. 1990). In May 1990 Canning Resources and The Hill River Power Development Company finalised their ERMP (which was compiled by consultants Dames and Moore) and this was released by the EPA for public comment until July 30, 1990. The CALM Report (EPA Bulletin 424) was released at the same time.

CALM decided to prepare a review of the ERMP for the EPA; this publication constitutes that submission.

The ERMP does not show the full extent of disturbance that will be caused by the proposed project. It gives an area of land that will be disturbed at some stage of the project life of 1 150 ha within the proposed conservation reserve but this does not include the full area of disturbance since it ignores edge effects and other possible damage to vegetation such as from groundwater drawdown and air pollution. In order to assess better the possible impact of the proposed project, CALM developed an impact zone of 1 474.5 ha, which included a 100 m buffer strip around all cleared or flooded areas.

1.1 BACKGROUND

The proposed conservation reserve at Lesueur of 27 493 ha is near Jurien Bay, about 220 km north of Perth.

It has been recommended for reservation for nature conservation by botanists since the 1950s, the Australian Academy of Science in 1962, the Conservation Through Reserves Committee in 1974, the Environmental Protection Authority (EPA) in 1975 and many other persons and groups. The EPA recommendation was endorsed by State Cabinet in 1976 and again in 1983 but has not been implemented. The National Parks and Nature Conservation Authority recommended in 1989 that the Lesueur area be declared a national park.

In March 1989 Canning Resources Pty Ltd and The Hill River Power Development Company Pty Ltd submitted a Notice of Intent (NOI) to the EPA under the relevant provisions of the Environmental Protection Act. The NOI stated that the companies proposed to develop open cut coal mines and a power station to supply power to the State Energy Commission of Western Australia (SECWA). About half the area proposed to be mined and the conceptual location of the power station were within the proposed conservation reserve. The EPA decided that the proposal should be subject to the highest level of evaluation, and required the companies to prepare an Environmental Review and Management Programme (ERMP).

The EPA also sought from the Department of Conservation and Land Management (CALM) a detailed evaluation of the nature conservation, landscape, educational and recreational values of the proposed conservation reserve and "an assessment of any deficiencies in the data which would jeopardise conservation or other values if the data is not available prior to any decisions being taken on the proposal to mine coal and generate power in the area the availability and security elsewhere of values equivalent

to those at Mt Lesueur, if any" (Chairman, EPA *in litt.* to Executive Director, CALM, June 1989).

CALM provided its report to the EPA in August 1989 and it was published as EPA Bulletin 424, January 1990 (Burbidge *et al.* 1990).

In May 1990 Canning Resources and The Hill River Power Development Company finalised their ERMP (which was compiled by consultants Dames and Moore) and this was released by the EPA for public comment until July 30, 1990. The CALM Report (EPA Bulletin 424) was released at the same time.

CALM decided to prepare a new submission to the EPA consisting of

- a review of Bulletin 424 in the light of any new information now available,
- a review of the ERMP,
- its evaluation of the impact of the proposed development on the proposed conservation reserve at Lesueur, and
- its conclusions.

Because of the great public interest in possible environmental impacts of the proposed development, the Executive Director of CALM decided that the submission would be published.

CALM's 1989 report to the EPA (Burbidge *et al.* 1990) provided a detailed account of the background to the proposed conservation reserve, the European exploration of the area, and the geology, landforms, soils, climate, drainage, vegetation, flora and fauna of the proposed park. It then summarised two recent studies that documented inter-relationships between animals and plants in the area. It described the occurrence of dieback disease caused by *Phytophthora cinnamomi* and other *Phytophthora* species in the region and the impact that dieback would have on the Lesueur area if introduced. It went on to describe the landscape, recreational and educational values of the proposed conservation reserve. Finally it assessed the status of current knowledge on the Lesueur area and provided an evaluation of the significance of the proposed conservation reserve on a world, national, State and regional basis.

For readers who do not have access to CALM's 1989 report to the EPA (Burbidge *et al.* 1990) the Executive Summary is reproduced in Appendix 1 at the end of this publication.

A draft of CALM's report to the EPA contained a chapter that provided a preliminary assessment of the impact of the proposed mines and power station on the area. It was decided not to include this chapter in the report in advance of the ERMP, but to provide a more detailed assessment after the ERMP had been released. However, this draft was obtained by a non-Government conservation organization and released to the news media. CALM then made the chapter public. The Abstract of that chapter is reproduced in Appendix 2, but it is superseded by this report.

1.2 INFORMATION ASSESSED

The ERMP provides little information on the vegetation, flora or fauna of the proposed conservation reserve or on the vegetation, flora or fauna of nearby areas. The companies have commissioned studies by consultants on various aspects of these subjects. Many reports by consultants are referred to in the ERMP but are unpublished and were not released with the ERMP. CALM sought and obtained copies of relevant reports from the proponents to enable it properly to assess all available data.

We have not assessed the possible effects of the disposal of blowdown water into the ocean off Jurien. We draw attention to the rich marine ecosystems in this area, including seabirds and sealions, which are at the top of the food chain and could be affected by any contaminates, such as heavy metals, in the water.

1.3 AREA OF IMPACT

Any assessment of the possible impacts of the coal mines and power station requires the delineation of areas of land that would be affected should the proposal proceed. The ERMP includes a number of maps that show the location of the mines and the approximate location of the power station but do not show the total area proposed to be cleared (e.g. Figures 4.3, 4.8, 4.11, 4.12, 4.14). ERMP Figures 5.1 and 7.4 show the full project detail, but these also do not show the full extent of disturbance; indeed the ERMP does not present such data, it only gives figures for "the total area of land that will be be disturbed at some stage of the Project life": 1 150 hectares within the proposed conservation reserve (ERMP p. 6-1 and Table 6.1).

In order to assess better the possible impact of the proposed project, CALM developed a map based on ERMP Figure 7.4 (but with the access road extended to the south as shown in ERMP Figure 5.1) plus a 100 m buffer strip around all cleared or flooded areas (Figure 1.1). A Geographic Information System was used to make calculations of impact, for example, on the different landforms and vegetation types. Calculations of the area disturbed, including the

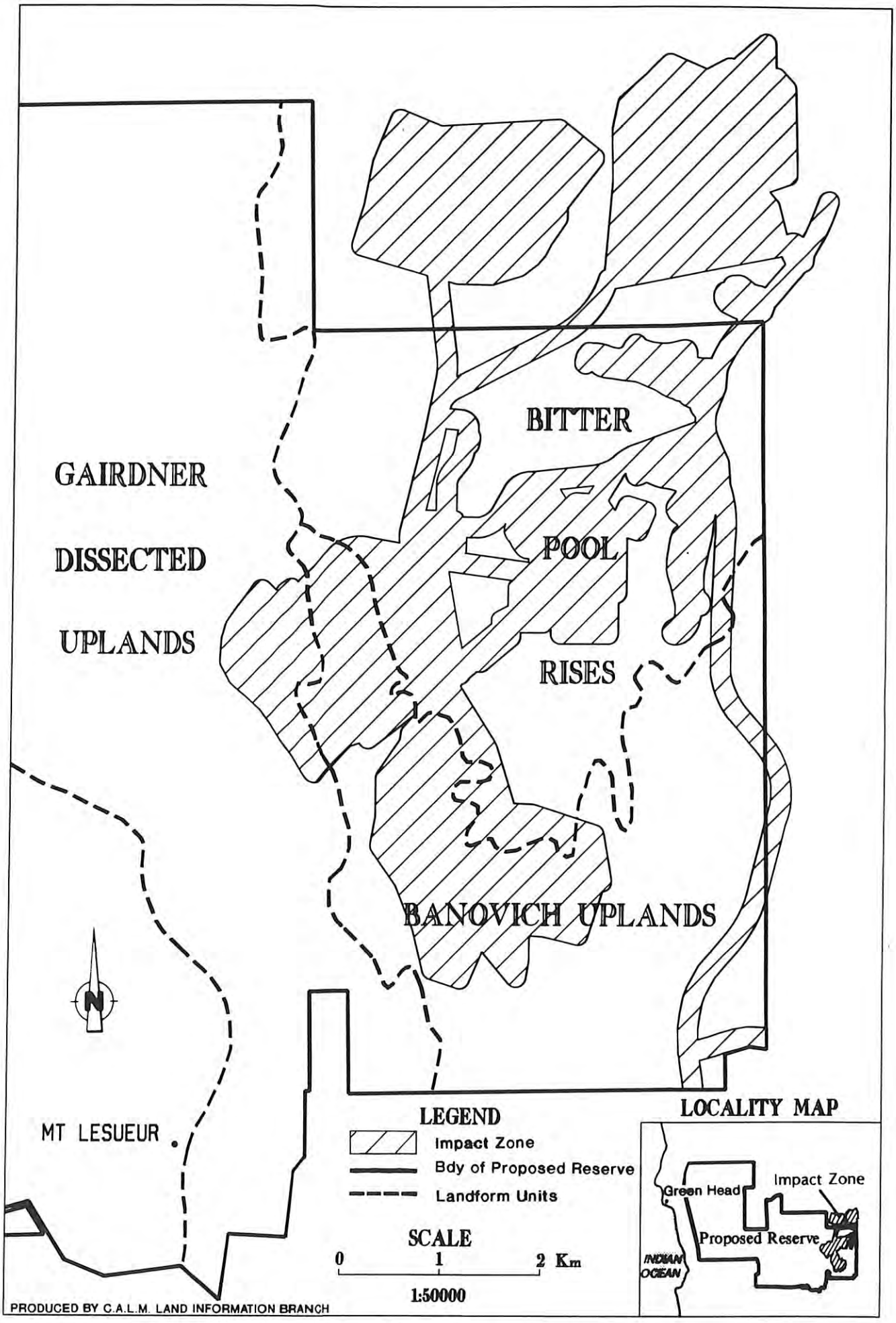

Figure 1.1

Impact zone of Hill River Project ; from ERMP Fig 7.4 with a 100m buffer strip.

100 m strip, gave a total area of 1 474.5 ha within the proposed conservation reserve.

The figure of 100 m was chosen arbitrarily but is based on CALM's experience with long term effects of disturbances on remnant vegetation in the wheatbelt and northern kwongan. We believe the width of the buffer strip to be conservative, especially since the mines have a projected life of 30 years.

The reason for assessing impact within a 100 m buffer as well as in the cleared area is that effects of disturbances are not confined to an actual area of vegetation that is destroyed. There will, for example, be additional disturbances outside the cleared area, such as the construction of power lines, extra fire breaks and gravel pits. In addition, edge effects such as changed micro-meterological conditions, dust, polluted water and air, and added nutrients all cause detrimental changes in the composition and density of vegetation near the edge of a road or clearing. Invasion of weeds occurs mainly from the edge.

Changed hydrological regimes from groundwater drawdowns, de-watering of the pits and modification of surface drainage will also affect adjacent uncleared vegetation as well as the area's natural springs. The effects of drawdown from the pits is likely to extend "... 2-3 km downdip from each pit... " (ERMP p. 5-8). Construction of bunds, dams and over-burden dumps is likely to change patterns of water flow in the area. The fact that many plant species in the area are deep rooted and possess scleromorphic characteristics does not render the vegetation immune to adverse impacts resulting from reduced water availability.

Flooding may also have detrimental effects. The Bitter Pool Rises landform unit, for example, is characterised by sluggish drainage and heavy soils. The vegetation types reflect the drainage and soils pattern, having extensive areas dominated by *Calothamnus quadrifidus* heath. At Eneabba, large areas of similar vegetation have been killed by flooding caused by increased run-off from the mineral sands treatment plant.

Several small pockets of vegetation will be left within the area that will be cleared. Small areas of vegetation, which have a relatively high perimeter to area ratio, degrade faster than larger ones (Ehrlich and Murphy 1987, Taylor 1987). Areas of vegetation of less than 10 ha within the development will have very low nature conservation values in the long term.

Faunal use of vegetation next to cleared areas is also reduced, even if the vegetation does not degrade (Lynch 1987).

The 100 m buffer strip does not take into account the possible extensive effects of air pollution on the vegetation (Chapter 2, this publication) nor the extensive, major disturbances that will happen if dieback disease (*Phytophthora* species) is introduced as a result of the project (Hill 1990, Chapter 5, this publication).

1.4 DURATION OF THE PROJECT

The EPA guidelines require information on "... the scope and timing of the proposal, including any plans for progression to future coal reserves." (ERMP Attachment 1, p. 2). The duration of the project is stated as 30 years. During this time it is proposed to mine 64 Mt of coal from total known reserves of 450 Mt. Future developments are scarcely mentioned in the ERMP. However, on pp 5-1 and 5-2 the location of the power station within the proposed conservation reserve rather than in cleared land to the north or south is justified partly on the basis that "... the construction of mine facilities on either location restrict access to remaining coal reserves ...". Thus, there is a possibility that the project, if approved, would continue beyond the stated 30 year time span.

Chapter 2

VEGETATION

by Neil Gibson and A.J.M. Hopkins

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Abstract

The high priority accorded to the establishment of a major conservation reserve in the Lesueur area is largely attributable to its unique floristic values. Within the proposed reserve are found high levels of species endemism, a high degree of species richness, and a very fine scale and hence complex mosaic of vegetation types. The proponents' regional analysis covering other conservation reserves in northern kwongan failed to locate most of the vegetation types found at Lesueur. Our analysis showed that the proposed development will have a severe direct impact on at least eleven of the 38 vegetation types so far defined. Nine of these communities are not known from outside the project area.

We also considered the likely indirect impacts of the proposed mine and power station development on the vegetation of the region. The information provided in the ERMP is inadequate to allay serious concerns about the acute and/or chronic effects of the various stack emissions on the vegetation over a wide area. Given the high biological significance of the area, the possibility of retrogressive succession occurring in the area is of considerable concern. The impacts of some trace elements in both air and water effluent have not been considered in the ERMP, nor have the effects of groundwater drawdown or changes in surface drainage been adequately dealt with.

The combined direct impacts and indirect effects of the proposed development on the vegetation of the region are likely to be very significant.

2.1 INTRODUCTION

The flora and vegetation of the Lesueur area have long been recognized as having very high conservation significance (Drummond 1853, Gardner 1947, Speck 1958, Griffin *et al.* 1983). The conservation significance of this area stems from both the high species richness of the area (averaging 76 spp/100m^2) and a very fine scale mosaic of vegetation types. The reasons for this richness are not fully understood but may be related to habitat continuity since the Tertiary, migration barriers, nutrient poor soils and recurrent climatic stress (Hopper 1979, Griffin *et al.* 1983, Hopkins and Griffin 1984).

Only one quantitative regional floristic survey has been carried out covering the Lesueur area. This was the work of Griffin *et al.* (1983); it was restricted to the lateritic uplands and covered some 500 000 ha. This survey highlighted the distinctness of the Lesueur area, which contained vegetation types not found elsewhere in the region. Studies of the distribution patterns of the 259 regional endemic plant species of the northern kwongan reinforce this conclusion (Griffin *et al.* 1990).

In the guidelines to the preparation of the ERMP for the proposed power station and coal mine the EPA stated "... a detailed assessment of the area's conservation status will be required. This is to ascertain if the conservation values in the area proposed for mining are adequately represented and preserved outside the area to be mined. If there are suitable areas of other land which could be included into existing reserves to replace lost conservation values the appropriate replacement proposals should be made. Details of the following would be required to adequately determine the relative values of... the proposed reserve areas that may be affected by mining.

- distribution and description of vegetation types. ...
- conservation status of vegetation." (ERMP Attachment 1, p. 7).

In assessing the ERMP in light of these guidelines it was found that the vegetation section was most superficial. It was not possible to even broadly assess the local impacts of this proposal without first calculating areas of each vegetation type affected; this information was not contained in the ERMP. The section dealing with the regional significance of the vegetation of the Lesueur area was inadequate, the small amount of data provided (in consultants' reports, not the ERMP) indicate the high conservation significance of the proposed

conservation reserve at Lesueur, yet are interpreted in precisely the opposite way.

2.2 DIRECT EFFECTS OF THE POWER STATION AND COAL MINES ON THE NATIVE VEGETATION

2.21 Local vegetation

The proponents commissioned detailed vegetation mapping over most of the uplands of the proposed reserve. This showed a complex mosaic comprising 38 basic vegetation types. These basic types were mapped in the eastern end of the proposed conservation reserve. However, in some areas the consultants were not able to map the basic type and instead mapped an amalgamated unit (e.g. in the project area Type A was mapped when the consultants could not allocate vegetation to A1, A2.1, A2.2, A4.1, or A4.2) or a mosaic unit (e.g. DEH was mapped when the vegetation appeared to be a complex of Type D (which has 3 sub-types), and Types E and H). These maps were not provided in the ERMP where the vegetation was discussed in terms of "seven basic vegetation types" (ERMP p. 4-17, figure 4.17). This level of simplification is inadequate to properly assess the impact of this proposal on vegetation of the proposed conservation reserve at Lesueur.

The 38 basic vegetation types were defined by the consultants from an analysis of data collected from 226 quadrats spread over the project area (Martinick and Associates 1988). This analysis was of a high standard although apparently spurious conclusions were drawn from it. In particular Martinick and Associates (1988, p. 6) stated that "there may be still a few undefined vegetation types, but these are likely to be very limited in area and unimportant".

Griffin and Hopkins (1990) showed the homotoneity of many of Martinick and Associates' floristic groups was low (their Table 4.3) and inspection of Martinick and Associates' (1988) two-way table shows that nine of their 38 groups were defined by only one or two quadrats. On this basis, the assurance that all major vegetation types are adequately defined must be seriously questioned. It is likely that the complexity of the vegetation is considerably greater than that suggested by Martinick and Associates' analysis.

The consultants used the floristic classification to produce a key based on landform, structure and indicator species which is used to define mapping units. Inspection of their two-way table indicates that this key is subject to some degree of misclassification (for example types A2.1 and A2.2, types B3.1 and B3.2 and C1, C2, C3). Hence the maps produced for the eastern section of the proposed conservation reserve at Lesueur are both simplifications and approximations of reality.

Table 2.1 shows the extent to which the various vegetation units will be affected by the proposed development. This table was developed by overlaying the impact zone (see Chapter 1, this publication) with the detailed vegetation maps of Martinick and Associates (1988). It was found that the degree of discrimination in the vegetation mapping was variable. In some areas vegetation was broken down into its basic units (i.e. one of the 38 floristic groups) while in other areas it was lumped into larger vegetation types (e.g. Sand heath (type A) cf. *Stirlingia - Adenanthos* Heath on sandplain (type A2.1)). It is important to note that these major vegetation types only refer to those areas which were not differentiated into the finer vegetation units. As a result of this lack of discrimination it was not possible to determine precisely the impact of the proposal on the 38 previously defined basic vegetation types; nonetheless general trends are clear.

Our analysis (Table 2.1) shows 11 of the 19 basic vegetation types, five of the ten amalgamated vegetation types and seven of the eight mosaic units will be impacted severely with more than 25% of their known extent in the eastern uplands being affected.

One of the most severely affected on a proportional basis is the drainage line vegetation (types L and M, subtypes L2 and L3, mosaic unit LM) which will be reduced by up to 50%. This will particularly affect the *Melaleuca* heaths.

Three sand heath units will be severely affected (A2.1, A2.2 and A4.2). Of these Martinick and Associates (1989a) have reported only the *Stirlingia - Adenanthos* heath (A2.1) from other conservation reserves in the region.

Two lateritic heaths will also be severely impacted (B1.4.1 and B3.2), although Griffin and Hopkins (1990) have reported *Banksia micrantha* heath (B1.4.1) from the Lesueur Dissected Uplands landform unit outside the project area.

Other vegetation types to be severely affected by the proposal include the *Gastrolobium spinosum* scrub (type I) which will suffer a 64% reduction, the *Petrophile seminuda* heath (type H) which will suffer a 40% reduction and the *Calothamnus quadrifidus* heath (type J) which will suffer a 30% reduction. Griffin and Hopkins (1990) note the unusual nature of vegetation type J. These authors also point out that the *Ecdeiocolea monostachya* heath (type E) occurs on two different substrates in the northern and eastern vacant Crown land blocks proposed for inclusion in the conservation reserve at Lesueur. Details available from Martinick and Associates' mapping does not

Table 2.1

Areas of the vegetation types in the direct impact zone (including the 100 m buffer) of the proposed power station and coal mine.

Vegetation type[1]	Area directly impacted[2] (ha)	Total area of mapped vegetation in proposed reserve[3] (ha)	Percentage impacted
Individual units			
A2.1	83.6	193.0	43.3
A2.2	2.8	11.0	25.5
A4.1	41.3	189.0	21.9
A4.2	143.2	327.0	43.8
B1.1	0.6	3.0	20.0
B1.2	0.4	51.0	0.8
B1.4.1	9.5	21.0	45.2
B1.4.2	15.5	73.0	21.2
B3.1	3.4	35.0	9.7
B3.2	134.2	426.0	31.5
C1	11.2	16.0	70.0
C3	9.1	30.0	30.3
E	54.4	79.0	68.9
H	45.3	114.0	39.7
I	3.2	5.0	64.0
K	9.1	644.0	1.4
L2	23.2	45.0	51.6
L3	1.9	9.0	21.1
M1	2.3	27.0	8.5
Amalgamated units			
A	63.0	1859.0	3.4
A1	2.7	31.0	8.7
B	72.4	731.0	9.9
B1	1.9	1.0	190.0*
B1.4	23.7	24.0	98.8
C	19.9	390.0	5.1
D	163.5	871.0	18.8
J	12.8	43.0	29.8
L	6.3	22.0	28.6
M	8.3	7.0	118.6*
Mosaic units			
AL	8.1	25.0	32.4
CDF	31.6	115.0	27.5
DEH	29.3	36.0	81.4
FG	6.6	70.0	9.4
FGH	341.5	851.0	40.1
FGHJ	60.0	117.0	51.3
JHL	11.7	30.0	39.0
LM	15.0	31.0	48.4

1 See Table 4.6 of the ERMP

2 Data calculated by CALM from digital information

3 Data from Martinick & Associates (1989b), refers to eastern portion of proposed reserve.

*Percentages >100% result from minor differences in digitized data as calculated by CALM and Martinick & Associates (1989b).

allow the impact on these two subtypes to be assessed. Overall 69% of this combined vegetation type will be impacted.

In addition, two of the three sandstone heaths (C1 and C3) will be significantly affected by this proposal (70% and 30% respectively). The consequences of this proposal on the *Banksia tricuspis* scrub heath (subtype C1) are of special concern given the high conservation significance of this species and its demonstrated interaction with the local bird fauna.

The impact of the proposal on the wandoo woodlands is also of concern. Although only a relatively small area is involved (9.1 ha), this particular area contains the best stands of *Eucalyptus wandoo* with *Trymalium* understorey on deeply incised valley slopes in the region. Wandoo woodlands are known to be important for tree hole nesting birds. Such nest holes are a limiting resource in this area and any reduction in availability could have serious consequences (Hopkins and Saunders 1987).

From the available data it is clear that nine vegetation units (A2.2, A4.2, B3.2, C1, C3, E, H, I, L2), which are not known from outside the project area, will be severely affected by the proposal (Table 2.1). In addition the impact of the proposal on the wandoo woodlands is of serious concern.

2.22 Regional vegetation

Despite the requirement by the EPA (cited above) that the proponents assess the conservation status of the impact area in a regional context, the regional study provided in the ERMP was very superficial. The proponents stated in the ERMP that "it was not practical ...to carry out detailed quantitative studies of any vegetation on the regional reserves because of the large areas involved" (ERMP p. 4-15).

This large area defined by the proponents as some 50 000 ha (ERMP p. 4-15) was very much smaller than that studied by Griffin *et al.* (1983) in their regional survey of the vegetation on the lateritic uplands, which included the Lesueur area. It is much smaller than any of the normal quadrat-based regional surveys undertaken by CALM (e.g. Nullarbor (McKenzie and Robinson 1987) and kwongan of the wheatbelt (Brown 1989)) and smaller than detailed surveys undertaken of some single reserves (Cape Arid, Fitzgerald River). Clearly the proponents have not allocated the resources necessary to properly address this task.

Instead of a detailed regional floristic survey the proponents' regional survey consisted of attempting to identify the 38 Lesueur floristic groups (these were the basic mapping units in the project area) in selected conservation reserves in the region. These floristic groups were identified using a key based on landform, structure and the presence of indicator species. As indicated above this method is potentially subject to some degree of misclassification. This survey did not cover any areas outside existing or proposed reserves. No information is given either in the ERMP or in the consultants' reports of how many sites in each reserve were visited.

Of these 38 mapping units only two are definitely found outside the Lesueur region (types A1 and A2.1). (Martinick and Associates (1989a) state incorrectly that there are three - see their Table 2.) Of the remaining 36 units, similar but not identical vegetation has been recorded for another 10 units. This leaves 28 units not being recorded outside the Lesueur area. None of these statistics appear in the ERMP nor can they be derived from information presented there.

In the ERMP the proponents claimed that "the heaths on sandy slopes and valleys, the most common vegetation type in the project area, was also widely distributed in the region although there was some localised sub-types. Similar results were obtained for heaths on lateritic uplands and heaths and woodlands on gravelly hills and slopes, although the former were extremely variable" (p. 4-16).

Data from Martinick and Associates (1989a, Table 2) clearly show this not to be the case (Table 2.2). The proponents' statement that the vegetation types defined in the Lesueur area are widespread in the region is clearly not correct. The statement is based on their attempt to simplify the complex vegetation of the Lesueur area by amalgamating many of the basic vegetation types that are present there into only seven "basic" types.

All data presently available (including the proponents') clearly indicate the uniqueness of many of the vegetation units found in the project area (Griffin *et al.* 1983, Froend 1988, Griffin and Keighery 1989, Griffin and Hopkins 1990). According to the consultants' data only 5% of vegetation types mapped at Lesueur are found in existing or proposed reserves elsewhere. The consultants reported that similar vegetation is reserved for a further 26% of vegetation types, although the data presented are incomplete. The overwhelming majority of vegetation types (68%) have not been recorded in existing reserves or proposed reserves outside the proposed conservation reserve at Lesueur. These data clearly demonstrate the great importance of the Lesueur area for the conservation of the vegetation types of the region.

The proponents have failed to provide a detailed assessment of the conservation status of the vegetation found in the project area as requested by the EPA.

Table 2.2

Occurrence of the same or similar major vegetation types outside the Lesueur area.

Vegetation category	No. of subtypes	No. of same type found outside Lesueur	No. of similar type found outside Lesueur
Sand heaths	6	2	2
Lateritic heaths	8	0	2
Gravel heaths	5	0	0
Woodlands	1	0	1

Table 2.3

Impact on landforms in the proposed Lesueur conservation reserve.

Landform	Total area in proposed reserve (ha)	Impact area (ha)	%
Gairdner Dissected Uplands	2325	124	4
Banovich Uplands	1615	585	36
Bitter Pool Rises	1699	766	45

Further they have not been able to demonstrate alternative areas which could be reserved to protect the plant communities found in the Lesueur area. They appear to have attempted to play down the significance of the Lesueur area's vegetation.

2.23 Impact on Landforms

Table 2.3 provides data on the area of the three landforms that will be affected by the proposed mine and power station. These figures were calculated from digital maps prepared by CALM's Land Information Branch using data in the ERMP and Martinick and Associates (1989b).

The major impact of this proposal will be on the Bitter Pool Rises (45.1%) and the Banovich Uplands (36.2%) with a minor degree of impact on the Gairdner Dissected Uplands (3.6%).

The currently protected upper portions of the catchments of Cockleshell Gully, Munbinia Creek and Coomallo Creek would all be affected by the mine and would cease to be of value in "bench mark" studies to provide information for catchment management in the region.

The very high impact of the proposed development on the Bitter Pool Rises landform and its associated vegetation types is of particular concern. This unit is comprised mainly of heavy clayey soils and has a very sluggish (mature) drainage system feeding into Coomallo Creek to the east. The particular combination of low relief, heavy soils and poor drainage is unique in the region.

2.3 EFFECTS OF EMISSIONS FROM THE POWER STATION ON THE NATIVE VEGETATION

2.31 Model reliability

Calculations of predicted concentrations of aerial emissions to be produced by the power station are based on the mathematical model AUSPLUME. The proponents state that this model has been widely used in Australia despite its known limitations under certain meteorological conditions. These limitations are not discussed nor is any illustration of model versus actual emission presented for any currently operating power station. It is thus impossible to determine the confidence limits that can be placed on the output of this model. The adequacy of this approach needs to be determined by persons with expertise in this area. Since the release of the ERMP, another consultant's report has become available (Steedman Science and Engineering 1990a) that discusses the sensitivity and accuracy of the model.

2.32 Sulphur dioxide

There are few detailed data in the literature on the effects of either acute or chronic exposure to sulphur dioxide (SO_2) on Australian native vegetation. Data on these effects on the 821 species occurring in the proposed conservation reserve at Lesueur are almost entirely lacking.

Given this lack of data it is difficult to determine the potential area of vegetation that may be affected by either chronic or acute exposures. The proponents estimate (ERMP Figure 8.4) that 21 000 ha are likely to get at least a one hour exposure of 350 g/m^3/year, 9 000 ha will get at least a one hour exposure of 500 g/m^3/year and 2 000 ha will get at least a one hour exposure of 700 g/m^3/year. These data give some indication of the potential area that may be affected by SO_2 exposure.

The section of the ERMP dealing with this topic is both superficial and incorrect in matters of interpretation. The major data source considered by the proponents in their assessment of the effects on the vegetation in the project area are two papers by O'Connor *et al.* (1974, 1976) which look at the response of 131 Australian tree and shrub species to acute SO_2 exposure. Only one of these species occurs in the project area, but it is probably of a different genotype.

The proponents state that these data suggest "the decreasing order of susceptibility to SO_2 in the study area can be broadly categorised into :

(a) Eucalypts - probably most susceptible
(b) Broad - leaved species
(c) Narrow - leaved species
(d) Acacias - probably the least susceptible." (ERMP p. 8-10).

Analysis of the data in the O'Connor *et al.* (1974) shows no such pattern. These researchers ranked SO_2 from 0 to 6 with 0 being most resistant and 6 being most susceptible.

An analysis of variance of these data broken down by the four classes suggested by the proponents showed -

Class	Mean sensitivity score
Eucalypts	4.02^a
Broad leaved spp.	1.75^b
Narrow leaved spp.	2.57^b
Acacias	2.26^b

This analysis showed only the eucalypts as significantly more sensitive to SO_2 than the other three classes ($P < 0.01$) while the trend in the

Table 2.4

Relative sensitivity of Australian native genera to SO_2 exposure. Number of species in each of seven classes shown. Classes range from 0 (most resistant) to 6 (most sensitive). (After O'Connor *et al.* 1974)

SENSITIVITY	0	1	2	3	4	5	6
CASUARINACEAE							
Casuarina	4	2					
CONIFERAE							
Callitris		2		2			
LABIATAE							
Prostanthera			1		1		
MALVACEAE							
Lagunaria	1						
MIMOSACEAE							
Albizia			2				
Acacia	1	8	9	5	1	2	1
MYOPORACEAE							
Myoporum	1						
MYRTACEAE							
Agonis		1	1				
Angophora				1			
Callistemon				5	2		
Eucalyptus	2	3	2	7	8	13	8
Eugenia		1					
Leptospermum		2	1			1	
Melaleuca		3	2	5		5	
Syncarpia		1					
Tristania		2					
PROTEACEAE							
Banksia		1			2	2	
Grevillea				1			
Hakea		1	1			1	
RUTACEAE							
Correa				1			
STERCULIACEAE							
Brachychiton		1					

remaining classes is not as suggested by the proponents. (Categories in the analysis with the same superscript are not significantly different from each other; categories with different superscripts are significantly different at the 1% level.)

Tabulation of the data from O'Connor *et al.* (1974) (Table 2.4) clearly shows that SO_2 sensitivity is highly variable within families and genera, and other data indicate that this variability in response also occurs within species and varieties (O'Connor *et al.* 1974, Thompson *et al.* 1980, Murray and Wilson 1988a).

As outlined in the ERMP, Murray (1988) has reviewed the impact of very high levels of SO_2 exposure for short periods on the vegetation around the Kalgoorlie nickel smelters. These emissions have had a surprisingly limited impact on the vegetation of the area (most visible damage restricted to within 2 km of the stack, severe damage limited to the NW quadrant). Similar resistance to SO_2 damage has been reported for species from the deserts of North America (Hill and Barrett 1974, Thompson *et al.* 1980).

What is not stated in the ERMP is Murray's conclusion that "...SO_2 concentrations around the Kalgoorlie Nickel Smelter would destroy most crop plants and most plants native to less arid areas of Australia..." (Murray 1988, p. 3). It is clearly not valid to compare the semi-arid to arid zone plants of the Kalgoorlie area with the Mediterranean climate plants of the Lesueur area. Data on the response of plants from Kalgoorlie cannot therefore be used to predict possible impacts on the plant communities found at Lesueur.

The proponents also fail to discuss the effects of chronic SO_2 exposure (i.e. low concentration, long exposure time) on the vegetation. Studies by Horsman *et al.* (1979), Ayazloo and Bell (1981) and Garsed and Rutter (1982) have shown a lack of correlation between acute and chronic sensitivity for a variety of taxa. As yet little work has been undertaken on effects of chronic exposure on Australian native species (Murray 1984, Murray and Wilson 1988b).

It is widely recognized that biochemical and ultra-structural changes may occur at concentrations well below that at which visible damage is apparent (Murray 1984). The SO_2-sensitive species of a community may show visible damage or may simply show reduction in growth rate and/or reproductive success (Murray 1984, Preston 1988). Either way such stress could eventually result in the elimination of such species, permanently changing the composition and structure of these communities.

Guderian (1977) shows a worst case scenario in an oak - beech forest where all plants are killed in the immediate area of the emission source. At a greater distances from the source there occurred a zone of highly resistant plants, a grass and scrub zone, a zone of dying trees and finally a forest zone. These patterns resulted from high level acute exposures to the pollutants. Such retrogressive successions have been reported in several different communities in the United States (Gordon and Gorham 1963, Westman 1985, Preston 1988). Much more subtle changes could be expected with long term chronic exposures.

If a proportion of the flora of the Lesueur area is sensitive to chronic exposures, then over the life of this project (30 years) significant changes may occur in the composition and structure of some or all of the 38 vegetation types found in this area. The effect of these changes on the fauna are likely to be profound.

In early July, some six weeks after the release of the ERMP, two additional consultants' reports became available which further assessed the potential impacts of SO_2 emissions on the local vegetation (Steedman Science and Engineering 1990b, Murray *et al.* 1990). These documents report on detailed studies on the SO_2 sensitivity of five species common in the project area. These five taxa were selected on the basis of their high sensitivity to SO_2 from "34 species of importance in the native flora" (Murray et al. 1990 p. 2). The other 29 taxa screened were not identified nor was the screening method specified.

The five taxa studied were *Acacia saligna, Banksia attenuata, Banksia menziesii, Eucalyptus wandoo* and *Hakea incrassata*. Steedman Science and Engineering (1990b) concluded that as a conservative estimate the SO_2 from the proposed power station would result in "areas of minor damage for E. wandoo up to 5 km for areas around the power station." and "minor damage to the sensitive species B. menziesii within 10 km of the stack for all directions, except the northeast quadrant where minor damage is likely to extend out to 20 km" (Steedman Science and Engineering 1990b, p. 6).

In their more detailed report Murray *et al.* (1990) showed that the growth response varied with SO_2 concentration and plant species. In the most sensitive species (*Eucalyptus wandoo* and *Acacia saligna*) there was no effect or a stimulation of growth at low concentrations of SO_2 exposure but growth inhibition occurred as toxicity developed at higher concentrations. In contrast the other three species showed no response or some growth stimulation. Murray *et al.* (1990) review the several possible mechanisms which may explain the variable results obtained.

These findings have important implications for the vegetation of the Lesueur area. The more resistant species tested showed a differing growth response at the levels of SO_2 exposures that can expected to be produced by the power station. Further, significant

growth inhibition is likely in the two more sensitive species. Given this variation in response of the five taxa studied, it appears that significant changes in the composition and structure of the plant communities within a five to ten kilometre radius of the power station could be expected over the life span of this development (30 years). These five taxa represent only slightly more than half of one percent of the species that occur in the Lesueur area. More detailed assessments of the direction and rates of change can not be made until many more species have been similarly screened. O'Connor *et al.* (1974) point out that young plants (which were tested in the experiments of Murray *et al.* (1990), tend to be less sensitive to SO_2 exposure than mature plants. This implies that the above findings are likely to be conservative.

Given that the high biological significance of the proposed conservation reserve at Lesueur stems in part from its highly complex and species-rich plant communities, the possibility of retrogressive succession resulting from atmospheric pollutants is of major concern.

As a minimum requirement, the acute and chronic sensitivities of a wide range of the plant species occurring at Lesueur would need to be determined before the full ecological implications of the proposed power station on the highly diverse and species-rich communities in this area could be assessed. The endemic component of the flora would need special screening. The question of synergistic effects of SO_2 with other pollutants also needs to be addressed (Murray and Wilson 1988a, 1988b), as does the possible impacts on the fauna (e.g. potential loss of nest sites for Carnaby's Black-Cockatoo through tree loss).

2.33 Nitrogen oxides

Again there is almost a complete lack of knowledge of the sensitivity of Australian plant taxa to nitrogen oxides (NO_X). The overseas literature suggests that, as for SO_2, effects vary greatly within and between families, genera and species (Hill and Barrett 1974, Thompson *et al.* 1980). Most often NO_X have been tested in conjunction with SO_2; in some cases the resulting damage has been much greater than that seen when one pollutant is tested in isolation (Tingey *et al.* 1971, White *et al.* 1974, and others).

In light of the lack of data the proponents' statement that "it is believed that there will be no detrimental effects of NO_X on the native vegetation " (ERMP p. 8-14) can not be substantiated.

2.34 Hydrogen fluoride

The ERMP states that hydrogen fluoride (HF) emissions will not occur from the power station ("Many studies have tried to examine synergistic effects between SO_2 and NO_X or with substances that will not occur in the Hill River Project (e.g. hydrogen fluoride" ERMP p. 8-11). Since the ERMP was released a consultant's report has become available (Steedman Science and Engineering 1990a) that states "Very small amounts of chlorides, fluorides, carbon monoxide, hydrocarbons and trace metals will also be released." (p. 3). No amounts are given.

CALM sought from Canning Resources access to an earlier consultant's report by Burmot Australia, which was referred to by Steedman Science and Engineering and which we believed might give more precise data on fluoride in the flue gases. Canning Resources advised us that this report contained confidential commercial information and arranged for Burmot Australia to provide advice on fluorine.

Burmot Australia advised as follows:

"Burmot Power Station Stack Discharge Report 8842/4/2, dated July 1989, includes table 4 on page 12 which gives indicative quantities of constituents in typical coal and fly ash. Fluorine in coal ranges from 70 to 120 ug/g and in fly ash from < to 250 ug/g. We have conservatively estimated the maximum amount of fluorine in flue gas as 0.016 g/m3 on the basis of the following:

- Fluorine in coal 250 ug/g
- Fluorine in fly ash 100 ug/g
- Both generating units operating at maximum continuous rating

This maximum concentration is a factor of approximately three less than the NH&MRC standard of 0.05 g/m3." (Burmot Australia in litt. to Canning Resources, 27 July 1990).

It is clear that, contrary to the statement in the ERMP, there will be fluoride emissions. No estimates of ground concentrations of fluoride in the vicinity of the power station are available and the significance of these emissions on the native vegetation at Lesueur has not been addressed in the ERMP.

Fluoride is emitted by power stations in Victoria, Queensland and the Hunter Valley of New South Wales (Horning and Mitchell 1982). Data from 134 species of native Australian plants show that they have highly variable responses to HF exposure, indicating that the response of individual species is impossible to predict (Horning and Mitchell 1982, their Tables 1 and 2). Examination of their data indicates that only 0.5% of species, and species from 7.5% of genera and 23.7% of families occurring at Lesueur have been screened.

As with SO_2, significant internal injury may occur before visible symptoms are apparent (Doley 1981) and, furthermore, fluoride damage can occur at very much lower levels of emission than is seen for SO_2 (Mitchell *et al.* 1981). HF is also reputed to have

synergistic effects with some other pollutants, at least for some species (Murray and Wilson 1988b).

Retrogressive successions have also been reported around fluorine emission sources both in Australia and overseas (Murray 1981, Treshow and Anderson 1982). As discussed above, such possible changes are cause for serious concern in the Lesueur area.

The question of fluoride emission by the power station obviously needs clarification. Since emissions will occur much more detailed data on their effects on the vegetation of the project area are needed.

2.35 Ash

The section in the ERMP dealing with ash emissions is both contradictory and incomplete. Of primary concern is the possible toxicity of the ash. The proponents state that, based on their analysis, the ash is non-toxic and contains many elements beneficial to plant growth. Examination of the data provided in Appendix E indicates that four trace elements (beryllium, boron, selenium and antimony) in the coal (Appendix E, Table 1) have not been analysed in their leachate studies.

The absence of data on boron is of particular concern. This element has been shown to reach toxic levels in Australian and Western Australian coals and is recognized as the major toxicity problem in utilization of ash for agricultural purposes in Australia (Aitken *et al.* 1984). Further, in glasshouse trials in the United States, it has been shown to cause growth depression and leaf necrosis in some taxa (Glaubig and Bigham 1985). Other work from the United States suggests that boron accumulates to very high levels in some woody species (Scanlon and Duggan 1979).

The failure of the proponents to consider possible boron toxicity makes their assurance of the non-toxic nature of the ash difficult to accept. Their assurance is further qualified by their discussion of ash burial methods within the overburden dumps. In Appendix E it is suggested the most appropriate way of disposing of the ash is straight burial without the use of barriers. Yet within the main body of the ERMP it is stated that "the ash would be placed in layers, compacted by rolling and, when at a designated depth, covered with a layer of impermeable clay to restrict natural moisture ingress" (ERMP p. 7-4). The reason for advocating a different ash disposal method to the one suggested by the consultants is not clear.

A further concern with regard to ash is the direct effect the emitted ash has on the vegetation in the general area close to the power plant. It has been shown that ash emitted from the Gladstone power station in Queensland has the potential to significantly damage plant cuticles (QEGB 1984). In a study on damage to a mango crop 5 km from the power station scanning electron micrographs showed ash particles embedded into the leaf surface. Spectrographic analysis of these embedded particles confirmed them to be fly ash. The effects of this leaf scarring, its possible effects on pollutant uptake and individual species sensitivity all need further study. Some work from the United States suggests that cuticle damage can facilitate fluoride (Chamel and Garrec 1977). None of these potential impacts of ash emissions on the local vegetation have been discussed in the ERMP.

2.4 EFFECTS OF WATER DISPOSAL AND DRAWDOWN ON NATIVE VEGETATION

2.41 Acid water disposal

The disposal of water collected in the various mining pits from rainfall, groundwater inflow and seepage from overburden dumps is inadequately dealt with in the ERMP. The proponents expect to deal with up to 1.5 million litres of waste water per day per pit. The suggested disposal method is to pump to lined surface holding ponds where it will either be treated to adjust pH and then discharged to sedimentation ponds or left to evaporate. The sedimentation ponds will be unlined due to the sediments having been previously caught in sumps. These sedimentation ponds will discharge into the natural drainage lines.

Acid mine drainage is recognized as a major water pollution problem (Letterman and Mitsch 1978). It forms whenever water containing oxygen comes in contact with sulphur present as sulphides (particularly pyrites) in coal or surrounding country rock. In addition to low pH, acid mine waters may have a large number of other contaminants (Barton 1978). Acid mine drainage could clearly be a problem with the high levels of sulphur in the Lesueur coal and the presence of iron pyrites.

The proposal that the waste water at Lesueur will only be adjusted for pH then discharged via an unlined sedimentation pond into the natural drainage lines is clearly inadequate. The proponents should, as a minimum, have discussed the likely contaminates of this effluent and outlined strategies to remove toxic materials before it is discharged into unlined ponds and natural drainage systems. Untreated discharge of waste water containing heavy metals, for example, has been demonstrated to cause heavy metal build up in plants, soils and animals in Victoria (Evans *et al.* 1977).

2.42 Water drawdown

There will be two major sources of water drawdown if this project proceeds: that surrounding the mine pits and that resulting from the bore field operations.

The proponents give no indication in their ERMP of the possible area affected by water drawdown around the mine pits but do comment "Drawdowns as a result of dewatering and depressurisation are expected to be limited to a distance of 2-3 km down dip of each pit, and should not adversely impact on the xerophyte vegetation (heath or agriculture) ..." (ERMP p. 5-8).

This assumption that the vegetation will not be impacted by radical changes in the water table by virtue of the xeromorphic anatomy of the component plants is not born out by other workers. Dodd *et al.* (1982) have shown that species comprising kwongan vegetation possess a variety of root morphologies, suggesting a wide range of responses to changes in water table depth. That xeromorphic kwongan vegetation is susceptible to changes in water availability was demonstrated by Hnatiuk and Hopkins (1980) who reported water stress in 124 native species at Eneabba in the second consecutive year of below average rainfall. They found differential responses both spatially and between different families. In addition, Heddle (1980), working in *Banksia* woodlands on the Swan coastal plain north of Perth, suggested that any long term decrease in water availability may result in a slow shift in floristic composition.

It is clear from these data that the changes in the water table due to the mine pits could be expected to have a significant effect on the surrounding vegetation. No attempt has been made to quantify the extent of these disturbances in the ERMP.

From the ERMP it is not clear to what extent the proposed bore field would affect the vegetation in the proposed Coomallo National Park. The proponents have not determined to what extent the abstraction of water from the Yarragadee Formation will affect the water table of the upper unconfined aquifers or semiperched aquifers, but appear again to rely on the "xerophytic" (ERMP p. 8-20) nature of the vegetation to ensure no adverse impacts. Given the very large extent of the proposed borefield this lack of detailed knowledge of the effects of drawdown on the local hydrology is a source of considerable concern.

A more recent consultant's report (Australian Groundwater Consultants 1990), which became available after the ERMP was released, states in relation to the surficial water aquifer "The maximum drawdown from a 30-year simulation was less than 5 m." (p. 21, see also Figure 41). The effect of even a three metre drawdown on the local vegetation is likely to be significant, given the studies referred to above.

This report also makes it clear that, on the basis of available information and studies, it is still not possible to predict whether trees and associated vegetation in the Hill River valley depend on artesian seepage for their water requirements. Thus, this vegetation may also be detrimentally affected by the operation of the bore field.

2.43 Drainage changes

Significant changes in surface drainage can be expected to result from the proposed development. As a consequence major changes in composition and structure of some communities must be expected. For example the *Calothamnus quadrifidus* heath associated with the clayey soils of the Bitter Pool Rises landform appears to be particularly susceptible to even small changes in soil moisture conditions. A similar *C. quadrifidus* heath has been severely impacted by changed hydrological conditions near the mineral sand mining separation plant at Eneabba. The question of such impacts or their likely extent has not been defined in the ERMP.

Chapter 3

FLORA

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Abstract

The Hill River Project ERMP does not adequately address the EPA guidelines particularly in its assessment of the conservation status of, and impact on, Declared Rare Flora (DRF) and regional endemic taxa. Although the conservation status of DRF is briefly reviewed there is no reference to their security on existing or proposed reserves and there are insufficient data relating to the numbers of populations and individuals that are known to exist. The ERMP lists 48 "vulnerable taxa" which occur in the Lesueur area. These taxa, however, were not surveyed and consequently their distribution and conservation status, and impact of the project on them, has not been determined. There are also a further 56 regionally endemic taxa occurring in the project area which require some assessment of their conservation status. Populations of taxa at the limit of their range and relictual species have not been treated in the ERMP although they represent a genetic resource unique to the Lesueur area.

There is some discordance between the proponents' and CALM's assessment of the impact of the project on numbers of individuals of DRF, particularly for Asterolasia drummondii and Hakea megalosperma.

Although the ERMP proposes to re-establish DRF and other regional endemics found in the project area, the data and methodologies provided are insufficient to confidently predict the survival of many taxa proposed for re-introduction.

Cryptogams have not been considered by the proponents.

3.1 INTRODUCTION

The proposed conservation reserve at Lesueur has a known vascular flora of 821 taxa, representing approximately 10% of the State's recognised vascular flora and a third of the taxa found in the Irwin Botanical District. Moreover, the area contains 111 of the 259 northern kwongan regional endemics, including seven species that have been gazetted as Declared Rare Flora (DRF) and 48 poorly known taxa considered to be threatened or vulnerable. Also occurring within the area are 81 taxa at their northern or southern distributional limits. The numbers of DRF, endemics and taxa at the edge of their geographic ranges are the highest of any area in the Irwin Botanical District. The proposed Lesueur conservation reserve ranks as one of the three most important areas for flora conservation in southern Western Australia (Griffin *et al.* 1990).

This chapter provides an assessment of those sections of the Hill River Project ERMP that pertain to the flora. The impact of the proposed development on the DRF and endemic species of the region and those of the Lesueur area will be discussed. The chapter also considers the re-establishment of regional endemic taxa.

3.2 ASSESSMENT OF THE ERMP

The ERMP for the Hill River Project is required to satisfy a number of guidelines as defined by the EPA (ERMP Attachment 1). With regard to Declared Rare and poorly known flora two key issues to be addressed by the project proponents in their ERMP were:

"detailed mapping of gazetted rare species as well as poorly known species" (ERMP Attachment 1, p. 7)

and to:

"consider the conservation status of rare or poorly known flora .... with particular emphasis on their security in conservation reserves" (ERMP Attachment 1, p. 6).

The proponents have not adequately addressed either of these issues.

Detailed mapping of Declared Rare and poorly known flora is not presented in the ERMP. Such data may have been withheld to ensure that the detailed locality information for DRF populations is not widely publicised, as is consistent with CALM Policy. However, the information that is provided is not adequate to determine the impact of the proposal and

there is no indication that any such mapping was carried out. Although the conservation status of the DRF is briefly mentioned, there is no reference to their security on existing or proposed conservation reserves and there are insufficient data relating to the numbers of populations and individuals that exist. For example, the approximate number of plants known for *Asterolasia drummondii*, *Banksia tricuspis* and *Hakea megalosperma* are provided (ERMP Section 4.2.1.5), but numbers for each population and the distribution of populations both within and outside the project area are not presented. Details on the numbers of plants, their distribution among populations and the distribution of these within the project area and the proposed conservation reserve at Lesueur are not presented for the remaining DRF species, namely *Acacia forrestiana*, *Eucalyptus lateritica*, *Eucalyptus suberea* and *Thelymitra stellata*.

The proponents make a number of statements in the ERMP in relation to the conservation status of DRF which require clarification or are inaccurate. These statements are that:

1. Other suitable sites for *Acacia forrestiana* exist (ERMP Section 4.2.1.5, p 4.17); however, they fail to mention where these sites are located or their conservation status.
2. *Banksia tricuspis* is stated as "occurring mostly in the Gairdner Range area" (ERMP Section 4.2.1.5, p 4.19). Current data available to CALM indicate that this species is endemic to the Gairdner Range, i.e. it does not occur elsewhere.
3. "Several hundred individuals" (ERMP Section 4.2.1.5, p 4.20) of *Eucalyptus lateritica* and *Eucalyptus suberea* exist. Less than 200 individuals of each species are known by CALM. These individuals are distributed among 13 and 12 populations respectively.
4. *Thelymitra stellata* has been the target of numerous surveys by the Western Australian Native Orchid Study and Conservation Group and botanists from CALM. The results of such surveys indicate that it is a very rare species and not poorly known as stated in the ERMP (Section 4.2.1.5, p 4.20). If "poorly known" was the most appropriate status for this species then it would not fulfil the survey requirements for declaration as a rare species as outlined in CALM's Policy Statement No. 9 (Hopper *et al.* 1990).

The proponents list and recognise the importance of 48 "vulnerable taxa" which occur in the proposed conservation reserve at Lesueur (ERMP Table 4.7); however, the distribution and conservation status of these species has not been determined. Therefore, no assessment has been made of the impact of the project on these taxa nor their security on conservation reserves. This omission is of some concern to CALM given the large number of species involved and the very restricted distribution of many. All have a geographic range of less than 160 km with twenty six of these being very geographically restricted with a range of less than 50 km. In addition to the 48 "vulnerable taxa" and seven DRF species there are a further 56 regionally endemic taxa (Griffin *et al.* 1990) which occur within the project area and also require survey and an assessment of their conservation status.

The ERMP guidelines also require the issue of relic populations to be addressed (ERMP Attachment 1, p 3). These populations are often of special interest because of genetic divergence from mainstream populations and can be a valuable genetic resource (Hopper and Coates 1990). The 48 "vulnerable taxa" referred to in the ERMP are stated as including species "at the limits of their range or in areas outside their normal ranges or habitats" (ERMP Section 4.2.1.5, p 4-20); that is, the list includes species which have relic populations in the Lesueur area. Although some species in this category have been listed there are many others, including more common species, some disjunct, which are at the limit of their range. Typical examples are Jarrah (*Eucalyptus marginata*), Swamp Banksia (*Banksia littoralis*) and Bull Banksia (*Banksia grandis*) (Griffin *et al.* 1990). Populations of such species, however, have not been considered in the ERMP. Likewise, the impacts on populations of plant species which are considered to be relictual have not been assessed. Such species represent a valuable genetic resource. They include local endemics such as *Darwinia sanguinea*, *Hakea megalosperma*, *Hakea neurophylla*, species with disjunct distributions (*Hakea marginata*, *Isopogon sphaerocephalus*) and others (*Isopogon linearis*).

3.3 IMPACT OF THE PROJECT ON PLANT SPECIES

From available information, the impact of reducing population numbers on the risk of extinction for almost all rare, poorly known and regionally endemic taxa is unknown. Data on cryptogams in the Lesueur area have not been collected, so no statement on potential impacts on these groups can be made.

3.31 Declared Rare Flora

Available CALM survey data (Table 3.1) enable a quantitative assessment of the impact of the project on the numbers of the seven species of DRF affected in the proposed conservation reserve at Lesueur.

Within the impact zone (Table 3.1, Figure 1.1) all species except *Acacia forrestiana* would be affected.

Hakea megalosperma, *Eucalyptus lateritica*, *Banksia tricuspis*, and *Thelymitra stellata* would sustain the greatest loss of individual plants (19.6%, 15.5%, 10.6% and 9.1% of the total known respectively), while *Eucalyptus suberea* (8.3%) and *Asterolasia drummondii* (1.6%) would sustain smaller losses. Of the individuals currently known to occur within the conservation reserve proposed for the Lesueur area, 45.5% of *Thelymitra stellata*, 25% of *Eucalyptus lateritica*, 13.3% of *Hakea megalosperma*, 11.8 % of *Eucalyptus suberea* and 10.5% of *Banksia tricuspis* would be destroyed.

These data contrast with those provided by the proponents, based on the mine plan (ERMP Section 6.2.2) for some species, especially *Asterolasia drummondii*. In that case the proponents state that up to 50% of known individuals are within the zone of impact. However, CALM's data suggest that only about 1.6% of known individuals will be affected. Differences in the number of individuals which occur in the impact zone are also encountered for *Eucalyptus lateritica* and *Hakea megalosperma* where CALM's values for impact are 50% and 100% higher respectively. There is agreement that one population of *Thelymitra stellata* and no populations of *Acacia forrestiana* occur in the impact zone.

Whether or not the remaining plants in the proposed conservation reserve at Lesueur would constitute viable populations is a matter requiring careful research. Enzyme analysis of the mating systems of *Banksia tricuspis* (van Leeuwen and Coates unpublished) and of *Eucalyptus rhodantha* (Sampson 1988) have shown that normal levels of outbreeding of 60% or more may drop to around 30% or less when populations become small and isolated. An enhanced probability of population extinction is likely as a consequence unless active genetic management is practised (Soule 1987; Hopper and Coates 1990). This approach, combined with studies on population dynamics and other critical factors limiting recruitment, would be essential to develop an adequate understanding of the impact of the project on the rare flora in the Lesueur area.

3.32 Regional endemics

A preliminary analysis of the numbers of known populations of regional endemics affected by the project is possible, although we caution that many of these plants are poorly known, the exact locations of populations is vague and they require further survey to establish their precise distribution and abundance in the Lesueur area and elsewhere.

Griffin *et al.* (1990) determined that 259 plant species were endemic to the northern kwongan, the area between the Moore and Irwin Rivers and west of the Midlands Highway. Of the regional endemics, 95% of those which occur on proposed conservation reserves (42 in total) have been recorded only in the proposed conservation reserve at Lesueur. A further 139 currently occur on existing conservation reserves with 71 of these also in the proposed conservation reserve at Lesueur. The remainder are not represented on existing or proposed reserves (Table 3.2).

Analysis of the distribution of the regionally endemic species indicated that 111 occur in the proposed conservation reserve at Lesueur (Table 3.3). More regional endemics have been recorded from this proposed reserve than any other existing or proposed reserve in the northern kwongan.

All known populations of the 111 regional endemics were plotted onto a 1:1 000 000 base map showing boundaries of all existing and proposed conservation reserves in the northern kwongan. The total number of known, separately mapped populations was counted and their occurrence was determined in all existing and proposed conservation reserves, including the proposed conservation reserve at Lesueur. In addition, the possible occurrence of these regional endemics within the eastern block of the proposed conservation reserve at Lesueur and therefore possibly within the impact zone of the Hill River Project was determined.

A useful check on the accuracy of this approach in estimating impacts is available in the case of the seven species of DRF. Table 3.4 compares estimates of impact on known populations using the 1:1 000 000 mapping approach compared with accurate mapping at 1:50 000 using detailed field survey data. The average per cent difference between the two approaches is 14%. Thus, the impact statistics which follow should be interpreted as being accurate within about 15%.

Of the 111 regional endemics in the conservation reserve proposed for Lesueur (Burbidge *et al.* 1990, Appendix 2), two thirds (72, 65%) have populations within the eastern block of the proposed reserve. This coincides with the zone that will be impacted by this project. Regionally endemic taxa that will be affected (excluding the DRF species) include *Hypocalymma* aff. *ericifolium* (E.A. Griffin 1972), *Eucalyptus* aff. *haematoxylon*, *Thysanotus sparteus*, *Tetratheca remota*, *Persoonia rudis*, *Patersonia argyrea*, *Hakea auriculata* var. *spathulata*, *Gompholobium* aff. *polymorphum* and *Acacia plicata*.

If substantiated by further surveys of poorly known taxa among the regional endemics, these statistics indicate that the project would have a significant impact on a large number of the species of special conservation significance. In the context of regionally endemic species, eight taxa have been found to occur

Table 3.1

Impact on Declared Rare Flora in the Lesueur area of the proposed Hill River Project.

	Total		In proposed conservation reserve		Impact area	
	No. Pop	No. Plants	Pop	Plants	Pop	Plants
Acacia forrestiana						
number	5	920	4	820	0	0
% total populations	-	-	80.0	89.1	0	0
% PCR* populations	-	-	-	-	0	0
Asterolasia drummondii						
number	13	3342	11	1842	2	55
% total populations	-	-	84.6	55.1	15.4	1.6
% PCR populations	-	-	-	-	18.2	3.0
Banksia tricuspis						
number	72	19031	65	18940	13	2016
% total populations	-	-	90.3	97.2	18.1	10.6
% PCR populations	-	-	-	-	20.0	10.5
Eucalyptus lateritica						
number	13	260	8	160	2	40
% total populations	-	-	61.5	61.5	15.4	15.5
% PCR populations	-	-	-	-	25.0	25.0
Eucalyptus suberea						
number	12	240	9	170	1	20
% total populations	-	-	75.0	70.8	8.3	8.3
% PCR populations	-	-	-	-	11.1	11.8
Hakea megalosperma						
number	12	1326	7	1202	3	250
% total populations	-	-	58.3	90.6	25.0	19.6
% PCR populations	-	-	-	-	42.9	20.8
Thelymitra stellata						
number	12	55	4	11	1	5
% total populations	-	-	33.3	20.0	8.3	9.1
% PCR populations	-	-	-	-	25.0	45.5
MEAN						
% TOTAL POPULATIONS (± SE)	-	-	69.0 18.1	69.2 24.8	12.9 7.5	9.2 6.5
% PCR POPULATIONS (± SE)	-	-	-	-	20.3 12.3	16.7 14.4

*PCR = Proposed Lesueur Conservation Reserve

Table 3.2

Distribution of the 259 regional endemics of the northern kwongan by reservation status with reference to the proposed conservation reserve at Lesueur

Taxa in existing reserves		Taxa in proposed reserves		Unreserved Taxa
Total	Lesueur	Total	Lesueur	Total
139	71	42	40	78

Table 3.3

Distribution by reserve of the 259 regional endemics of the northern kwongan

LOCATION	NO. OF TAXA
RESERVES	
Alexander Morrison National Park	40
Badgingarra National Park	41
Beekeeper's Reserve	6
Beekeeper's Road Nature Reserve	13
Boothendarra Nature Reserve	14
Drover's Cave National Park	4
Lake Logue Nature Reserve	18
Minyulo Nature Reserve	5
Mt. Adams Road Nature Reserve	4
Namming Nature Reserve	4
Pinjarrega Nature Reserve	2
South Eneabba Nature Reserve	53
Southern Beekeeper's Reserve	1
Tathra National Park	20
Watheroo National Park	27
Watto Nature Reserve	6
PROPOSED RESERVES	
Proposed Arrowsmith Nature Reserve	6
Proposed Badgingarra National Park extension	6
Proposed Coomallo National Park	56
Proposed Mt Adams Nature Reserve	4
Proposed Lesueur conservation reserve	111

only in the eastern section of the proposed reserve at Lesueur (Table 3.5) and therefore may not be represented in the reserve should the project receive approval. All are represented elsewhere on conservation reserves.

Perhaps of greater concern are the nine taxa endemic to the proposed conservation reserve and the impact that the project will have on them (Griffin *et al.* 1990, Table 5.6). *Hypocalymma* aff. *ericifolium* (E.A. Griffin 1972) has two known populations, one of which occurs in the zone to be impacted by the project. Comparable figures for *Eucalyptus* aff. *haematoxylon* (E.A. Griffin 2451) are seven populations with a possibility of three being affected while *Persoonia rudis*, *Grevillea thelemanniana* ssp. *delta* and *Gompholobium* aff. *polymorphum* (E.A. Griffin 2304) each have three populations of which one may be affected. *Leucopogon plumuliflorus* has six populations of which one may be affected. None of the two known populations of *Andersonia longifolia*, five of *Phlebocarya pilosissima* ssp. *teretifolia* nor the one of *Restio* sp. (Briggs 7473 and Johnson) are known to occur in the impact zone. Urgent further survey of all these endemics is a high priority to adequately assess the impact of the project on the conservation status of these species.

There are twenty six very geographically restricted taxa (maximum range 50 km) that occur in the project area. Twenty of these taxa are not known on existing conservation reserves (Table 3.6).

3.33 Taxa at their northern or southern limit

There are 81 species within the proposed conservation reserve at Lesueur which exist at the northern and southern limit of their distribution. Of these, 45 may be affected by the project as they occur within the project impact zone or in the eastern section of the proposed reserve (Burbidge *et al.* 1990, Appendix 1). Ten are not found elsewhere on the proposed conservation reserve and six of these, including species such as *Acacia drummondii*, *Thelymitra crinita* and *Baumea preissii*, are at the northern limit of a continuous distribution. The remaining four, *Eucalyptus exilis*, *Goodenia fasciculata*, *Polypompholyx multifida* and *Utricularia menziesii* are disjunct northern outliers of otherwise more southern distributions. Populations of species with such distributions are significant because they may be of relictual origin, and therefore are of evolutionary significance and important in the conservation of the genetic resources of each species.

3.34 Widespread species

Populations of many widespread species will be destroyed should the project proceed. Depletion of such populations need not necessarily be of concern. However, studies such as that of Coates and James (1979) and Coates (1980) on *Stylidium crossocephalum* indicate that major genetic variation may lie hidden within a common species. A project like the one proposed by the proponents in the ERMP has the potential to destroy local genetic races in such species, but the actual potential impact is unknown because no more than a handful of Lesueur's *ca* 700 widespread species have been studied throughout their range by population geneticists.

3.4 RE-ESTABLISHMENT OF REGIONAL ENDEMIC PLANTS

The proponents proposed to re-establish DRF and other rare regional endemics as part of the project's rehabilitation program. Although commendable, re-introduction and establishment of any of the regionally endemic taxa is likely to be a difficult task unless ecosystem reconstruction is achievable (see Rehabilitation, Chapter 7). Furthermore, if establishment is achieved there is still the need to ensure the long term survival of the new populations. Genetic structuring within populations, levels of genetic variability and inbreeding are all factors essential in population survival (Soule 1987), yet with the exception of *Banksia tricuspis*, *Eucalyptus lateritica* and *Eucalyptus suberea* this information is not available for regional endemics or any other taxa likely to be used in re-introduction programs. Given our current lack of understanding of genetic factors, competition and demographic factors in population survival the chances of successful re-establishment of rare plant populations is unlikely, without further extensive research.

The following are a number of issues, some relevant to points made in the ERMP, relating to the re-introduction of rare plant species to the Lesueur area which will need to be addressed.

1. Although seed from many Western Australian plant species can be readily collected and germinated there are some native species, particularly in certain groups (e.g. Epacridaceae, Restionaceae, Rutaceae) where this is not possible or has so far proved to be very difficult.
2. The ERMP provides no hard data on the propagation of DRF or any other regional endemic plant species targeted for rehabilitation programs.
3. The proponents state that potted plants of rare species will be used to re-establish such species on rehabilitation sites and that such re-establishment will not occur in the early stages of rehabilitation (ERMP Section 5.12.3). *Banksia tricuspis* would be best suited to introduction in the early stages of the rehabilitation program, especially if it is to be introduced as seed or seedlings. This approach

Table 3.4

Per cent mappable populations of Declared Rare Flora affected by the proposed Hill River Project

	Mapping Scale			
	1:1 000 000		1:50 000	
Acacia forrestiana	0%	(5)*	0%	(5)
Asterolasia drummondii	33%	(6)	15%	(13)
Banksia tricuspis	67%	(12)	18%	(72)
Eucalyptus lateritica	11%	(9)	15%	(13)
Eucalyptus suberea	17%	(12)	8%	(12)
Hakea megalosperma	33%	(9)	25%	(12)
Thelymitra stellata	17%	(6)	8%	(12)

* Total number of mappable populations known for the species

Table 3.5

Regional endemics, total number of known populations and the per cent on existing conservation reserves which are only found in the eastern section of the proposed Lesueur conservation reserve

Taxa	No. of known populations	Per cent on existing conservation reserves
Banksia chamaephyton	31	19%
Beaufortia bicolor	14	28%
Dryandra aff. *falcata* (E.A. Griffin 3459)	50	20%
Dryandra aff. *patens* (E.A. Griffin 1507)	22	18%
Dryandra carlinoides	89	10%
Dryandra tortifolia	7	14%
Phlebocarya pilosissima ssp. *pilosissima*	13	15%
Stylidium maitlandianum	15	20%

Table 3.6

Very geographically restricted taxa (maximum range 50 km) that occur within the Hill River Project area. Their total number of known mappable populations (at 1:1 000 000 scale) and the percentage of these populations on current conservation reserves.

Species	Total number mappable pop.	% on conservation reserves
Acacia retrorsa	8	12
Banksia tricuspis	12	0
Darwinia helichrysoides	9	0
Daviesia sp. (M.D. Crisp 6213)	5	20
Daviesia epiphyllum	4	0
Daviesia sp. (M.D. Crisp 5429)	8	0
Dryandra sclerophylla	35	22
Eucalyptus aff. *haematoxylon*	7	0
Eucalyptus lateritica	13	7
Eucalyptus suberea	11	0
Genus nov. aff. *Ecdeiocolea* E.A. Griffin 2157	7	28
Gompholobium aff. *polymorphum* (E.A. Griffin 2304)	3	0
Grevillea acrobotrya ssp. *uniforma*	6	0
Grevillea thelemanniana ssp. *delta*	2	0
Hakea erinacea var. *longiflora*	8	12
Hakea neurophylla	10	0
Hypocalymma aff. *ericifolium*	2	0
Leucopogon plumuliflorus	6	0
Patersonia argyrea	3	0
Persoonia rudis	3	0
Phlebocarys pilosissima ssp. *teretifolia*	5	0
Stylidium aeonioides	6	16
Tetratheca remota	2	0
Thysanotus aff. *sparteus*	3	0
Thysanotus vernalis	4	0
Xanthosia tomentosa	15	0

would be the most suitable because seedling recruitment under natural conditions does not occur unless there is some form of disturbance. Recruitment of *Banksia tricuspis* without disturbance is negligible. Another important feature to consider with this species is its site specificity with regard to soil type and aspect (microclimatic environment). Under natural conditions *Banksia tricuspis* has very specific site requirements. Indeed this is a factor that should be considered for all rare species when attempting to introduce them to rehabilitation sites.

4. Re-establishment of rare species in the rehabilitation area should take into consideration the genetic structure of populations under natural conditions. Moran & Hopper (1987) found that genetic structuring in populations of both *Eucalyptus lateritica* and *Eucalyptus suberea* is very important and needs to be considered if populations are to be managed (this includes re-establishing them in disturbed areas).

5. Cuttings may be an efficient way to re-establish some species in the rehabilitation sites (e.g. *Verticordia grandis*) but for rare species, the effect that such a procedure may have on the genetic structure within populations must be considered. If cuttings from only a few plants from one area are used, loss of genetic variability and inbreeding depression may reduce chances of long term population survival.

6. *Hakea megalosperma* usually only re-establishes naturally if root stocks are present as it is a very poor producer of seed, although a prolific resprouter after disturbance, especially fire. It is also a very site specific species, only growing on lateritic rises and not in deep sands. Prolific regeneration by self seeding is extremely unlikely, contrary to statements in the ERMP (Section 5.12.3). This species probably also has an interesting genetic structure and is important because it is considered to be one of the oldest (relictual) members of the genus. Without a sufficient seed stock for re-establishment, *Hakea megalosperma* is likely to be a difficult species to re-introduce.

7. The use of fertilizers on the rehabilitation sites as suggested in the ERMP (Section 5.12.4) needs to be carefully considered for the following reasons:

- it encourages the establishment of weeds.
- it may encourage the rapid establishment of short-lived plants and some types of disturbance opportunists such as species of *Acacia*; such plants may cause a problem in terms of competition or may create a significant fire hazard.
- some species may become dependent on the supply of fertilizers which could lead to their demise when the project is decommissioned and fertilizers are no longer applied.
- it may lead to unnatural competition between species as some species may be able to more rapidly assimilate the additional nutrients and have a competitive advantage over other species.
- some genera/species are not able to handle even the smallest application of fertilizers and die (e.g. some *Banksia* species, Lamont *et al.* 1985)
- run-off from the rehabilitation dumps may have excess nutrient loads as a result of fertilizer application and this could cause problems with algal bloom in sedimentation ponds and along drainage lines.

Chapter 4

FAUNA

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Abstract

The ERMP does not adequately address the EPA guidelines and makes inadequate commitments for fauna conservation and rehabilitation. The vertebrate survey was limited in terms of seasons when sampling took place and because of this the ERMP makes unsupportable statements concerning animals' association with or dependence on particular habitats as well as the seasonality of habitat use. No surveys of terrestrial invertebrates were conducted and the ERMP makes unjustified statements about the difficulty and usefulness of such work as well as making unsupported assumptions concerning the relationships of invertebrates with vegetation types. Surveys of aquatic fauna were conducted at inappropriate times of the year, and consequently the ERMP makes unwarranted statements about the composition of the aquatic fauna. The ERMP contains no assessment of the regional conservation status of the aquatic fauna of the area. No surveys were conducted of the aquatic fauna of Cockleshell Gully, the largest catchment in the proposed conservation reserve, even though this catchment will be affected by the project.

No surveys were made of the fauna of most of the proposed conservation reserve at Lesueur, nor of nearby conservation reserves and no attempt was made by the proponents to assess the conservation status of the Lesueur fauna, particularly those occurring in the area to be mined or otherwise disturbed, in nearby conservation reserves.

The ERMP fails to recognise the importance of the whole Lesueur - Coomallo region for the survival of Carnaby's Black-Cockatoo and that the Cockatoo is important because it is implicated in the survival of Banksia tricuspis, a Declared Rare Flora species. It does not mention the cockatoo's need for fresh water sources (which must have shady trees around them), nor the possible effects of mining and water extraction in this context, although the Hill River and the Hill River Spring are highlighted as areas most likely to suffer from water table drawdown.

4.1 A REVIEW OF THE INFORMATION IN THE ERMP

In the guidelines for the preparation of the ERMP, the EPA stated:

> "The critical issue for the coal mine is likely to be the subject of mining in a proposed nature reserve. It is critical therefore that the ERMP shows a detailed understanding of conservation values in the area, if they are represented elsewhere and their relationship to disturbances due to the proposal ..... the key issues should include: ... native fauna ... inter-relationships of the biota and environment (eg ....)" (ERMP Attachment 1, pp. 2, 3)

4.11 Terrestrial fauna

Consultants Martinick and Associates carried out for the proponents a survey of terrestrial vertebrates in an area confined to the immediate vicinity of the proposed mines and power station (Martinick and Associates 1989c). For mammals, reptiles and frogs, 32 sample sites were established - these were trapped with pit-fall traps and Elliott traps. There were two trapping sessions: 10 days in September/October 1988 and seven days in December 1988. Opportunistic observational data were also recorded, and searches for nocturnal vertebrates were conducted. No attempt was made to survey bats. Birds were counted at 20 of the 32 sites, with 30 minute counts on five consecutive days during the September/October 1988 session only. The daily order of the bird counts was rotated to reduce bias associated with time after dawn.

Although the number of trap-nights (= survey effort) appears relatively high, this was achieved by leaving the traps open, but in the same position, for much longer periods than is normal for broad vertebrate survey studies (10 and 7 days). Four or five nights per session is usual.

The surveys were restricted in terms of season - studies were only conducted in September - October and early December. As pointed out by Burbidge and Hopper (1990) such surveys should be conducted in several seasons (at least two non-adjacent ones, e.g. spring and autumn). Data from surveys of the Eastern Goldfields (McKenzie 1984) and the Fitzgerald River National Park (Newbey and Chapman 1987) clearly demonstrate this point.

Use of, or dependence on, particular habitats can also vary with season and population density (McKenzie 1984; Rosenzweig and Abramsky 1986; Wiens 1981). Thus the data presented in the ERMP are inadequate to make any statement concerning a lack of seasonality in habitat use. The statement in the ERMP "there is little evidence for strong seasonal differences in habitat use..." (ERMP p. 4-23) is not supported by the data because of inadequate survey design.

Returning to the key issues as identified by the EPA, it is clear that the consultants only tried to assess whether:

1. any species might be limited to the study site,
2. any endangered species were present, and
3. patterns in vertebrate occurrence matched broad vegetation categories. (This was done to assess whether the categories in the environs of the power station and mine sites had recognisably distinct vertebrate communities.

With respect to points 1 and 2, the following quotes are relevant.

> "The fauna survey described here was designed to cover the area likely to be impacted by the Hill River Project"
>
> "The fauna survey described here was not extended to cover all the proposed reserve because there will be no direct physical impact on the land to the west and some habitats present in the western side are different to those seen in the area of impact" (Martinick and Associates 1989c, p. 4).

The sampled area was very small; no similar surveys were made of the remainder of the proposed conservation reserve at Lesueur, nor of nearby existing or proposed conservation reserves. Nor was any attempt made to compare the species present in the study area with those known to be present in the remainder of the proposed conservation reserve, or to other conservation reserves in the region. Instead, the consultants attempted to assess their own sampling "efficiency" (i.e. how exhaustive their sampling was) ... "by looking at the total range of species which might be expected to occur in the study area" (Martinick and Associates 1989c, p. 9). They listed species of mammals and reptiles previously recorded within 50 km of the proposed project and others that range through the area. (Incidentally, we can find no evidence that *Sminthopsis hirtipes* has been recorded south of Kalbarri; its inclusion in Table 9 in Martinick and Associates (1989c) mammal list is probably a mistake.)

The consultants state in the review of their efficiency that their sampling of some groups, reptiles in particular, was inadequate, but they did not attempt to locate species from these groups which might occur in the area, including the rare or endangered species identified during this review.

Although the consultants' lists of species "which could be expected to occur on the study site" (Tables 8 and 9), developed during their review of efficiency, include species recorded within 50 km of the study site, Table 9 omits the Dibbler *Parantechinus apicalis*, a declared endangered species, that is known from Boullanger and Whitlock Islands in Jurien Bay, 25 km from Lesueur (Fuller and Burbidge 1989). Although these are island populations:

a. Dibblers are difficult to trap and searches in the northern kwongan have not been sufficient to reasonably demonstrate that it does not occur in the district,
b. Dibblers occur in areas of similar rainfall, vegetation and substrate on the south coast, and
c. the proponents' consultants suspected that Dibblers were present: "During the pit trapping in September/October an unknown animal consumed part of a specimen of House Mouse and then escaped. From the way in which the mouse was eaten and the depth of the pit, it was possible that this animal was the Dibbler (Parantechinus apicalis). The surrounding area was trapped intensively with Elliott traps but no Dibblers were caught. This was at Trapline 26." (Martinick and Associates 1989c)

There is no mention of the possible Dibbler record in the ERMP (see p. 4-24).

With regard to point 3 (above), the consultants made no numerical analyses of their data. Instead, species in each class of vertebrates were grouped "by eye" according to broad substrate/vegetation categories. Only the pit trapping and bird counting data were used for this purpose. To assess the validity of the groups distinguished by the consultants (see Table 2 in Martinick and Associates 1989c), the reptile data set was analysed using the CSIRO numerical analysis package PATN (Belbin 1989). A standard classification pathway was used and default options were selected. Eight groups were selected to provide consistency. The results of this analysis are presented in Table 4.1; the groups distinguished by Martinick and Associates are superimposed for comparison. Very different groupings of trap lines (= reptile habitats) were found.

Examination of the reptile data revealed that genera such as *Lerista, Morethia* and *Cryptoblepharus* were inconsistently detected at traplines in apparently suitable habitat. It appears most likely that under-sampling is confounding the data; without more thorough, multi-seasonal data, no conclusion should be drawn on species usage of different substrate categories.

These considerations also bear on the thoroughness of the overall species lists of terrestrial vertebrates compiled by the consultants for the area. "The fauna described here is diverse. It includes a substantial part

of the typical south-western fauna, and must be regarded as in good condition because of the size and integrity of the area." (ERMP p.4-24).

Field work subsequent to both the consultants' 1988 studies, and to the compilation of data in mid-1989 by Burbidge and Fuller (1990), has been carried out by:

1 G. Connell and students from The University of Western Australia (Connell *et al.* 1990)

2. the Royal Australasian Ornithologists Union.

Though these additional surveys have been cursory, or are as yet uncompiled (Connell *et al.*), additional species have been recorded (cf. Burbidge and Fuller 1990), and are listed below.

Mammals

Dibbler, *Parantechinus apicalis* (possible record only, discussed above).

Birds

Eight additional species have been recorded. Two were added by Martinick and Associates (1989c), six by the Royal Australasian Ornithologists Union (Wilder 1990, personal communication[1]) and two by Craig (in Connell *et al.* 1990); one species was added by all three. Data presented below are in the same format as Table 6.2 in Burbidge and Fuller (1990).

Little Black Cormorant, *Phalacrocorax sulcirostris*, recorded by Martinick, but no abundance or habitat data provided.

Little Pied Cormorant, *Phalacrocorax melanoleucos*, single bird in flight, September 1989.

Straw-necked Ibis, *Threskiornis spinicollis*, small flock over woodland.

Square-tailed Kite, *Lophoictinia isura,* scarce, woodlands.

Painted Button-quail, *Turnix varia*, uncommon, woodland.

Fan-tailed Cuckoo, *Cuculus pyrrhophanus,* moderately common, kwongan and woodland.

White-naped Honeyeater, *Melithreptus lunatus*, uncommon, kwongan.

New Holland Honeyeater, *Phylidonyris novaehollandiae*, uncommon, kwongan.

The White-naped Honeyeater is at the northern limit of its range.

Craig (in Connell *et al.* 1990) found some species to be more abundant or widespread than were indicated by earlier data. These include the Emu, Maned Duck, Scarlet Robin, Hooded Robin, Western Thornbill, Australian Magpie-lark and Australian Magpie. Bird counts he reports show very high densities of nectarivores; densities reported were higher than those in published records for other parts of south west Australia.

These data bring the total number of bird species known from the Lesueur area to 130 indigenous and two introduced species; more than are known from any other conservation reserve in the south west of Western Australia except the much larger Kalbarri, Fitzgerald River and Cape Arid National Parks, all of which include coastal habitats (Table 12.2 in Hopper and Burbidge 1990; Cape Arid National Park of 310 000 ha has a recorded bird fauna of about 170 species, Burbidge and Talbot 1990) and Yanchep National Park of 5 900 ha (including proposed additions), which has 130 native species; this reserve contains extensive wetland habitats.

Reptiles

Moloch horridus - photographed at Mt Peron by S. van Leeuwen.

Morelia stimsoni stimsoni - previously recorded in the Lesueur Area, but range extended by Connell *et al.* (1990).

The number of reptile species now known from the proposed conservation reserve is 49. It has more species than any conservation reserve in the south west, except the much larger Kalbarri National Park.

Frogs

No additional species has been recorded, but collections by Connell *et al.* (1990) show that the Banovich Uplands are the major breeding areas for some species in the area, e.g. *Neobatrachus pelobatoides.*

Terrestrial Invertebrates

The proponents commissioned no surveys of terrestrial invertebrates. The ERMP states that "such studies would be impossible without many years of work, and basically would achieve little because:

- findings in any invertebrate group would not necessarily reflect what is happening with any other group;

1 C. Wilder, RAOU (W.A. Group).

- there are no comparative data with which to correlate results; and
- the findings would have no real implications for management except in the most unusual circumstances." (ERMP p. 4-22)

We do not agree with these statements. Firstly, studies of some terrestrial invertebrate groups, e.g. molluscs, spiders and ants, are relatively easy and comparative data do exist that allow interpretation of data. Furthermore, invertebrates have been shown to be useful groups to monitor in assessments of rehabilitation success (see Majer 1989 for a review).

A brief survey of the area by Connell *et al.* (1990) in the winter of 1989 revealed a rich invertebrate fauna. They report on collections of spiders, pseudoscorpions, scorpions, opilones, mites, centipedes, ants and terrestrial molluscs. The spider collection, for example, comprised 87 species, a high number for a winter sample, and included 37 species (42%) that were either new species or were unknown to Dr B.Y. Main, Western Australia's leading spider specialist. The ant fauna was also rich, with about 80 species in the collection. The snail collection, which was identified by the Curator of Molluscs at the Western Australian Museum, comprised three species, including the geographically restricted northern kwongan endemic *Bothriembryon perobesus* (see Burbidge and Fuller 1990, p. 81) and two undescribed species of *Bothriembryon*, one of which is new to science and only known from the Lesueur area.

Further details of these collections are contained in a submission to the EPA from Connell and his colleagues. Their data indicate the importance of terrestrial invertebrate studies in assessing fauna conservation values, and the species diversity available for measuring change during disturbance and rehabilitation.

The ERMP also makes some assumptions about terrestrial invertebrates: "... richness in plant species in the area undoubtedly provides for a diversity of pollen and nectar feeding insects. However, the floristically-rich heath covers an area considerably greater than the Project area. Implications of clearing in the Project area on these species are not known, but could be expected to be small because there are unlikely to be any insects so restricted in distribution." (ERMP p. 4-22). This statement does not recognise the enormous diversity in the composition of the various 'heaths' in the Lesueur area (Griffin and Hopkins 1990) and is not supported by any data or references.

4.12 Aquatic fauna

Streamtec Ecological Consultants carried out a survey of the aquatic macro-invertebrates and vertebrates of the Gairdner Range creeks for the proponents in October 1988. This was assessed in Burbidge and Fuller (1990). Since EPA Bulletin 424 was written, an additional survey of aquatic fauna of the Hill River has been carried out.

4.121 Gairdner Range creeks survey

This work was conducted at an inappropriate time (October) when most creeks were drying. All creeks in the Cockleshell Gully Catchment were dry and therefore were not sampled. An August survey is required, as was recommended by the consultants (Streamtec 1988, p. 19).

The ERMP summarises the data in Streamtec's survey report but does not recognise its inadequacies. Thus the statement "Despite the extensive survey, no species of fish were found" (ERMP p. 4-25) over-emphasises the adequacy of the survey and does not acknowledge that the lack of fish in the samples could be a result of the time of sampling. Similarly, the statements about trophic groups reflect the time of sampling rather than the nature of the streams.

4.122 Hill River survey

The ERMP deals with the Streamtec (1989) report quite fairly. However, the major problem with the Hill River work (as acknowledged by Streamtec) was the date of sampling (May). Another survey should have been carried out in August/September when the river was flowing strongly.

4.2 ASSESSMENT OF ERMP CONCLUSIONS ON CONSERVATION STATUS

4.21 Terrestrial fauna

No attempt was made by the proponents to assess the conservation status of the Lesueur fauna in nearby conservation reserves. Table 4.2 provides available data on mammals, reptiles and frogs from the data-bases of the Western Australian Museum. It should be emphasised that no systematic surveys have been made of these national parks (although fairly intensive trapping for reptiles has been carried out at Badgingarra National Park, see Murray 1980). The EPA guidelines for the preparation of the ERMP (see 4.1 above) have not been fulfilled because of the lack of such surveys.

Conservation status is discussed mainly in terms of endangered vertebrate species: "Despite the diversity of species present, there are few of particular conservation interest either by being endangered or having restricted distributions" (ERMP p. 4-24). At least three issues needed to be considered with more care:

'Total fauna' versus 'vertebrate fauna'

Throughout the consultants' report on fauna surveys and in most of the ERMP the word 'fauna' is used synonymously with vertebrates. As discussed above, the section of the ERMP on terrestrial invertebrates (p. 4-22) is inadequate. For instance, the discussion under ERMP sub-heading "4.2.2.2 Faunal Communities" does not mention invertebrates. This confounds the reader by concealing the lack of data on terrestrial invertebrate groups. The proponents focus their arguments concerning fauna on local endemism yet, at the scale of the study area, only the invertebrates are likely to show the patterns of local endemism seen in the flora. In the ERMP's section on invertebrates (p. 4-22), the examples chosen are large, mobile species (cockroaches, jewel beetles) rather than spiders, snails, worms and litter arthropods. Both scientifically and in the Wildlife Conservation Act, the definition of 'fauna' includes invertebrates. Indeed, the vast majority of animals are invertebrates and it is recognised that vertebrates and other macro-organisms merely ride on the energy flow connections of small invertebrates and micro-organisms (Price 1988).

Species inter-relationships

The ERMP under-emphasises the inter-dependence between plant and animal species, especially terrestrial invertebrates (see below).

> "Faunal communities are usually tied, either directly or indirectly, to the vegetation and soil assemblages in their habitat" (ERMP p. 4-22).

Most ecologists would argue that this is a two-way interaction; for example soil invertebrates such as ants and termites have a profound affect on water infiltration, aeration and nutrient recycling in the soil (Anderson 1988; Lal 1988; Lee 1983; van Schagen 1986; Wood and Sands 1977; etc).

There should be a difference between a biological survey designed to select reserves that represent a region or district (e.g. McKenzie and Robinson 1988), one carried out as a precursor to *status quo* or restoration management of essentially natural ecosystems in a park (e.g. Newbey and Chapman 1987), and one undertaken to assess a location subject to an ERMP where areas will be effectively destroyed as fauna habitat and post-mining rehabilitation or restoration will be needed. A survey for an ERMP must focus on the sorts of organisms likely to be most affected by the disturbance, rather than only attempting to determine and monitor patterns in the biota (e.g. see Hobbs and Hopkins 1990). As well as species-habitat patterning and conservation status appraisals, a biological survey for an ERMP should include site-inventories of the sorts of organisms most likely to be affected by the disturbances that will be imposed. When these sets of quadrats are inventoried for subsequent monitoring, the "size and complexity of invertebrate groups" should not "preclude all but the most superficial study", as claimed in the ERMP (p. 4-22). Ants, for instance, have been monitored on mined sites elsewhere in Western Australia (van Schagen 1986; Majer 1989) and many other invertebrate groups have been monitored elsewhere (see Majer 1989 for a review).

Ecosystem conservation

The ERMP shows no understanding of the need for the conservation of communities and the need for the protection of areas of both typical and special habitat in conservation reserves to minimise the number of now common indigenous species entering the endangered category. As was pointed out earlier in this chapter, the ERMP made no similar surveys of the remainder of the proposed Lesueur conservation reserve or of nearby conservation reserves. Indeed, no attempt was made to compare the species present in the study area to those in the remainder of the proposed reserve, nor to other conservation reserves in the region.

4.22 Aquatic fauna

The ERMP contains no assessment of the conservation status of the aquatic fauna of ephemeral streams in the project area.

With regard to the Hill River, the perennial watercourse into which Munbinea Creek and Coomallo Creek flow, it could be argued that the occurrence of the dragonflies *Hesperocordulia berthoudi* (from the south west) and *Crocothemis nigrifrons* (from north Australia), together with three undescribed species of chironomid in the Gairdner Range creeks, shows that the area has special biogeographic importance. It may be a zone where elements of the northern and south-western aquatic faunas meet.

4.3 THE ERMP ASSESSMENT OF THE IMPACT OF THE PROPOSED PROJECT ON FAUNA

4.31 Terrestrial fauna

In the context of the area's fauna, the ERMP does not assess the direct and indirect effects of:

1. Long-term fallout or air pollution from the power station.
2. Changes to substrate (compaction, moisture availability) in or adjacent to pits, ponds, roads, overburden dumps, buildings, etc.

This is understandable, since their consultants did not collect or compile data on terrestrial invertebrates, and the vertebrate faunal survey

concentrated on species' presence or absence. The survey appears to have been too superficial to allow any quantitative appraisal of responses by vertebrate species to attributes of substrate or vegetation. No literature is cited to suggest the proponents reviewed relevant knowledge on the affects on fauna of coal mines/power stations elsewhere in Australia or the world.

The narrow scope and brevity of the fauna sampling do not justify the ERMP conclusion: "while some individuals will be affected by the project, the impacts will be such that no known species will be significantly affected." (ERMP p. 6-6). That such data did not provide "... any evidence that there were restricted habitats or any faunal species which could be endangered by the project" (ERMP p. 6-7), does not allow their conclusion: "... that the project will not have major detrimental impacts on the fauna." (ERMP p. 6-7).

Only for the vertebrate terrestrial fauna is there an undertaking to:

1. Improve the data-base prior to construction.
2. Monitor the affect of the project on fauna (ERMP p. 6-7).

The proponents aim only at vertebrate fauna rehabilitation, whereas air pollution from the stack, changes to soil water flow and the probable introduction of dieback disease are likely to disturb parts of the adjacent proposed Lesueur conservation reserve. For nature conservation purposes, total restoration of all the indigenous fauna would be required in a conservation reserve.

The ERMP briefly discusses the possible effects of the project on Carnaby's Black-Cockatoo *Calyptorhynchus latirostris*. It discusses two concerns:

1. that it will be disadvantaged by the removal of one its food plants, *Banksia tricuspis,* and
2. that it requires the interface between woodland and heath, using the woodland as a breeding location and the heath to forage.

The ERMP states "... the birds consume a wide variety of seeds and (that) Carnabys Cockatoo is not dependent on Banksia tricuspis. ... the Cockatoo is not dependent on the Hill River habitats for its survival, as it has a wide range of movement and several breeding locations" (ERMP pp 6-6, 6-7).

The inter-relationships between Carnaby's Black-Cockatoo and its environment were discussed by van Leeuwen *et al.* (1990). They showed that the presence of Carnaby's Black-Cockatoos was very important for the long-term survival of *Banksia tricuspis* rather than the reverse as implied in the ERMP. They concluded that "Management of B. tricuspis should ensure that all organisms involved in its inter-relationships are catered for. In the Cockatoos' case this is extremely important and will require protection of wandoo woodlands, kwongan and fresh water sources throughout the Lesueur - Coomallo region."

As well as failing to recognise that the Cockatoo is important, not only for its own sake, but also because it is implicated in the survival of a Declared Rare Flora species, the ERMP also does not discuss the need for fresh water sources (which must have shady trees around them), nor the possible effects of mining and water extraction in this context, although the Hill River Spring is highlighted as the area most likely to suffer from water table drawdown (ERMP p. 8-21). The Hill River is also predicted to change from a permanent watercourse to a temporary one. In this context, it is important to note that the Hill River Nature Reserve (Class A Reserve no. 36093, 882 ha) was declared to protect vital summer-feeding habitat of Carnaby's Black-Cockatoos along the Hill River. Here there is a combination of fresh water surrounded by shady trees, plus Marri (*Eucalyptus calophylla*) for food. The Hill River Spring is immediately adjacent to this nature reserve, within the proposed Coomallo National Park.

In addition, the ERMP fails to recognise the importance of the whole Lesueur - Coomallo region for the survival of Carnaby's Black-Cockatoo (Hopkins and Saunders 1987). This aspect is covered in a submission from Dr D.A. Saunders, CSIRO Division of Wildlife and Ecology, who is the expert on this species, and is not discussed further here.

4.32 Aquatic fauna

The richness of the aquatic fauna of the Gairdner Range creeks, as demonstrated by Streamtec (1988), has been discussed by Burbidge and Fuller (1990). The possible impact of the project on this fauna has not been discussed in the ERMP. Surface water flows from the mines will be sent along natural drainage lines after treatment, but nowhere in the ERMP was the effect on invertebrates of these changed flow regimes considered, nor were water quality criteria set. There is insufficient information in the ERMP about water management for us to assess what is likely to happen.

The lack of any survey of the aquatic fauna of Cockleshell Gully is disturbing, given that the ERMP states that the area will be affected by mining operations, with streams having an increased sediment load (ERMP Section 6.5.2). Although it appears efforts will be made to minimize the impact of mining, given that much of the proposed conservation reserve is downstream from the mine, more data about the fauna and stream types are required.

In relation to the Hill River, the statement in the ERMP that "There is no evidence that there are any restricted

habitats or faunal species that could be endangered by the project" (ERMP p. viii) is incorrect. The Hill River is a very restricted habitat for aquatic fauna and is threatened by the borefield (and possibly by mine waste water and run-off).

Steamtec (1989) stresses the importance of the Hill River as a permanent stream because permanent streams possess a distinct community (the occurrence of distinct communities in temporary and permanent streams in Australia is well documented, (e.g. Storey *et al.* (1990) for Jarrah forest streams and Boulton (1989) for Victorian streams) and because "permanent water ... may serve as a refugia (sic) of permanent water species which may re-invade other systems in wetter years" (Streamtec 1989, p. 13). The section in the ERMP on the impacts of the borefield on aquatic fauna (Section 8.3.3) states that "The greatest effects of the functioning of the aquatic ecosystem as a result of a lowering of the water table is expected to be due to the change from permanent to temporary flow in the affected streams, although the degree to which the stream will be made temporary is unknown..." (ERMP p. 8-23). The degree to which the Hill River will be made temporary is not stated. Our reading of the ERMP suggests that the River will change from permanent (i.e. free water or groundwater immediately under the streambed) to temporary (i.e. dry, including the soil of the streambed) and impact should have been assessed on that basis. We can find no mention of aquatic fauna under "Impacts and Management" (ERMP Section 6.0). A consultant's report (Australian Groundwater Consultants 1989) states "... correlating these model-predicted water table drawdowns with the surface topography reveals that the 'potentially gaining reach' of the Hill River lies outside the main drawdown area but is expected to suffer some water table lowering. This may be such as to remove the hydraulic gradient which is contributing seepage from below up to the river bed." (p. 21). This supports our contention that the Hill River may change to a temporary watercourse.

The ERMP states that "Regular monitoring will identify any adverse trend before unacceptable impact on vegetation or fauna occurs, and will allow sufficient time to implement an alternative water supply source or effect other remedial measures" (ERMP p. 8-22). We believe monitoring is unlikely to allow adverse impacts on the vegetation and aquatic fauna to be halted before they become unacceptable because of the long lead time required to develop other water sources. Also, there are insufficient base line data, particularly for aquatic invertebrates.

4.4 COMMITMENTS BY THE COMPANIES

Commitments in relation to fauna are given on p. 6-7 and summarised in Section 10.8. These are stated to be:

"8a. Native fauna will be protected by the following actions:

- minimisation of vegetation disturbance;
- prohibition of firearms and pets from site; and
- bunding of large excavations

8b. Faunal surveys and monitoring programmes will continue and will be reported to the appropriate authorities"

These commitments reflect the ERMP's mis-understanding of fauna conservation principles. Two of the commitments, while necessary for any such project, relate only to marginal issues in fauna conservation - hunting is not a serious concern in the conservation of any species that occur at Lesueur, nor is the occasional deaths that may occur if animals fell into pits.

Simply reporting the results of surveys (for which there is no commitment regarding detail or adequacy) is of little value if there is no commitment to standards or criteria relating to impact and rehabilitation.

This leaves the commitment to minimise vegetation disturbance. Again no standards are provided, nor is it explained how this will reduce impact to acceptable levels.

Table 4.1
Numerical classification of reptile data

Trap lines (numbers read vertically)	123111 1320405	2 89	112 24873	331 216	222 7084	121 361629	21 79	2 2 551
Aclys concinna	* *							
Notechis curtus	*							
Delma fraseri	**				*			
Pygopus lepidopodus	*	**		*		*		
Lerista distinguenda			***			*		
Diplodactylus granariensis			*		*	*		***
Diplodactylus spinigerus	* *	*		**		** **	*	*
Tiliqua rugosa	**					*****	*	
Ctenotus fallens	******		** **	***	****	******		
Morethia obscura	*		*****		* *	** *		
Ctenotus pantherinus	** **	*	** *			*		*
Pogona minor	*******	**	*****		*	*** **		*
Menetia greyii	******	*	*	* *	**	*	*	*
Crenodactylus ocellatus	*			*	*			*
Phyllurus milii	*				*	*	**	
Pletholax gracilis				*	*	*		
Lerista christinae				*				
Morethia lineoocellata		*			** *			
Ramphotyphlops australis			*		****	*		
Varanus tristis			*		*			
Ctenotus lesueuri	*							
Varanus gouldii	**					*		
Lialis burtonis	*		*		*	* *		
Cryptoblepharus plagiocephalus	*		*				*	
Diplodactylus polyopthalmus								*
Tympanocryptus adelaidensis	* *				*			*
Delma grayii						*		*
Rhinoplocephalus gouldii						*		
Martinick's Groups*	1145735	56	12444	126	1581	126337	48	688

* 1 = deep sands, 2 = sandy drainage lines, 3 = low lying sands, 4 = sandstone soils, 5 = gravels, 6 = laterite, 7 = low lying clays, 8 = wandoo clay

Table 4.2

Vertebrates known to occur within the Lesueur area and which are not known to occur in nearby existing and proposed conservation reserves (data from W.A. Museum).

A. MAMMALS

Badgingarra National Park

Echidna	*Tachyglossus aculeatus*
White-bellied Dunnart	*Sminthopsis dolichura*
Fat-tailed Dunnart	*Sminthopsis crassicaudata*
Euro	*Macropus robustus*
Gould's Wattled Bat	*Chalinolobus gouldii*
Chocolate Bat	*Chalinolobus morio*
King River Eptesicus	*Eptesicus regulus*
Lesser Long-eared Bat	*Nyctophilus geoffroyi*
Southern Bush Rat	*Rattus fuscipes*

Alexander Morrison National Park

Echidna	*Tachyglossus aculeatus*
Grey-bellied Dunnart	*Sminthopsis griseoventer*
White-bellied Dunnart	*Sminthopsis dolichura*
Fat-tailed Dunnart	*Sminthopsis crassicaudata*
White-tailed Dunnart	*Sminthopsis granulipes*
Honey Possum	*Tarsipes rostratus*
Brush Wallaby	*Macropus irma*
Euro	*Macropus robustus*
Gould's Wattled Bat	*Chalinolobus gouldii*
Chocolate Bat	*Chalinolobus morio*
King River Eptesicus	*Eptesicus regulus*
Lesser Long-eared Bat	*Nyctophilus geoffroyi*
Ash-grey Mouse	*Pseudomys albocinereus*
Southern Bush Rat	*Rattus fuscipes*

Drovers Cave National Park

Echidna	*Tachyglossus aculeatus*
Grey-bellied Dunnart	*Sminthopsis griseoventer*
White-bellied Dunnart	*Sminthopsis dolichura*
Fat-tailed Dunnart	*Sminthopsis crassicaudata*
White-tailed Dunnart	*Sminthopsis granulipes*
Honey Possum	*Tarsipes rostratus*
Brush Wallaby	*Macropus irma*
Euro	*Macropus robustus*
King River Eptesicus	*Eptesicus regulus*
Lesser Long-eared Bat	*Nyctophilus geoffroyi*

Nambung National Park

Echidna	*Tachyglossus aculeatus*
Grey-bellied Dunnart	*Sminthopsis griseoventer*
White-bellied Dunnart	*Sminthopsis dolichura*
Fat-tailed Dunnart	*Sminthopsis crassicaudata*
White-tailed Dunnart	*Sminthopsis granulipes*
Brush Wallaby	*Macropus irma*
Euro	*Macropus robustus*
Gould's Wattled Bat	*Chalinolobus gouldii*
Chocolate Bat	*Chalinolobus morio*
King River Eptesicus	*Eptesicus regulus*
Lesser Long-eared Bat	*Nyctophilus geoffroyi*

Proposed Coomallo National Park

Echidna	*Tachyglossus aculeatus*
Grey-bellied Dunnart	*Sminthopsis griseoventer*
White-bellied Dunnart	*Sminthopsis dolichura*
Fat-tailed Dunnart	*Sminthopsis crassicaudata*
White-tailed Dunnart	*Sminthopsis granulipes*
Honey Possum	*Tarsipes rostratus*
Brush Wallaby	*Macropus irma*
Euro	*Macropus robustus*
Gould's Wattled Bat	*Chalinolobus gouldii*
Chocolate Bat	*Chalinolobus morio*
King River Eptesicus	*Eptesicus regulus*
Lesser Long-eared Bat	*Nyctophilus geoffroyi*
Ash-grey Mouse	*Pseudomys albocinereus*
Southern Bush Rat	*Rattus fuscipes*

B. REPTILES

Badgingarra National Park

Ctenophorus maculatus maculatus
Crenadactylus ocellatus ocellatus
Diplodactylus alboguttatus
Diplodactylus granariensis granariensis
Diplodactylus polyopthalmus
Gehyra variegata
Phyllodactylus marmoratus marmoratus
Underwoodisaurus millii
Delma fraseri
Delma grayii
Pletholax gracilis
Cryptoblepharus plagiocephalus
Egernia kingii
Egernia multiscutata bos
Lerista distinguenda
Lerista elegans
Lerista planiventralis decora
Lerista praepedita

Omolepida branchialis
Varanus gouldii
Varanus tristis tristis
Morelia stimsoni stimsoni
Demansia psammophis reticulata
Notechis curtus
Pseudonaja nuchalis
Pseudechis australis
Vermicella littoralis

Alexander Morrison National Park

Ctenophorus maculatus maculatus
Pogona minor minor
Tympanocryptis adelaidensis adelaidensis
Crenadactylus ocellatus ocellatus
Diplodactylus alboguttatus
Diplodactylus granariensis granariensis
Diplodactylus ornatus
Diplodactylus polyopthalmus
Diplodactylus spinigerus spinigerus
Gehyra variegata
Phyllodactylus marmoratus marmoratus
Underwoodisaurus millii
Aclys concinna concinna
Delma fraseri
Delma grayii
Lialis burtonis
Pletholax gracilis
Pygopus lepidopodus lepidopodus
Cryptoblepharus plagiocephalus
Ctenotus fallens
Ctenotus impar
Ctenotus lesueurii
Ctenotus pantherinus pantherinus
Egernia kingii
Egernia multiscutata bos
Egernia napoleonis
Lerista christinae
Lerista distinguenda
Lerista elegans
Lerista planiventralis decora
Lerista praepedita
Menetia greyii
Morethia lineoocellata
Morethia obscura
Omolepida branchialis
Tiliqua occipitalis
Tiliqua rugosa rugosa
Varanus gouldii
Varanus tristis tristis
Morelia stimsoni stimsoni
Demansia psammophis reticulata
Notechis curtus
Pseudonaja nuchalis
Pseudechis australis
Rhinoplocephalus gouldii
Vermicella littoralis
Vermicella bimaculatus
Ramphotyphlops australis

Drovers Cave National Park

Ctenophorus maculatus maculatus
Crenadactylus ocellatus ocellatus
Diplodactylus granariensis granariensis
Diplodactylus polyopthalmus
Gehyra variegata
Phyllodactylus marmoratus marmoratus
Aclys concinna concinna
Delma fraseri
Delma grayii
Lialis burtonis
Pletholax gracilis
Cryptoblepharus plagiocephalus
Ctenotus impar
Ctenotus pantherinus pantherinus
Egernia kingii
Egernia multiscutata bos
Lerista christinae
Lerista distinguenda
Lerista elegans
Lerista planiventralis decora
Menetia greyii
Morethia lineoocellata
Tiliqua rugosa rugosa
Varanus gouldii
Varanus tristis tristis
Morelia stimsoni stimsoni
Demansia psammophis reticulata
Notechis curtus
Pseudonaja nuchalis
Pseudechis australis
Rhinoplocephalus gouldii
Vermicella littoralis
Vermicella bimaculatus

Nambung National Park

Ctenophorus maculatus maculatus
Pogona minor minor
Tympanocryptis adelaidensis adelaidensis
Crenadactylus ocellatus ocellatus

Diplodactylus alboguttatus
Diplodactylus granariensis granariensis
Diplodactylus ornatus
Diplodactylus polyopthalmus
Diplodactylus spinigerus spinigerus
Gehyra variegata
Underwoodisaurus millii
Aclys concinna concinna
Delma fraseri
Delma grayii
Lialis burtonis
Pletholax gracilis
Ctenotus impar
Ctenotus lesueurii
Ctenotus pantherinus pantherinus
Egernia kingii
Egernia multiscutata bos
Egernia napoleonis
Lerista christinae
Lerista distinguenda
Lerista elegans
Lerista planiventralis decora
Lerista praepedita
Menetia greyii
Morethia lineoocellata
Morethia obscura
Omolepida branchialis
Tiliqua occipitalis
Tiliqua rugosa rugosa
Varanus gouldii
Varanus tristis tristis
Morelia stimsoni stimsoni
Notechis curtus
Pseudonaja nuchalis
Pseudechis australis
Rhinoplocephalus gouldii
Vermicella littoralis
Vermicella bimaculatus
Ramphotyphlops australis

Proposed Coomallo National Park

Ctenophorus maculatus maculatus
Pogona minor minor
Tympanocryptis adelaidensis adelaidensis
Crenadactylus ocellatus ocellatus
Diplodactylus alboguttatus
Diplodactylus granariensis granariensis
Diplodactylus ornatus
Diplodactylus polyopthalmus
Diplodactylus spinigerus spinigerus
Gehyra variegata
Phyllodactylus marmoratus marmoratus
Underwoodisaurus millii
Aclys concinna concinna
Delma fraseri
Delma grayii
Lialis burtonis
Pletholax gracilis
Pygopus lepidopodus lepidopodus
Cryptoblepharus plagiocephalus
Ctenotus fallens
Ctenotus impar
Ctenotus lesueurii
Egernia kingii
Egernia multiscutata bos
Egernia napoleonis
Lerista christinae
Lerista distinguenda
Lerista elegans
Lerista planiventralis decora
Lerista praepedita
Menetia greyii
Morethia lineoocellata
Morethia obscura
Omolepida branchialis
Tiliqua occipitalis
Tiliqua rugosa rugosa
Varanus gouldii
Varanus tristis tristis
Morelia stimsoni stimsoni
Demansia psammophis reticulata
Notechis curtus
Pseudonaja nuchalis
Pseudechis australis
Rhinoplocephalus gouldii
Vermicella littoralis
Vermicella bimaculatus
Ramphotyphlops australis

C. FROGS

Badgingarra National Park

Litoria moorei
Ranidella pseudinsignifera
Heleioporus psammophilus
Neobatrachus pelobatoides

Alexander Morrison National Park

Litoria moorei
Myobatrachus gouldii

Ranidella pseudinsignifera
Heleioporus albopunctatus
Heleioporus eyrei
Heleioporus psammophilus
Limnodynastes dorsalis
Neobatrachus pelobatoides
Pseudophryne guentheri

Drovers Cave National Park

Litoria moorei
Myobatrachus gouldii
Ranidella pseudinsignifera
Heleioporus albopunctatus
Heleioporus psammophilus
Limnodynastes dorsalis
Neobatrachus pelobatoides

Nambung National Park

Litoria moorei
Myobatrachus gouldii
Ranidella pseudinsignifera
Heleioporus albopunctatus
Heleioporus eyrei
Heleioporus psammophilus
Limnodynastes dorsalis
Neobatrachus pelobatoides
Pseudophryne guentheri

Proposed Coomallo National Park

Litoria moorei
Myobatrachus gouldii
Ranidella pseudinsignifera
Heleioporus albopunctatus
Heleioporus eyrei
Heleioporus psammophilus
Limnodynastes dorsalis
Neobatrachus pelobatoides
Pseudophryne guentheri

Chapter 5

PHYTOPHTHORA AND OTHER FUNGAL PLANT DISEASES

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Abstract

Diseases caused by introduced and native fungi are part of the biological environment of native plant communities throughout south-western Australia. Any development requiring the large scale modification of the natural environment must consider the impact that diseases have on susceptible plant communities and species and make a commitment to design appropriate disease management policies. These requirements have not been addressed in the ERMP for the Hill River Project. The proponents have only addressed the issue of dieback disease caused by Phytophthora species and no consideration has been given to other plant diseases that may occur in the area.

Dieback disease associated with Phytophthora species is briefly mentioned in the ERMP. Despite having acknowledged that the Lesueur area contains many susceptible and sensitive plant groups and that there is potential for the spread of the disease, the proponents have failed to address vital issues relating to the potential impacts of the project. These issues are: an assessment of the hazard to susceptible vegetation, an appraisal of the risk of infestation and spread of the disease, and a commitment to disease management in terms of prevention and monitoring.

The risk of introduction of plant diseases during the 30 year time frame of the project is high. If introduced, Phytophthora species would have a high impact on the vegetation, causing local extinctions of many plant species and massive changes in species diversity.

5.1 INTRODUCTION

Diseases caused by fungi are part of the biological environment of native plant communities throughout south-western Australia. Land use must take into consideration the occurrence and impact of soil-borne fungi, mainly *Phytophthora* species, although others like *Armillaria luteobubalina* and those which cause plant cankers need to be considered.

Proposals for development within the Lesueur area, like the Hill River Project, need to take into account the occurrence of plant diseases and the significant impacts they can have on native vegetation. A clear understanding of the biology and impacts of such diseases on the biological environment in a local or regional context, along with an assessment of how they will be managed and monitored if introduction occurs, would be the minimum requirement needed to assess the likely impact of such a project in the Lesueur area. The proponents of the Hill River Project have failed to address these issues adequately in their ERMP.

5.2 PLANT DISEASES OF THE NORTHERN KWONGAN - A REVIEW

Before an assessment of the proponents treatment of the plant disease issues, as presented in the ERMP for the Hill River Project can be made, it would be appropriate to discuss aspects of our understanding of the diseases in the northern kwongan and in particular the Lesueur area which are of relevance to the project. This review follows on from Hill's (1990) report, updating information where new data have become available. It also provides information on aspects of the biology of *Phytophthora* species which is relevant to any discussion on the impacts of such a project. In addition, this review provides information on two other plant diseases caused by fungi which have the potential to have significant impacts on the flora of the Lesueur area.

5.21 Dieback diseases caused by soil-borne *Phytophthora* species

Dieback disease caused by soil-borne *Phytophthora* species is a major threat to the ecology and

conservation of susceptible plant communities in south-western Australia (Shearer 1990). Four species of *Phytophthora* have been isolated from patches of dying native vegetation within a 30 km radius of the proposed Hill River Project (Hill 1990, Department of Conservation and Land Management 1990, Figure 5.1). They are *P. cinnamomi*, *P. citricola*, *P. megasperma* var. *megasperma* and *P. nicotianae* var. *parasitica*. At least two areas infected with *P. citricola* occur within 10 km of the proposed project.

The following summarizes key aspects of the biology of *Phytophthora* species in south-western Australia relevant to the Lesueur area and statements made by the proponents within the ERMP:

i. *Phytophthora* species have been introduced into the south-west of Australia (Podger 1972; Shearer and Tippett 1989). Seven taxa of *Phytophthora* have been isolated from dying native vegetation in this State (Shearer 1990).

ii. Humans have been the main agents of dispersal through the movement of infected moist soil and plant material. Operations involving disturbance and movement of soil have a high risk of introducing and spreading *Phytophthora* species.

iii. Spores of the fungi are also passively dispersed in water. Inoculum can be dispersed in lateral seepage of water within 5 m of the soil surface and in overland flow following introduction of the fungus into a site. Activities favouring sub-surface seepage and overland flow of water through disturbance and ponding of water have a high risk of introducing and spreading *Phytophthora* species.

iv. *Phytophthora citricola*, *P. megasperma* var. *megasperma* and *P. nicotianae* var. *parasitica* are homothallic and readily produce thick walled oospores that survive unfavourable conditions. *Phytophthora nicotianae* var. *parasitica* also readily produces resistant chlamydospores. These spore types enable the *Phytophthora* species to persist for long periods.

v. All the *Phytophthora* species recovered from native plant communities kill a wide range of plant species; the flora of the Lesueur area, particularly the area surrounding the proposed mine and power station contains a large number of susceptible species (Hill 1990).

Our understanding of the distribution and biology of *Phytophthora* species north of Perth is very incomplete. Current knowledge of the distribution of the disease can quickly change as a result of continuing surveys. For example, recent isolations of *P. cinnamomi* and *P. citricola* (Figure 5.1) have greatly extended the known distribution of these *Phytophthora* species.

North of Perth, the occurrence of dieback disease caused by *Phytophthora* species is consistently associated with sites near roads which are prone to seasonally wet conditions (Department of Conservation and Land Management 1990; Hill 1990). This suggests that *Phytophthora* species are probably recent introductions into the area. Infected soil and gravel carried by vehicles and machinery would be the main source of introduction. Seasonally wet sites are usually the first infected because of high soil moisture conditions which are favourable for survival, sporulation and dispersal of the pathogens and infection of host tissue.

Once established in the most susceptible sites, *Phytophthora* species have the potential to infect neighbouring areas. At Wanneroo and in the Moore River National Park, infection by *P. cinnamomi* has spread from seasonally wet locations and is now destroying the surrounding *Banksia* woodlands (Hill 1990; Shearer and Hill 1989). The current distribution and impact could therefore underestimate the potential impact of the *Phytophthora* species north of Perth. Protection of healthy areas from *Phytophthora* infection must therefore have a high priority.

5.22 Disease caused by *Armillaria*.

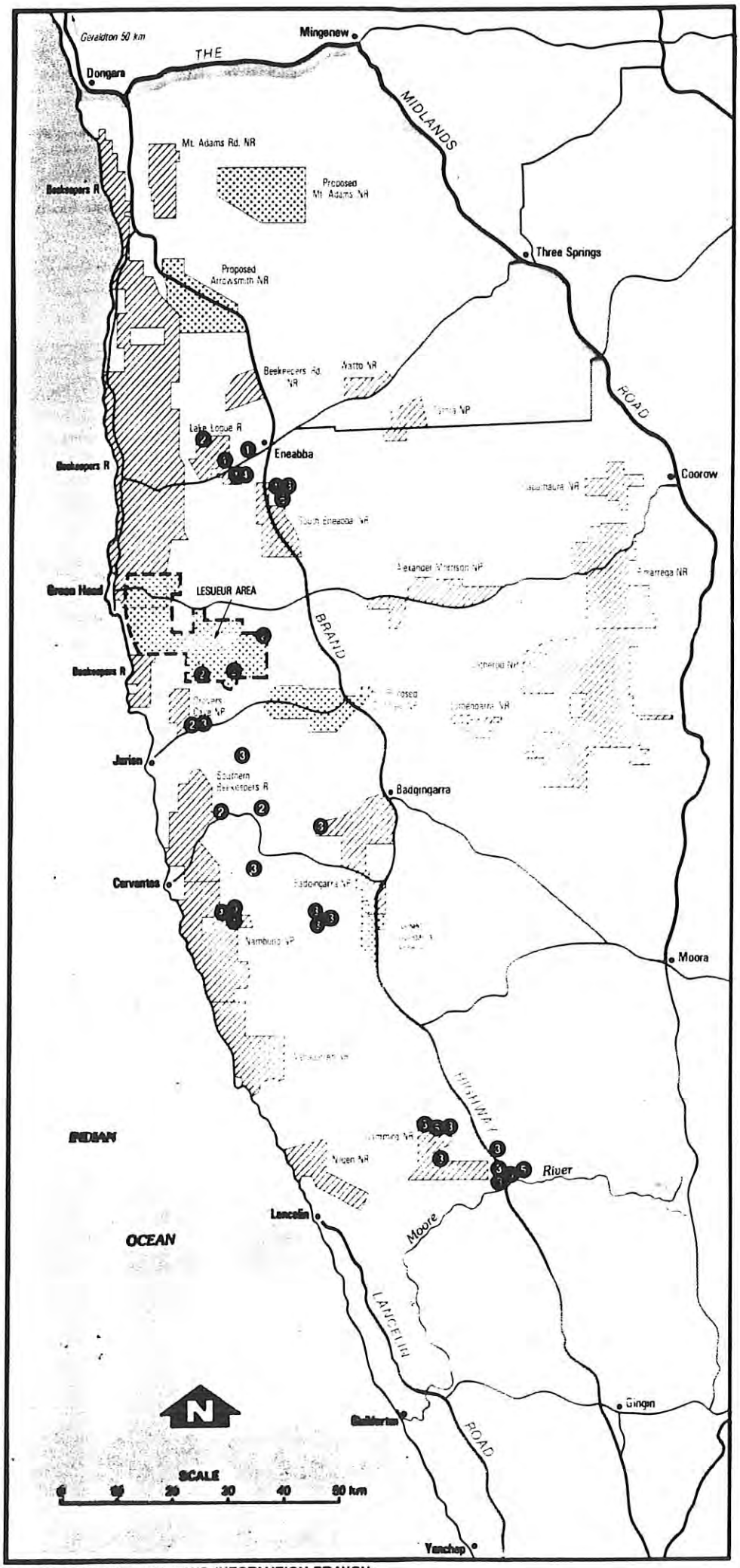
Armillaria luteobubalina is a widespread primary pathogen occurring in native plant communities throughout south-western Australia. This native pathogen has not been found north of Yanchep. However, the present northern limit for *A. luteobubalina* is probably more a reflection of the limited number of surveys than of the true distribution of the pathogen. *Eucalyptus wandoo* is very susceptible to infection and dies once the pathogen reaches the collar (Shearer and Tippett 1988). This species is a major component of the woodland vegetation associations present within the Lesueur area and is an important source of nesting hollows for a variety of bird species, including Carnaby's Black-Cockatoo.

5.23 Diseases caused by canker fungi

The major canker-causing fungus in Western Australia is *Botryosphaeria ribis*. This fungus is an aggressive pathogen causing cankering of the aerial parts of a wide range of woody plants in the Northern Hemisphere. In native communities of south-western Australia, *B. ribis* causes cankers in *Eucalyptus* and *Banksia* species, and a wide range of other woody plants. The spores are air-borne and hosts can be predisposed to infection by water stress and air pollutants. Shearer *et al.* (1987) suggest that environmental stress is also a factor favouring infection of some plant species by *B. ribis*.

The fungus *B. ribis* has been isolated from cankers associated with branch dieback of *Banksia attenuata*

Figure 5.1
PHYTOPHTHORA SPECIES NORTH OF GUILDERTON

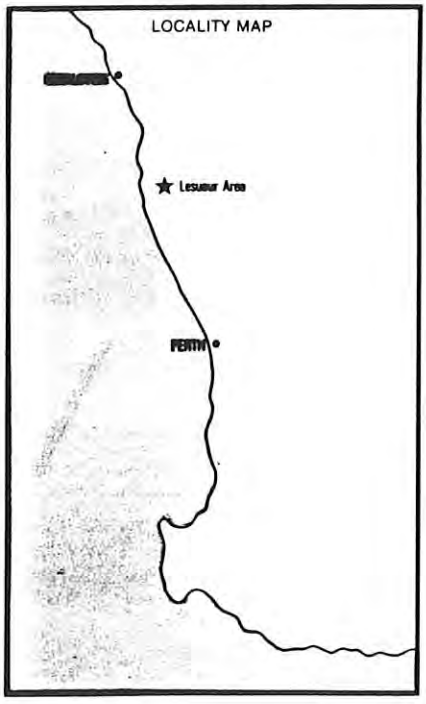


LEGEND

- Major Road
- Minor Road
- Study Area
- Existing National Park, Nature Reserve
- Existing "other" Conservation Reserve
- Proposed National Park, Nature Reserve
- Lesueur Area

Occurrence/Species

1. *Phytophthora cinnamomi*
2. *Phytophthora citricola*
3. *Phytophthora megasperma var megasperma*
4. *Phytophthora megasperma var sojae*
5. *Phytophthora dreschleri*
6. *Phytophthora nicotianae var parasitica*



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and *B. menziesii* on Banovich Road. This locality is on the eastern edge of the proposed conservation reserve at Lesueur.

5.3 ASSESSMENT OF THE ERMP, ITS CONCLUSIONS AND COMMITMENTS IN RELATION TO PLANT DISEASES

The ERMP does not assess the potential effect of the Hill River Project plant diseases. No mention is made of plant diseases other than those caused by *Phytophthora* species. Stress factors such as disturbance, drought, waterlogging and air pollution can predispose plants to infection by *Armillaria* and canker fungi. Disease management should include an evaluation of the effects of the proposed project not only on *Phytophthora* caused disease but on disease caused by *Armillaria* and canker fungi.

5.31 Dieback diseases caused by soil-borne *Phytophthora* species

The ERMP considered the potential impact of *Phytophthora* in Section 6.2.3 and the following general statements are relevant:

> "The potential for spread from these infestations is recognized." (ERMP p. 6-3)

and

> "Vegetation of the Hill River area has a high proportion of the most susceptible and sensitive plant groups and Phytophthora is widely distributed in the region." (ERMP p. 6-3)

ERMP Section 6.3 on disease management is vague and generally lacking specific information for the type of operations proposed. This is despite their own statements in the ERMP about the susceptibility and sensitivity of the flora within the Lesueur area and despite their recognition of the potential for the spread of this disease. This lack of a suitable treatment for the plant disease issue in the ERMP conflicts with it being identified by the EPA as a key issue which should be addressed. The ERMP should have provided details on:

1. the hazard of infection of susceptible vegetation;
2. the affect of the operations on the risk of introducing and spreading *Phytophthora* species;

and

3. the procedures to be used for disease management to prevent the introduction of *Phytophthora* species and/or monitor their spread.

Hazard

Hill (1990) has rated the major vegetation types for hazard if *Phytophthora* species were introduced into the Lesueur area. High hazard plant communities occupy 40.8% of the impact zone (Figure 1.1), some of which will be progressively cleared. These are the vegetation types C, D, H, M1, X and the mosaic types DEH, FGH, DFH, DFG and AE. High hazard plant communities also occur adjacent to and down-slope from areas where earth-moving machinery and other vehicles will operate over a long period of time if the project proceeds. Susceptible species dominate these high hazard vegetation types, and infection by *Phytophthora* species characteristically results in loss of over 50% of the biomass and irreversible decline in diversity of such areas. Infection by *Phytophthora* species is likely to cause localised extinction of many plant species and, perhaps, total extinction of susceptible local endemics, such as *Banksia tricuspis* (Hill 1990). All the other vegetation types (except Type K, wandoo woodland) in the area near the project are of medium hazard and these also will suffer significant loss of species and a decrease in biodiversity if the disease becomes established. In all, over 90% of the eastern end of the proposed conservation reserve at Lesueur, that was mapped by Martinick and Associates (1988) is of high or medium hazard.

Current impact of *P. cinnamomi* in the Stirling Range National Park provides a stark warning of the potential deleterious consequences of *Phytophthora* infection on the vegetation of the Lesueur area. The climate, soils and topography of the Stirling Range National Park are similar to that of the Lesueur area (Hill 1990). *Phytophthora cinnamomi* infection is reducing diverse plant communities within the Stirling Range National Park to impoverished sedgelands, with the localised extinction of many plant species. The protection of the diverse, but vulnerable flora of the proposed conservation reserve at Lesueur from infection by *Phytophthora* species must therefore be a high priority.

Risk of Infection

The ERMP should contain a detailed analysis of the risks of introduction of *Phytophthora* species through the various phases of the project, such as construction of the power station and ancillary facilities, including the blowdown pipeline to the ocean, the mining operation, road construction and haulage and rehabilitation. Similarly, when the route for the power transmission lines has been determined a detailed analysis of risks will also be required.

Such an analysis needs to take into consideration factors such as the scale and duration of the operation, changes to the local hydrology caused by the operation and the areas placed at risk through the interactions between hydrology and position in the landscape.

Scale and Duration of Operation

The construction of the power station and the mining operations will result in massive disturbance associated with the movement of large amounts of soil and continual extensive use of large earthmoving machinery. Experience in south-western Australia and in other parts of Australia has already shown the high risk of introducing and spreading *Phytophthora* species associated with these types of disturbances. The proponents need to clearly outline the specific procedures they plan to implement to prevent the introduction and spread of *Phytophthora*. Particular attention needs to be given as to how the specific procedures will be effective for the large scale of the operations proposed. Consideration also needs to be given to how the specific procedures to reduce the risk of infection will operate over the 30 year life time of the mine and when it is decommissioned.

Hydrological and landscape position considerations

The ERMP does not discuss how the surface hydrology of the area could influence the rapid dispersal of *Phytophthora* species. In addition, the ERMP does not consider how various operations such as roading, mining and overburden dumps along with their subsequent rehabilitation and the holding, evaporation and sedimentation ponds may change the surface and near-surface hydrological balance to affect site susceptibility to *Phytophthora* infestation.

Dispersal of *Phytophthora* species in near-surface seepage and overland flow of water would be favoured by the soils and topography of the Lesueur area. Dispersal of *Phytophthora* at depth in the soil profile is favoured by lateral near-surface seepage of water over impeding layers of duricrust, clay, rock or gravel pans within course gravelly and sandy soils (Shearer and Tippett 1989). In conjunction with dispersal in near-surface lateral flows of water, *Phytophthora* species can be active in the water table up to 5 metres below the soil surface.

As described in the ERMP, shallow soils over an impeding layer predominate within the Lesueur area. Even the sands that occur on the Banovich Upland landform unit are underlain by impeding gravel pans. In addition, the steep slopes and shallow hard gravelly soils favour dispersal in overland flow.

Changes in the hydrological balance in areas below active pits, overburden dumps, roads and holding ponds can favour near-surface seepage of water. The shallower the soils, the more likely it is that near-surface seepage will be increased below the proposed activity. Enhanced near-surface seepage of water increases site susceptibility to infection and rapid dispersal of *Phytophthora* species should they be introduced. The wetter soil environment can also favour host infection and disease intensification.

Proposed mining areas and roads occupy elevated points in the landscape, providing high risk of infection in overland and near-surface seepage of water. Proposed mining activities would directly impinge on three major catchments (Coomallo Creek, Cockleshell Gully and Munbinia Creek), which together drain the bulk of the area containing rare and vulnerable vegetation. A fourth catchment present in the proposed conservation reserve at Lesueur, Stockyard Gully, will also be affected by the proposed mine sites on private land to the north of the proposed reserve boundary. Every opportunity, therefore, exists for *Phytophthora* species to rapidly contaminate the heart of the proposed conservation reserve if introduced, particularly if Cockleshell Gully were infected.

Procedures for Disease Management and Monitoring

General statements in the ERMP recognize the high hazard of *Phytophthora* infection to the vulnerable vegetation of the Lesueur area, the occurrence of *Phythophthora* species in the area and the potential for the spread of infection. Despite this, the short section on disease management fails to provide specific details on how effective monitoring and control can be accomplished, particularly in relation to the size and duration of the proposed project.

There is no assessment of the research and resources needed for effective disease management for the large scale and duration of the operation. The proponents have made no firm commitment in the ERMP to undertake or fund the required research to develop procedures to control and monitor *Phytophthora* diseases, especially in areas of massive disturbance.

The ERMP places considerable reliance on CALM to provide the necessary information on monitoring and disease control. The proponents fail to realise that the procedures developed by CALM are specifically for native communities exposed to minimal disturbance and cannot be simply adapted to the massive scale disturbance proposed for the Lesueur area. New disease management procedures will need to be developed specifically for the proposed project if it proceeds.

As part of the evaluation procedure, the proponents should have provided specific details of the disease management procedures for the various

phases of the operation together with the likely consequences should infections occur and control measures fail.

In the ERMP the proponents have stated that: "Disease management procedures are in place, and have been followed during exploration work" (Section 6.2.3). It has been documented by CALM, however, that on one occasion the proponents' disease management procedures failed. This breakdown occurred when commercially grown potted seedlings were used in an attempt to rehabilitate an old drill pad. The seedlings and potting medium were not screened to determine if dieback disease was present.

This breakdown in disease management occurred during the relatively short exploration phase and we are concerned at the possibility of future breakdowns occurring during the life of the project (30 years). This incident highlights the problems that the proponents face in implementing an adequate disease management and monitoring program and how easily such a program can break down, no matter how genuine the intentions of the proponents may be.

In relatively undisturbed situations, accurate monitoring of disease occurrence depends on a complexity of many factors. Accurate monitoring over large, highly disturbed areas over long periods of time is extremely difficult. The proponents have failed to provide details on how accurate monitoring can be accomplished, and what procedures will be followed should plant diseases be detected.

Chapter 6

LANDSCAPE, NATURE-BASED RECREATION AND TOURISM VALUES

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Abstract

Should the coal mines and power station project proceed, the natural character and scenic beauty of what are some of the most attractive landscapes within the northern kwongan will be severely degraded. The most scenic parts of the proposed conservation reserve at Lesueur would not be mined. However, there will be a significant impact on visual resource values if the mine goes ahead, as the area that will be mined is a supporting landscape and an important foreground to the eastern flank of the Gairdner Range. The viewsheds east and northeast from the Gairdner Range would also be affected and the coal-fired power station, with its 200 metre high stack, would be visible from a considerable distance, from both within and outside the reserve.

The project would also significantly impact on those recreationists, tourists and residents who value the relatively pristine natural environment of the Lesueur area which presently exists. In particular, outdoor recreation activities such as bushwalking, nature study and sightseeing which are dependent on the region's natural values would suffer the most.

The proponent's ERMP fails to adequately address these issues and does not provide sufficient information on which to arrive at informed conclusions. The ERMP also fails to identify important 'non-use' values associated with the region's unspoilt character.

6.1 INTRODUCTION

As part of the Environmental Review and Management Program (ERMP) and Draft Environmental Impact Statement for the Hill River Project, the project proponents were directed by the EPA to address a number of key issues including:

- impact on "landscape and recreation values" (ERMP Attachment 1, p. 3) and
- impact on resources necessary for farming, fishing, tourism, beekeeping and other livelihoods.

The proponents were also directed by the EPA to broadly define the commitments which would be made to protect the environment (i.e. impact mitigation) should this project receive government approval.

The proponents' assessment of these two particular issues and the subsequent conclusions reached in the ERMP raise a number of concerns, the major ones which can be summarised as follows:

1. The ERMP fails to identify and/or evaluate the full range of potential impacts that this project is likely to have on landscape values, and on nature-based recreation and tourism. In particular, the ERMP does not adequately address how and to what extent the project would impact upon visitors to the region's inland parks/reserves, including the proposed conservation reserve at Lesueur.
2. The assessment techniques employed by the project consultants to evaluate these key issues have not generated sufficient information on which to reach soundly based conclusions.

These and associated concerns are briefly discussed in the remainder of this chapter.

6.2 LANDSCAPE VALUES

6.21 Impact assessment brief

The proposed project represents a mining and industrial development of State as well as regional significance. Projects of this magnitude and duration can result in major, and in some instances irreversible, impacts which extend far beyond the confines of the project area. Such is the case with this project and its predicted impact on the region's visual resources.

The nature and significance of the impact that this project could have on the scenic resources of the

Lesueur area was clearly recognised by the EPA when it instructed the project proponents as follows:

> "Particular attention should be addressed to the landscape values, in a local and regional context, in a way which allows the pre-project values to be compared with those after completion" (ERMP Attachment 1, p. 6).

As discussed later in this chapter, the project's potential impact on the scenic values of the region is, according to the proponent's own data, also of major concern to local residents and visitors.

6.22 Study methodology

The issue of landscape impact has been addressed in some detail in the ERMP. Project consultants were employed to conduct a viewscape assessment of the proposed mine site and power station. In general terms, this assessment attempts to establish where and to what extent the mine's overburden dumps and power station stack will be visible from the four major public roads which surround the study area. A number of other view points including some within Badgingarra and Drover's Cave National Parks are also assessed and the results presented in Appendix D of the ERMP.

While the viewscape assessment provides useful information on which to assess potential visual impacts, it is deficient in two significant aspects:

1. The viewscape study as described does not constitute a thorough assessment of visual impact. While the study methodology provides a quite detailed statement on what project elements will be visible from major travel routes and other selected vantage points; it give no firm indication as to the nature and relative significance of the landscape values (i.e. visual quality values) which would be affected by this project. Consequently the study fails to establish or measure "pre-project" landscape values in other than superficial terms and does not fully comply with the EPA directive.
2. The study does not attempt to assess how and to what extent the project would visually impact on recreationists/tourists visiting the Lesueur area. This omission is acknowledged in the consultant's report when they state:

> "It should be noted that this viewscape assessment is intended to determine the degree of visual intrusion of the project on the general public. That is, it examines the impact likely to be experienced by people using local roads and living in towns in the region. It does not address the project impacts for people who deliberately visit the site or who purposefully gain access to locations from which they can oversee the project" (ERMP Appendix D, p. D1).

Given the regional importance of the scenic resource values of the proposed conservation reserve at Lesueur (as documented by Schmidt 1990a), this is a significant omission.

In simple terms, the viewscape assessment fails to adequately describe the nature, importance or full extent of scenic values which will be affected should this project proceed. Nor does the ERMP adequately address how these impacts will be mitigated.

6.23 Review of impact assessment results

To properly evaluate the potential visual impacts of this project, it is essential that the character and significance of existing landscape values for both the study area as a whole as well as the project area are first established. Such an inventory and evaluation was completed by CALM and is reported by Schmidt (1990a).

As described in EPA Bulletin 424 (Burbidge *et al.* 1990), the study area contains two distinctive landscape character types (a landscape character type is a broad-scale area of common distinguishing visual characteristics as identified by landform, vegetation, waterform and land use patterns). The first of these, the Northern Kwongan Landscape Character Type, covers all of the project site as well as the bulk of the study area including Mt Lesueur and the other nearby peaks, slopes and drainages of the Gairdner Range. The coastal or seaward portion of the study area consists of a separate Coastal Landscape Character Type. A brief description of each of these types is presented in Tables 6.1 and 6.2.

In terms of regional significance, the landscape encompassed by the project site and the area surrounding Mt Lesueur is of major importance. To quote Schmidt (1990a):

> "The Gairdner Ranger, which includes Mt Lesueur, Mt Michaud and Mt Peron, contains some of the highest and most scenically attractive landforms within the Northern Kwongan Landscape Character Type. The first two of these peaks, with their distinctive tableland or mesa shapes, are visible on the skyline up to 15km away from various vantage points along the Jurien and Coorow-Green Head Roads and the Brand Highway. Only the Morseby Range north and east of Geraldton contains topography of comparable scenic appeal.
>
> West of the Gairdner Range and Peron Fault, the Lesueur Area extends seawards across a broad, relatively flat sandplain to the coast. Here a line of outer reefs and small islands and an extensive chain of salt lakes which parallel the coastline provide added visual interest to an otherwise unspectacular seascape" (EPA Bulletin 424 p. 101).

and:

> "Immediately east of the escarpment, the landscape dramatically unfolds, revealing numerous hills, valleys and breakaways to the east and north. These are the Lesueur and Gairdner Dissected Uplands, the central core of the Gairdner Range and a landscape of High Scenic Quality. Further to the east and north, portions of the Banovich Uplands and Bitter Pool Rises as well as other more distant landforms, some up to 25km away, are clearly visible. To the west, views of the coastline and Indian Ocean complete this superlative panorama" (EPA Bulletin 424 p. 103).

and:

"Once on top of the escarpment, one can look down upon a large basin partially enclosed by the steep eastern flanks of Mt Peron, Mt Michaud and Mt Lesueur and by the Lesueur Fault further east. Cockleshell Gully, which arises on the eastern side of the Range, passes through this depression. The basin floor is in fact quite undulating, consisting of a maze of low hills, ridges, breakaways and shallow valleys. Some of the steeper slopes and breakaways have exposed outcrops of sandstone and extensive pockets and bands of eucalypt woodland scattered across the heath-covered slopes and valleys.

From the eastern edge of the Range, the distinctive tabletop forms of Mt Lesueur and Mt Michaud are particularly prominent, while Mt Peron dominates the northwestern skyline. One is afforded a spectacular enframed ocean view across the dissected uplands, where Cockleshell Gully cuts through the Peron Slopes.

This is, in summary, an area of high scenic appeal owing to the diversity of landforms and vegetation associations and the textual and colour patterns associated with these. In virtually every direction, one is confronted by an everchanging landscape of steep breakaways, low hills and gullies with sculptural eucalypt woodlands set amongst the heath-covered ranges" (EPA Bulletin 424 p. 103).

The project area itself is situated east of the Lesueur Fault in the Banovich Uplands and Bitter Pool Rises, a zone of Moderate Scenic Quality. The most scenic portions of the Gairdner Range landscape, the Lesueur and Gairdner Dissected Uplands, would be largely spared from mining. There will, however, be a significant impact on the visual resource values of the Lesueur area should the proposed mining operations and power station development proceed. These include:

1. Impairment of adjoining landscape values. The Banovich Uplands and Bitter Pool Rises are a supporting landscape and important foreground to the eastern flank of the Gairdner Range, a zone of High Scenic Quality. Any mining activity or development in this zone would have a major impact on the visual integrity of the adjoining landscape, irrespective of its ultimate vesting and use. In addition, the possible introduction of dieback, and the devastating impact this could have on many plant species and associations (see *Phytophthora* and Other Fungal Plant Diseases, Chapter 5) and hence landscape values, also is of concern.
2. Impact on major viewsheds and vistas. The areas proposed for mining such as the coal seam situated under the ridge south of the headwaters of Cockleshell Gully would be visible from numerous vantage points within the Lesueur and Gairdner Uplands. In particular, the viewsheds east from Mt Michaud, east and northeast from Mount Peron and from the eastern edge of the Gairdner Range would be significantly affected. The coal-fired power station, with its 200 metre high stack, would also be visible from a considerable distance, from both within and outside the reserve. The extent of such visual impacts can be accurately projected and mapped using computer-generated digital terrain models. Had such techniques been employed they would have enabled a much more comprehensive and detailed landscape impact assessment to have been made.

The results of the proponent's own viewscape assessment, incomplete as they are, are indicative of just how visually intrusive this project would be. As summarised in Table 1 of Appendix D of the ERMP (ERMP p. D6), it has been calculated that the mine overburden dumps would be visible for approximately 6% of the total distance from the four public roads which surround the project area. This is a significant finding given that many of the view transects analysed were in excess of 10km from the site and some over 20 km distant.

It is accepted that these overburden dumps, with their mesa/benched landforms, will be less conspicuous when viewed from more distant vantage points. From foreground (0 to 0.5 km) or middleground (0.5 to 6.5 km) observer positions however, the dumps will become increasingly evident due to form, line, colour and textural contrasts with adjoining undisturbed areas. The fore- and middleground zones in particular are critical in terms of visual impact assessment and management, as it is these zones in which form, textural and colour contrasts become visually dominant. In time such contrasts would be partially mitigated providing site rehabilitation efforts prove successful.

The same cannot be said of the power station complex, however. A 200 metre high cylindrical stack is a dominant element in any landscape, irrespective of the scale of the surrounding landforms. According to the ERMP viewscape assessment, the stack would be visible from 15% of the total distance of the four public roads surveyed, including sections of the Brand Highway over 20km distant (ERMP Appendix D, p. D6). The consultants have interpreted this result in a positive light by stating that:

"topographic high points will obscure the stack from the four major roads for about 85% of the transect distance" (ERMP Appendix D, p. D6).

While this figure is not disputed, the conclusion which is drawn can be interpreted in quite a different way. This same viewscape assessment indicates that Mt Lesueur itself is visible from 7.7% of the four road transects. In other words, the stack of the power station would, when compared with Mt Lesueur, be visible for nearly twice the length of the four roads assessed. This is a remarkable finding and indicative of just how visually intrusive the stack would be, given that Mt Lesueur is one of the most prominent landforms within the study area. Apart from sheer size, the stack's geometric shape when viewed as a skyline element set amongst a backdrop of broad undulating hills and ridges would serve to further

Table 6.1

Northern Kwongan Landscape Character Type

Scenic Quality	Landform	Vegetation	Waterform	Land Use
GENERAL DESCRIPTION	*Broad, flat to undulating sandplain ranging in elevation from 30-250 metres (highest in the eastern section) with pronounced escarpments and low ranges (up to 300 metres); some areas of exposed limestone and sandstone outcropping.	*Coastal heathlands and scattered banksia/eucalypt woodland; extensive agricultural pastoral clearing throughout much of the type.	*Numerous small streams and intermittent creeks; some larger streams and rivers which drain from east to west across the coastal plain; numerous wetland areas, primarily in the southern portion of the type.	*Combination of reserves and vacant Crown land supporting native vegetation with extensive freehold land supporting grazing and grain growing.
HIGH	*High rounded hills with steep slopes, mesa topped ranges and escarpments to 300 metres in elevation with sharp breakaways. *Steep sided gorges and strongly dissected valleys.	*Areas of high plant diversity (structural and/or species richness) which display distinctive textural and colour patterns. *Pockets or bands of vegetation which become focal points due to relative height, position in landscape, isolation or colour contrast.	*Larger wetlands, river pools and other permanent water features. *Steep sided gorges or valleys associated with major river drainages.	*Large expanses free of human disturbance or developments such as roads/firebreaks and where edge contrasts are not evident. *Spot developments which are in harmony with naturally established forms, lines, colours and textures.
MODERATE	*Gently undulating plains and rounded hills similar in gradient to surrounding landforms and which are not visually distinctive or prominent.	*Some structural and seasonal colour patterns evident in vegetation, but lacking in uniqueness or distinction relative to surrounding vegetation. *Gradual transition between heathland and woodland communities.	*Seasonal wetlands, intermittent streams and creeklines.	*Pastoral/agricultural landscapes in which clearings, firebreaks, roads and other human imposed developments borrow significantly from natural patterns; some discordant visual impacts apparent.
LOW	*Expansive plains with little or no dissection and with limited topographic features of specific visual interest.	*Extensive areas/vistas of similar vegetation cover with little or no structural diversity or colour/texture changes.	*Waterforms absent.	*Developments in which the form, line, colour and texture of introduced elements contrast markedly with natural features.

Table 6.2

Coastal Landscape Character Type

Scenic Quality	Landform	Vegetation	Waterform	Land Use
GENERAL DESCRIPTION	*Coastal Landforms include extensive sand beaches, dunes (both consolidated and mobile), offshore reefs, stacks and islands, high cliffs, headlands and coastal gorges.	*Range of vegetation communities including dune grasses, coastal heathlands, woodlands and mangrove thickets.	*Indian Ocean, numerous streams and rivers, extensive embayments and tidal estuaries.	*Several urban centres and numerous smaller coastal towns; some squatter settlements and scattered shacks; various recreation access points, some with developed areas and facilities.
HIGH	*Cliffs and headlands. *All islands, stacks, offshore sandbars and reefs. *Rock features, caves, faultlines, obviously banded sedimentary rocks. *Irregular coastline edges often emphasised by distinctive rock outcropping bays, inlets, and sand deposition patterns. *Primary dunes which display areas of active weathering, steep slopes and/or sandblown edges.	*Windshaped, gnarled or dwarfed vegetation unusual in form, colour or texture. *Single tree, shrubs or patches of vegetation which become focal points due to isolation or position in relation to rocks or water. *Strongly defined patterns of woodland, dune vegetation Melaleuca scrub, mangrove thickets and/or barren rock.	*All estuaries, inlets, lakes and swamps. *Unusual ocean shoreline motion as eddies due to islands, reefs, surf zones and shoreline configuration.	*Long stretches of coastal landscape free of human development and disturbance. *Spot developments which are in harmony with naturally existing forms, lines, colours and textures.
MODERATE	*Expanses of beach of uniform width and colour without rock outcroppings or local features. *Regular coast edges without bays, inlets, promotories, stacks or cliffs.	*Predominantly heath or beach grasses with some variation in colour, texture or pattern. *Some contrast caused by different colours.	*Uniform ocean shoreline and motion characteristics with little diversity.	*Coastal areas in which human-imposed developments/ disturbances borrow significantly from natural landscape patterns; some discordant visual impacts apparent.
LOW	*Expanses of uniform (indistinctly dissected) landform.	*Extensive areas of similar vegetation such as heath or beach grass, with very limited variation in colour or texture.	*Water, where present rates no lower than moderate in this LCT.	*Highly developed or disturbed areas with little or no vegetation cover. *Townsite, housing, harbour and other developments in which form line, colour and texture of introduced elements contrast markedly with natural features.

focus public attention on the project site. From many vista points and travel routes, the stack would become the dominant visual feature. This is one impact that cannot be readily mitigated, irrespective of what colour the stack is painted.

Apart from these more obvious visual impacts, there are other project elements which would also have a detrimental effect on the landscape values of the study area. These range from localised visual impacts associated with the construction of access and haul roads, sedimentation ponds and pipelines to the far more extensive visual impact of routing a 330kv powerline through the northern kwongan to link up with the power station. This latter development is of serious concern, as it has the potential to visually mar a much greater area, regardless where it is sited.

In conclusion, it is clear that the proposed mining operations and power station would impact significantly upon the visual quality of the proposed conservation reserve at Lesueur and the study area as a whole. The natural character and scenic beauty of what are some of the most attractive landscapes within the northern kwongan would be severely degraded should this project proceed. As a result, those recreational activities and human experiences that are dependent on the quality and integrity of the visual environment would suffer significantly. Landscape rehabilitation efforts, however well planned and executed, will not be able to restore the integrity and scenic beauty of this area once disturbed. Such impacts can not be dismissed lightly.

6.3 NATURE BASED RECREATION AND TOURISM VALUES

6.31 Background

The ERMP includes an assessment of the various social and economic impacts likely to occur should this project proceed. A total of eight separate issues are evaluated, including the effects the proposed coal mine and coal-fired power station would have on tourism and recreation in the surrounding region. As outlined in Section 6.7 of the Socio-Economic Impact Study (ERMP Appendix A, p. 52), an attempt is made to address the following recreation and tourism concerns: "

- What is the extent of tourism visitation to and recreation use of the coastal townships in the study area?
- What are the degrees of local and non-local use?
- What is the economic value of tourism to the study area?
- What are the tourism and recreation attributes of the study area?
- What are the potential effects, positive or negative, upon the tourism industry and recreational opportunities within the study area as a consequence of the proposed development?"

Due to a paucity of data on tourism in the region, the project consultants have carried out their own resident and visitor surveys in the coastal townships of Cervantes, Jurien, Greenhead and Leeman. The information generated from these two surveys, which is summarised and discussed in Appendix A of the ERMP, is augmented by Australian Bureau of Statistics data and information provided by the former State Planning Commission, W.A. Tourism Commission, local government authorities and other agencies.

6.32 Study methodology

Standard assessment methods (e.g. written questionnaire) were employed in an effort to acquire the information needed to address the five tourism and recreation issues listed for consideration. Although the visitor survey instrument itself appears to be well designed, its application and the data generated from this survey are inadequate for meaningful impact assessment, particularly in predicting how the project would affect nature-based forms of recreation and tourism in the study area. The major shortcomings of the data base and tourism and recreation impact assessment are briefly outlined.

6.33 Analysis of assessment results

The recreation survey (as distinct from the resident survey) was conducted over a three day period in March 1989. The result is a data base consisting of 255 questionnaire returns which have been collated and analysed. A survey of such limited size and duration would typically be regarded as a pilot study, to be followed up by a much more comprehensive study over an extended period of time.

Yet the results from this single "snapshot" of recreationists and tourists are used not only as the primary source of information for describing existing visitor use patterns and preferences, but also as the basis for speculating on how the project could impact on future tourism and recreation activity in the region. Clearly the information provided by this one-off survey is an inadequate basis on which to identify, evaluate and mitigate future impacts.

Apart from the limited data set, the recreation survey focuses primarily on visitors to the coastal strip (Cervantes, Jurien, Greenhead and Leeman), which is admittedly the zone of greatest recreation and tourist activity. However, it appears that no attempt has been made to survey visitors within the boundaries of the proposed conservation reserve at Lesueur. Nor has any information on recreation use and preferences been sought about visitors to other nearby northern kwongan reserves such as Nambung National Park,

despite the fact such data are available. Consequently, the survey results are biased towards coastal forms of recreational use, as contrasted with nature-based activities such as nature study and bushwalking which occur in these inland reserves.

The survey is also biased in the sense that it was conducted during a time of year (early March) when the inland landscapes are generally regarded as being least attractive. Had the survey been extended to cover the spring months when many heathland species are in flower and the landscape is a mosaic of colours, it is almost certain survey respondents would have placed even greater emphasis on those activities and attractions associated with nature-based recreation further inland. Consequently, the ERMP may significantly "undervalue" the importance which the Lesueur area, and other nearby kwongan reserves such as Alexander Morrison, Badgingarra and Drovers Cave National Parks, have in terms of regional tourism.

It is therefore particularly significant that, despite the locational and seasonal biases associated with the survey, a substantial percentage of respondents placed a high level of importance on the region's natural values. For instance, three of the environmental values (scenic landscapes, native flora and native wildlife) one would typically associate with national parks and nature reserves were ranked in the top seven attributes of the study area (ERMP Appendix A Table 7.21). Similarly a significant percentage of residents indicated factors such as unspoiled environment (83% of residents surveyed) and scenery (75%) were important in contributing to their satisfaction with their living environment (ERMP Appendix A, Table 7.16).

The importance of the natural environment to regional tourism and recreation within the study area is further highlighted by the recreation participation rates obtained from the visitor survey and reported in Table 7.17 of Appendix A of the ERMP. Of the 24 recreational activities listed, three (viewing scenery, bushwalking and nature study) of the top 12 activities typically occur within natural settings (i.e. free of human disturbance) while a further three (picnicking, driving for pleasure and camping) are commonly associated with the natural environment. This response is significant given that the survey was only conducted at the four coastal townsites as previously mentioned.

The ERMP briefly acknowledges the importance of the natural environment to recreation and tourism when it concludes:

> "The results of the survey of recreation users indicates (sic) that recreation and tourism within the study area is (sic) generally characterised by coastal-related recreation in groups, although inland features such as the national parks and wildflowers contribute to the leisure experience" (ERMP Appendix A, p. 3).

and

> "The 'low-key' natural attributes of the study area are the principal qualities that attract visitors. There is an apparent lack of support from existing recreation visitors for development in the area that might significantly change the current recreational setting" (ERMP Appendix A p. 3).

Clearly the natural values of the region in general and the natural landscapes protected within the existing system of kwongan parks and reserves are, by the proponents' consultant's own admission, very important tourism and recreational attractions. Yet, the ERMP fails to address or reconcile how the proposed project will impact on nature-based recreation in general and visitors to the Lesueur area in particular.

The impact assessment focuses almost exclusively on the projected changes to future tourism and recreation along the coast and ignores the inland areas. This is a major omission given that the mine site and power station would be situated partially within the boundaries of an area proposed as a future conservation reserve and within clear view of much of the surrounding countryside including Drover's Cave National Park (refer to Landscape Section). In conclusion, it is stretching the imagination to accept that a mining project of this nature and magnitude, with its associated overburden dumps, coal stockpiles, haul roads, sedimentation and evaporation ponds, pipe and SEC transmission lines would not contribute a <u>significant change</u> to the "recreation setting" of this area, to adopt the proponents' terminology.

Furthermore, the ERMP fails to adequately recognise the economic significance resulting from nature-based recreation and tourism in the study area. Nor does this document address how and to what extent the project will financially impact on the region's tourist economy, despite purporting to do so. This aspect is not subject to any detailed analysis, but rather is dismissed by the statements, that:

> "Although it is difficult to establish any direct relationship between the regional value of tourism and the proposed development it is possible that the inland presence of the coal mine and power station may have some negative affect upon those who enjoy what the region has to offer between the coast and the Brand Highway.
>
> "It is concluded that the implementation of the Hill River Project may change the nature of tourism in the region and the profile of the visitor. Whilst this may be of no economic disadvantage, possibly being an economic stimulus, the proponents are conscious of the significance of tourism to the region and the need to encourage planning strategies that recognise its role" (ERMP Appendix A, p. 9).

In other words, the proponents are in effect asking the Western Australian public and the local communities of Cervantes, Jurien, Greenhead and Leeman to <u>trust</u> that the project will not have a

deleterious effect on nature conservation values within the study area and on the local tourist economy dependent on these values. There is a large element of "blind faith" in this approach to impact assessment which is unacceptable for a project of this magnitude and importance.

While it is acknowledged that there are no comprehensive studies as to the value of recreation and tourism in this region, CALM has prepared an economic analysis for nearby Nambung National Park. As reported by Schmidt (1990b), this Park has experienced a substantial increase in visitation over the last 3-4 years which in turn has generated several million dollars of additional expenditure by tourists. While this economic analysis is by no means complete, it is indicative of the magnitude of the economic benefits associated with nature based tourism in Western Australia's national parks and forest areas.

Existing limited access to the Lesueur area except via four wheel drive puts a physical limitation on the current recreational use of the area. There is likely to be significant "latent" demand, as evidenced by the high recreational value generated by nearby Nambung National Park. This demand would be released through improved access.

Natural areas, such as Lesueur, also hold significant "non-use" values for the community at large. These values are often identified in the literature as "Option Value", "Existence Value" and "Bequest Value". The idea is that natural areas hold values for people who may never physically visit them. For example an individual may wish to maintain the option of visiting an area in the future, they may value simply knowing that the area exists, or they may value knowing that the area remains unspoilt for future generations. Given the restraint caused by poor vehicular access on recreation use values of the Lesueur area, it is possible that these "non-use" values may in fact be more significant. Non-use values are not unquantifiable as is often stated. A technique called "Contingent Valuation" is widely used to measure such values in the USA in cost-benefit analysis (Mitchell and Carson 1989). Failure to identify the "non-use" values of the Lesueur area or make any effort to quantify them is a major deficiency of the ERMP.

6.34 Other project impacts

In addition to the physical and visual impacts on nature-based recreation and the unknown economic effects on tourism within the region, there are two other important impacts this project would have on inland reserves. The first of these is the added visitor pressure on other natural areas that would inevitably accompany such a major increase in regional population resulting from the project.

The socio-economic impact study has logically predicted that if the project proceeds, then the local communities of Cervantes, Jurien, Greenhead and Leeman will experience a substantial increase in population. This in turn would place considerable demands on the local authorities and other government agencies for the delivery and management of additional facilities and services. The social impact study attempts to summarise the nature and extent of these changes in the context of a Planning Balance Sheet.

This assessment is very general and incomplete as it only considers impacts on recreation services and facilities in the four coastal communities rather than on the study area as a whole. Consequently, changes to visitor use patterns and pressures in the Region's national parks are ignored. Visitation to the northern kwongan national parks will unquestionably increase should the project proceed. One could similarly predict that visitation to the Lesueur area would also escalate dramatically, partially due to the publicity the area has received.

There is nothing inherently wrong about increased public use of our State's national park system, providing it is accompanied by appropriate management, in the form of access, sensitively located and well-designed facilities, adequate visitor information and increased staffing. All too often, natural areas and attractions suffer from over promotion and public use and abuse before such controls and facilities can be put in place, thereby resulting in environmental degradation and loss of conservation and amenity values. Such impacts are already occurring in the Lesueur area and are likely to accelerate without proper management input. Owing to the importance of this area in terms of nature conservation, it is essential that the likely impacts of increased public use are clearly identified and addressed irrespective of whether the project proceeds. It is therefore a serious omission of the ERMP that such impacts are not even mentioned, let alone assessed. Again this document ignores the potential impacts this project would have on nature-based tourism and recreation inland from the coast.

The ERMP also fails to identify or address the indirect impacts that the development and operation of an open cut coal mine and power plant would have on visitors to the Lesueur area in the future. Apart from the visual impact (refer to Landscape Section), the most obvious of these would be the emission of noise and dust from the project site and its effect on visitor use and enjoyment. The ERMP goes to some length to predict and model the extent of the study area which would be affected by these factors. As a result, it concludes that the coastal townships would not be adversely affected. However, no such

assessment is made as to how noise and dust emissions would impact on visitors to the proposed conservation reserve at Lesueur.

Quite clearly, the noise and dust emanating from a major open cut mining operation as well as the background noise and night-time lighting associated with the power plant would lead to a significant reduction in the level of visitor enjoyment and satisfaction. The development and operation of this project immediately adjacent to a relatively pristine natural environment is incompatible with activities such as bushwalking, nature study, camping and picnicking, yet the ERMP completely ignores this issue.

In conclusion, the ERMP fails to consider or address how the project proposal will impact on nature-based recreation and tourism in the study area. On the basis of the information provided, many of these impacts will be significant and not easily mitigated.

Chapter 7

REHABILITATION

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Abstract

Information contained in the ERMP is insufficient for assessment of the likely success of rehabilitation after mining and de-commissioning of the power station. The proponents have not detailed their rehabilitation program; instead they propose to produce a management plan prior to commencement of mining. Many of the general statements that are made in the ERMP and inconsistencies between formal commitments and stated rehabilitation objectives suggest a very superficial understanding of the complexities involved in rehabilitation. The proponents suggest that experiences gained in the Lesueur area and at Eneabba provide the basis for successful reconstruction / reclamation programs. However, this work has not yet been shown to be successful; furthermore there are significant differences between the types of disturbance at those sites and that proposed for Lesueur in the ERMP. It is concluded that reconstruction or reclamation is not achievable within a human life-time, but that revegetation with a limited range of native plant species may be.

7.1 INTRODUCTION

Having drawn attention in previous chapters to the extent to which present natural ecosystems might be destroyed, or at least seriously disturbed, by the proposed mine and power station, it is pertinent to consider the likely success of any rehabilitation program.

Allen (1988) has defined the various levels of post-mining land treatment thus:

- Reconstruction (which includes restoration) involves creation of ecosystems that are identical to those that were present prior to the disturbance.
- Reclamation involves establishing ecosystems that are similar, but not necessarily identical in terms of species composition, to the pre-disturbance ecosystems.
- Rehabilitation means that the land is made useful but that it usually has a purpose that differs from the pre-disturbance one and it is invariably composed of different species.

In Australia, the term rehabilitation is loosely used as a synonym of reconstruction and reclamation.

7.2 ASSESSMENT OF THE ERMP

In its guidelines for the preparation of the Environmental Review and Management Programme the Environmental Protection Authority (EPA) stated "It is important that sufficient information is contained in the ERMP to allow an assessment of the likely success of rehabilitation and other management proposals" (ERMP Attachment 1, p. 7). The proponents have not seriously addressed this requirement; instead they have sought to defer debate on this important issue by proposing to produce a rehabilitation management plan at some future date prior to the commencement of mining.

A little over six pages in the ERMP has been devoted to discussion of general issues associated with rehabilitation of the mined areas, overburden dumps, ash disposal areas, the evaporation pond, sedimentation ponds, the power station site, roads and other areas to be disturbed. It is a matter of concern to CALM that the statements in the ERMP indicate a very superficial understanding of the issues involved. The proponents have had the opportunity to research the topic and to conduct rehabilitation trials over the past few years; indeed it can be argued that a more pro-active approach to rehabilitation would have been prudent given the long acknowledged nature conservation values of the area proposed to be mined.

7.3 REHABILITATION OBJECTIVES AND COMMITMENTS

Commitments made by the proponents of the Hill River Project to rehabilitation are not consistent with the stated rehabilitation objectives as outlined in the ERMP. In the case of this project, the early statements in the ERMP suggest that reconstruction or at least reclamation will be undertaken, whereas the commitments are only to rehabilitation *sensu* Allen (1988). In simple terms, this is really the only option, since the proposed mining activities will lead to such a massive change in landform and substrate conditions that reconstruction and reclamation will not be achievable within a human time span (see also Hobbs and Hopkins 1990).

The stated preferred end land-use of the mine/power station area involves a return to native vegetation with a view to maximising conservation values (ERMP Section 5.2.5). Another long-term objective is to rehabilitate the full range of vegetation units disturbed during mining (and presumably by associated developments) (ERMP Section 6.8.2). However, these objectives are the subject of ongoing review and the details of how they might be achieved are not provided in the ERMP. The document merely commits the proponents to, amongst other things:

- preparation of a detailed rehabilitation management plan prior to mining (ERMP Section 6.8.2),
- conducting rehabilitation trials (ERMP Section 6.8.2), and
- progressive rehabilitation to local native species: (ERMP Section 10.16).

The proponents have not clearly identified an end land-use or rehabilitation objectives for the mined-out pits which will be left at the conclusion of the project. These pits will be very extensive, have steep batters at or approaching the angle of repose and will contain saline and most likely acidic waters (ERMP Section 5.13.1). The concept of leaving such large areas open is not consistent with the stated end land use for the project area as outlined in the ERMP.

7.4 POTENTIAL TO ACHIEVE REHABILITATION OBJECTIVES

The proponents suggest that the experiences already gained in the Lesueur area and at Eneabba provide the basis for successful reconstruction / reclamation programs. Work in the Hill River Project area to date is very limited and mainly involves revegetating drill pads. These are areas that have been scraped and compacted by vehicles. As a disturbance, this fits within the description of "utilization" as defined by Hobbs and Hopkins (1990): there is no major change in the chemical or nutritional states of the substrate, nor is there a major loss of the biotic component of the ecosystem. In contrast, mining involves complete removal of vegetation and soil and complete disruption of ecosystem processes and is categorised as "removal". Thus, the value of the experiences gained in the Lesueur area is very limited.

Mining for heavy mineral sands at Eneabba is more analogous to the proposed coal mining, although there are still major differences. It is, however, worthwhile to look at the Eneabba experience for insight into what might be undertaken within the project area at Lesueur.

Mining at Eneabba occurs on alluvial and colluvial deposits immediately to the west of the Gingin escarpment. The sands and clays are excavated in an open cut mining operation, the heavy minerals are removed in a wet, gravity separation process and the tailings are returned to the pits as a wet slurry that is left to dry and is then revegetated. Prior to mining, the native vegetation is harvested as brush. Topsoil is removed in a two-cut operation, sometimes stockpiled for short periods, and then relaid on dried tailings as the first part of the rehabilitation procedure. Areas are seeded with native plant species and sparse cereal crops for short-term stabilization and then covered with harvested brush. Small amounts of fertilizer (around 100 Kg/ha) are added and seedlings of selected species are planted out.

Results of the rehabilitation are assessed by the Mineral Sands Rehabilitation Co-ordinating Committee (MSRCC). The Committee has established a set of quantitative criteria to provide a framework for this assessment. Criteria relate to:

- **Species richness:**

  Numbers of species of native plants per unit area. Data on species are recorded in individual quadrats and in large rehabilitated blocks.

- **Plant density:**

  Numbers of individual plants (native species only) recorded in quadrats.

- **Canopy cover:**

  Cover of native plants, not including short-lived species.

Taken together it is believed that the criteria will provide useful insight into the long-term viability of the reconstructed plant communities. The data used to set the values for the criteria were derived from studies of the pristine native vegetation in the area. Values set for rehabilitation are between 40 and 50% of those recorded for pristine vegetation.

Full scale mining commenced in 1976. So far the company mining at Eneabba has not approached the

MSRCC with a view to having areas assessed as completely rehabilitated. It is believed that some of the recently treated areas approach the rehabilitation criteria values, but most of the areas treated before about 1986 will require ongoing treatment. Many species, particularly those in the Cyperaceae, Restionaceae, Orchidaceae, Epacridaceae and Rutaceae have failed to regenerate at all in mining-affected areas at Eneabba (K. Dixon[1] personal communication).

From the rehabilitation perspective, mining for coal in the Lesueur area will pose much greater problems than the sand mining at Eneabba. Two aspects are important:

1. Within the Lesueur area, the post-mining substrates (overburden dumps) will be quite different from the present environments. The area proposed to be mined includes a wide range of sedimentary rock types; these have been faulted, weathered and eroded to produce a complex mosaic of substrates which support the rich flora and vegetation for which the area is renowned (Griffin and Hopkins 1990; Griffin *et al.* 1990). The mining process will lead to a significant re-ordering of the geological sequence with fresh rock being brought to the surface. Overburden dumps will also be much less compacted than present substrates. Reconstruction after mining of the complex soil profiles and soil mosaics will be extremely difficult if not impossible.

   In contrast, it is possible to recreate a soil profile that is physically and chemically (but not biologically) similar to the pre-mined profile in the process of disposal of tailings after mineral sands mining at Eneabba. Hydraulic back-filling allows for blending of sand and clay fractions in a predetermined fashion and ensures that the sediments compact to a degree approaching that achieved under natural deposition.

2. The overburden is likely to be toxic to plant growth. Oxidation of minerals, particularly pyrite, in sediments following exposure through excavation generally causes major pH changes in the resultant soils. For example pH values of 2.5 to 3 are not uncommon in overburden dumps at Collie (Koch 1984). Release of heavy metals can also inhibit plant growth on tailings. Finally, activation of salts (NaCl and soluble Aluminium salts) in sediments of marine origin may cause problems for rehabilitation.

   Some of these problems may be addressed by special amendment programs such as liming and deep burial to ensure that the toxic materials are maintained under anaerobic conditions. Whether these techniques will be sufficient to permit successful establishment of local native plant species in the project area can only be conjectured at this stage.

   In contrast, tailings at Eneabba are relatively benign.

It is instructive to review progress in rehabilitation of coal mine overburden elsewhere in Australia. Hannon (1984) provides a general summary but notes that, at least up to 1983, there was limited experience in returning native vegetation. Some work has been done in recent years at Collie but detailed results are not available. Studies by Koch, Fox and others (e.g. Koch 1984; Koch and Bell 1985; Fox *et al.* 1985, 1987) have addressed some local problems particularly growth of native plant species in chemically hostile substrates. As a generalization, few native species establish naturally while a limited number will establish if planted in soils which have been treated to raise their pH and nutrient status.

Koch (1984) has also summarised the range of problems that arise in rehabilitation programs as a consequence of changes to physical and chemical properties of coal mine substrates. However, it is not possible at this stage to predict how these relate to the Lesueur situation: data provided in the ERMP are inadequate for assessment and the rehabilitation program has yet to be designed in detail.

A major problem for rehabilitation after mining that is only now coming to light at Eneabba is that associated with infection by species of *Phytophthora*. Hill (1990) discusses the potential of these fungi to seriously degrade native plant communities in the Lesueur area. Likewise, if *Phytophthora* becomes established in areas to be rehabilitated, it will seriously impede efforts to re-establish native plant species and vegetation communities.

Other issues which have not been adequately addressed or which are not consistent with the proponents rehabilitation objectives relate to the re-introduction of rare species and the rehabilitation of the mined out pits on decommissioning of the project. The proponents intend to re-introduce rare plants onto rehabilitated dumps (ERMP 5.12.3). However, the long-term success of such an operation in a synthetic community is extremely doubtful because so many other ecosystem components will be missing. Rare species by their very nature generally occupy specific and unusual niches in the environment. The potential for long-term survival of such species in an unrestored ecosystem is doubtful.

1 Dr K.W. Dixon, Kings Park and Botanic Garden, West Perth.

Similarly, the proponents claims that rehabilitated areas are likely to survive better than undisturbed bushland is unsubstantiated (ERMP 6.8.1).

The proponents themselves have identified that ecosystem restoration will be difficult by stating that rehabilitation will be "near natural" (ERMP Section 5.13). "Near natural" state is a dubious description for an ecological measure for rehabilitation. Further, the use of "near natural" as a measure of rehabilitation success is questionable given that the project impinges on a proposed conservation reserve, especially one that has been clearly documented to have high conservation, landscape and recreational values (Burbidge *et al.* 1990)

7.5 CONCLUSIONS

The proponents have not produced a compelling case to justify access to the conservation reserve proposed for the Lesueur area on the basis of their ability to return the area's nature conservation values after mining. Available information suggests that it will not be possible to reconstruct or reclaim the ecosystems presently represented in the area. Revegetation of overburden with a very limited range of native plant species (i.e. rehabilitation *sensu* Allen 1988) is achievable, although even this will be difficult because of changes to the substrates' physical and chemical properties.

Chapter 8

CONCLUSIONS

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Abstract

We and our colleagues have previously reported on the nature conservation, landscape and recreation values of the proposed conservation reserve at Lesueur. This report should be read in conjunction with that earlier one. The ERMP for the Hill River Project does not adequately comply with the EPA's guidelines in significant respects. We conclude that vegetation, flora and fauna of the proposed Lesueur conservation reserve is of world significance and its values are not repeated elsewhere. It is clear that the proposed mines and power station would impact significantly on the nature conservation, landscape and recreation values of the proposed reserve. Further, the ERMP has not demonstrated that the proponents rehabilitation aims can be met and there are serious doubts that anything but a simple vegetation can be established on the overburden dumps. The landforms of the area will be greatly modified and will not be returned to their original contours. The risk of introduction of plant diseases during the 30 year time frame of the project is high. Over 90% of the vegetation in the eastern end of the proposed conservation reserve at Lesueur is rated as high or medium hazard to Phytophthora and, if introduced, Phytophthora would have a high impact on the vegetation, causing local extinctions of many plant species, as well as reducing success of rehabilitation. We conclude that, from a nature conservation, landscape and recreation point of view, the project is environmentally unacceptable.

8.1 INTRODUCTION

We and our colleagues have previously reported on the nature conservation, landscape and recreation values of the proposed conservation reserve at Lesueur (Burbidge *et al.* 1990). This report should be read in conjunction with EPA Bulletin 424.

Chapters 2 to 4 in this publication assess the information provided and the commitments made in the Environmental Review and Management Program (ERMP) for the Hill River Project, both in the light of the guidelines provided to the proponents by the Environmental Protection Authority (EPA) and in the light of our knowledge of the nature conservation values of the proposed conservation reserve at Lesueur. Chapter 5 provides relevant information on the biology and management of dieback and other fungal diseases and comments on the information presented and commitments made in the ERMP in this regard while Chapter 6 assesses landscape and recreation information and impacts. Finally, Chapter 7 comments on the ERMP in relation to its rehabilitation objectives and in the light of current knowledge of rehabilitation of nearby mine sites.

8.2 THE ERMP IN RELATION TO THE EPA'S GUIDELINES

The ERMP does not adequately comply with the EPA's guidelines in significant respects. In addition, some conclusions are not supported by available data. These points are discussed in detail in the preceding chapters; some examples are:

- In relation to the proposed conservation reserve, the ERMP has only assessed impact on vegetation, flora and fauna for the area that will actually be cleared of native vegetation. This is less than the actual impact, since there will be many effects outside this area over the proposed 30 year life of the project. Edge effects, for example, degrade vegetation and faunal habitat adjacent to cleared areas. Some impacts, such as those resulting from stack emissions, will extend even further and groundwater drawdown may also have more extensive effects;
- Vegetation is discussed in very general terms in the ERMP, which lists "seven basic vegetation types" (ERMP p. 4-17). This is inadequate to assess properly the impact of this proposal on the species-rich, complex mosaic of vegetation types occurring in the Lesueur area;

- No breakdown was given of the proportion of each of the 38 vegetation types in the project area that would be directly affected by the proposal;
- From our analysis of digitised data it is clear that at least nine vegetation types, which are not known from outside the project area and its immediate environs, will be severely affected by the proposed project. In addition the impact of the project on the area's limited wandoo woodlands is of serious concern;
- The proponent's analysis of the regional significance of vegetation of the project area was very superficial. The proponents state in the ERMP that "it was not practical ... to carry out detailed quantitative studies of any vegetation on the regional reserves because of the large areas involved" (ERMP p. 4-15). The area surveyed, of some 50 000 ha, was very much smaller than that studied by Griffin *et al.* (1983) in their regional survey of the vegetation of the lateritic uplands, which included the Lesueur area. It is much smaller than any of the normal quadrat-based regional surveys undertaken by CALM (e.g. the Nullarbor and the kwongan of the wheatbelt);
- The proponents' statement that the vegetation types defined in the Lesueur area are widespread in the region is clearly not correct. The statement is based on their attempt to simplify the complex vegetation of the Lesueur area by amalgamating many of the basic vegetation types that are present there into only seven "basic" types;
- The proponents have failed to provide a detailed assessment of the conservation status of the area's vegetation as requested by the EPA. Further they have not been able to demonstrate that there are alternative areas which could be reserved to protect the plant communities found in the Lesueur area;
- The limited amount of data available suggests that SO_2 exposure over the life of the mine will result in changes in species composition and abundance. The degree to which this will occur is not possible to determine from the available data. Given the high biological significance of the area the possibility of retrogressive succession occurring in the area is of considerable concern;
- The section in the ERMP dealing with ash emissions is both contradictory and incomplete. Of primary concern is the possible toxicity of the ash. The proponents state that, based on their analysis, the ash is non-toxic and contains many elements beneficial to plant growth. Examination of the data provided in ERMP's Appendix E indicates that four trace elements (beryllium, boron, selenium and antimony) in the coal have not been analysed in their leachate studies. Of these omissions the absence of data on boron is of particular concern;
- The disposal of water collected in the mining pits is inadequately dealt with in the ERMP. The proponents expect to deal with up to 1.5 million litres of waste water per pit per day and the suggested disposal method is to pump to lined surface holding ponds where it will either be treated to adjust pH and then discharged to sedimentation ponds or left to evaporate. The sedimentation ponds will be un-lined and will be discharged into the natural drainage lines. Acid mine drainage is recognized as a major water pollution problem elsewhere and it could be a problem at Lesueur with the high levels of sulphur in the coal and the presence of iron pyrites;
- There will be two major sources of groundwater drawdown if this project proceeds, that surrounding the mine pits and that resulting from the bore field operations. The ERMP gives no indication of the possible area affected by water drawdown around the mine pits but does comment "Drawdowns as a result of dewatering and depressurisation are expected to be limited to a distance of 2-3 km down dip of each pit, and should not adversely impact on the xerophyte vegetation (heath or agriculture) ..." (ERMP p. 5-8). The assumption that the native vegetation will not be impacted by radical changes in the water table by virtue of the xeromorphic anatomy of many species is not born out by published research data. The degree of connection between the deeper aquifer to be utilised by the bore field and the surface aquifers is not clear, so an assessment of the effects of bore field drawdown on local vegetation can not be made;
- Although the conservation status of Declared Rare Flora is briefly reviewed there is no reference to their security on existing or proposed reserves and there are insufficient data relating to the numbers of populations and individuals that are known to exist. The ERMP lists 48 "vulnerable taxa" (ERMP Table 4.7) which occur in the Lesueur area. These taxa, however, were not surveyed and consequently their distribution and conservation status, and impact of the project on them, has not been determined. There are a further 56 regional endemic taxa occurring in the project area that require some assessment of their conservation status;
- There is some discordance between the proponents' and CALM's assessment of the impact of the project on numbers of individuals of Declared Rare Flora, particularly for *Asterolasia drummondii* and *Hakea megalosperma*;
- The proponents make a number of statements in the ERMP in relation to the conservation status of Declared Rare Flora which require clarification or are inaccurate;
- Populations of plant taxa at the limit of their range and relictual species have not been treated in the

ERMP although they represent a genetic resource unique to the Lesueur area;

- Cryptogamic plants have not been considered in the ERMP.
- The terrestrial fauna surveys were limited with respect to species, area and season. No similar surveys were made of the remainder of the proposed conservation reserve at Lesueur, nor of nearby existing or proposed conservation reserves. No attempt was made to compare the species present in the study area with those known to be present in the remainder of the proposed conservation reserve, nor did the proponents assess the conservation status of the Lesueur fauna in nearby conservation reserves;
- The proponents commissioned no surveys of terrestrial invertebrates. They gave reasons for not studying invertebrates but we do not agree with them;
- Throughout the consultant's report on fauna surveys, and in most of the ERMP, the word fauna is used synonymously with vertebrates. For instance, the section under ERMP sub-heading "4.2.2.2 Faunal Communities" does not mention invertebrates. The proponents focus their arguments concerning fauna on local endemism, yet, at the scale of the study area, only the invertebrates are likely to show the patterns of local endemism seen in the flora. In the ERMP's section on invertebrates (which is most superficial), the examples chosen are large, mobile species (cockroaches, jewel beetles) rather than the less mobile spiders, snails, worms and litter arthropods. Both scientifically and in the Wildlife Conservation Act, the definition of fauna includes invertebrates;
- The survey of the aquatic fauna of the Gairdner Range Creeks was conducted at an inappropriate time (October) when most creeks were drying; all creeks in the Cockleshell Gully Catchment were dry and therefore were not sampled. An August survey is required, as was recommended by the proponents' consultants. Similarly, the survey of the aquatic fauna of the Hill River was conducted in May; another survey should have been carried out in August/September when the River was flowing strongly;
- The ERMP fails to recognise the importance of the whole Lesueur - Coomallo region for the survival of Carnaby's Black-Cockatoo or recognise that the Cockatoo is important because it is implicated in the survival of *Banksia tricuspis,* a Declared Rare Flora species. It does not mention the possible effects of SO_2 on wandoo, which provide tree hollows for nesting, not the cockatoos' need for fresh water sources (which must have shady trees around them), nor the possible effects of mining and water extraction in this context, although the Hill River and the Hill River Spring are highlighted as areas most likely to suffer from the water table drawdown;
- The ERMP fails to identify and/or evaluate the full range of potential impacts that the project is likely to have on landscape values, and on nature-based recreation and tourism. In particular, the ERMP does not adequately address how and to what extent the project would impact upon visitors to the region's inland parks and reserves, including the proposed conservation reserve at Lesueur. The assessment techniques employed by the project consultants to evaluate these key issues have not generated sufficient information on which to reach soundly-based conclusions;
- The viewscape study does not constitute a thorough assessment of visual impact. While the study methodology provides a quite detailed statement on what project elements will be visible from major travel routes and other selected vantage points, it gives no firm indication as to the nature and relative significance of the landscape values (i.e. visual quality values) which would be affected by the project. Consequently the study fails to establish or measure "pre-project" landscape values in other than superficial terms and does not fully comply with the EPA guidelines;
- The ERMP fails to adequately address issues relating to dieback diseases caused by introduced and native fungi. It considers the potential impact of *Phytophthora* in very general terms only. This is despite statements in the ERMP about the susceptibility and sensitivity of the flora within the Lesueur area and despite recognition of the potential for the spread of this disease. This lack of a suitable treatment for the plant disease issue conflicts with it being identified by the EPA as a key issue which should be addressed. The short section on disease management fails to provide specific details on how effective monitoring and control can be accomplished, particularly in relation to the size and duration of the proposed project;
- The ERMP places considerable reliance on CALM to provide the necessary information on monitoring and disease control. The proponents fail to realise that the procedures developed by CALM are specifically for native communities exposed to minimal disturbance and cannot be simply adapted to the massive scale of disturbance proposed for the Lesueur area. New disease management procedures will need to be developed specifically for the operations proposed if they proceed;
- The stated preferred end land-use of the mines and power station area involves a return to native vegetation with a view to maximising conservation

values (ERMP Section 5.2.5). Another long-term objective is to rehabilitate the full range of vegetation units disturbed during mining (and presumably by associated developments) (ERMP Section 6.8.2). In its guidelines for the preparation of the ERMP the EPA stated "It is important that sufficient information is contained in the ERMP to allow an assessment of the likely success of rehabilitation and other management proposals" (ERMP Attachment 1, p. 7). The proponents have not seriously addressed this requirement; instead they have sought to defer debate on this important issue by proposing to produce a rehabilitation management plan at some future date prior to the commencement of mining.

- Commitments made by the proponents concerning rehabilitation are not consistent with the stated rehabilitation objectives as outlined in the ERMP;
- The proponents suggest that the experiences already gained in the Lesueur area and at Eneabba provide the basis for successful reconstruction/reclamation programs. At Lesueur, work in the project area to date is very limited and mainly involves revegetating drill pads. These are areas that have been scraped and compacted by vehicles, not areas subjected to massive disturbance. At Eneabba, an adequate level of rehabilitation has not yet been achieved after 14 years of mining, even though values set for rehabilitation are only between 40 and 50% of those recorded for pristine vegetation. Many species, particularly those in the Restionaceae, Cyperaceae, Orchidaceae and Epacridaceae, have failed to regenerate at all in mining-affected areas at Eneabba.

8.3 OUR CONCLUSIONS

Our conclusions in relation to the major effects of the project, if it is approved, on the nature conservation, landscape, recreation and education values of the proposed conservation reserve at Lesueur are:

1. The proposed conservation reserve at Lesueur is of world, national, State and regional significance (Hopper and Burbidge 1990) and its values are not repeated elsewhere. The proposed mines and power station will greatly affect the nature conservation values of parts of this proposed reserve, including parts that are not repeated in the remainder or elsewhere;
2. The vegetation and flora of the proposed conservation reserve at Lesueur is considered to be of the highest conservation significance. The conservation significance of this area stems from both the high species richness of the area (averaging 76 spp/100m^2) and a very fine scale mosaic of vegetation types. The proposed mines and power station would significantly damage the vegetation of the proposed reserve. The proponents were not able to find the same vegetation elsewhere in the region for the great majority of the vegetation units identified in the project area;
3. The proposed conservation reserve at Lesueur has a known flora of 821 taxa of vascular plants, representing approximately 10% of the State's known vascular flora and a third of the taxa found in the Irwin Botanical District. Moreover, the area contains 111 of the 259 northern kwongan regional endemics, including seven species of Declared Rare Flora (DRF) and 48 poorly known taxa considered to be threatened or vulnerable. Also occurring within the area are 81 taxa at their northern or southern distributional limits. The numbers of DRF, endemics and taxa at the edge of their geographical ranges are the highest of any area in the Irwin Botanical District. The proposed Lesueur conservation reserve ranks as one of the three most important areas for flora conservation in southern Western Australia (Griffin *et al.* 1990);
4. There are 22 populations of six species of Declared Rare Flora in the area to be cleared or in the 100 m buffer zone; destruction or degradation of these would have unknown long term consequences on the conservation of these species;
5. The proposed conservation reserve at Lesueur has a very rich vertebrate fauna. For example, 132 species of birds are known from Lesueur, more than are known from any conservation reserve in the south west of Western Australia except the much larger Kalbarri, Fitzgerald River and Cape Arid National Parks (all of which include coastal habitats) and Yanchep National Park (which includes wetlands). The number of reptile species known from Lesueur is 49, more than are known from any conservation reserve in the south west, except the much larger Kalbarri National Park. The scant data that are available on invertebrates suggest that Lesueur has a very rich invertebrate fauna as well, possibly including endemic species;
6. No plant or animal species are known to occur only in the area to be cleared for the mines and power station; however, the ERMP does not provide adequate data on invertebrates or non-vascular plants;
7. The risk of introduction of plant diseases during the 30 year time frame of the project is high. Over 90% of the vegetation in the eastern end of the proposed conservation reserve at Lesueur is rated as high or medium hazard to *Phytophthora*. Therefore, if introduced, *Phytophthora* species would have a high impact on the vegetation,

causing local extinctions of many plant species and massive changes in vegetation composition;

8. The possibility of retrogressive vegetation successions occurring over a large area as a result of the stack emissions is of serious concern. No adequate data are available to assess the degree to which this could take place;

9. It is clear that the proposed mining operations and power station would impact significantly upon the visual quality of the proposed conservation reserve at Lesueur and the Lesueur area as a whole. The natural character and scenic beauty of what are some of the most attractive landscapes within the northern kwongan would be severely degraded should this project proceed. As a result, those recreational activities and human experiences that are dependent on the quality and integrity of the visual environment would suffer significantly. Landscape rehabilitation efforts, however well planned and executed, will not be able to restore the integrity and scenic beauty of this area once disturbed. Such impacts can not be dismissed lightly;

10. The ERMP has not demonstrated that its own rehabilitation aims can be met and there are serious doubts that anything but a simple vegetation can be established on the overburden dumps. The landforms of the area will be greatly modified and will not be returned to their original contours;

11. From the rehabilitation perspective, mining for coal in the Lesueur area will pose much greater problems than the sand mining at Eneabba. The post-mining substrates (overburden dumps) will be quite different from the present environments and the overburden is likely to be toxic to plant growth. A major problem for rehabilitation after mining that is only now coming to light at Eneabba is that associated with infection by species of *Phytophthora*. If *Phytophthora* was introduced to Lesueur as well it would lead to major difficulties with rehabilitation;

12. The proponents have not proposed an end land use and have not outlined the rehabilitation objectives for the mined-out pits, which will have steep batters and which will contain saline, and most likely acidic, waters. The uses proposed do not complement the stated end land use for the project area as outlined in the ERMP.

As detailed above, and in earlier Chapters, the ERMP for the Hill River Project has significant shortcomings. Some of these could be overcome if further studies were made or if parts of the ERMP were re-written. However, we believe that, even if major shortcomings were overcome, the proposed project would still have significant detrimental effects on the nature conservation, landscape and recreation values of the proposed conservation reserve at Lesueur.

Given the nature of its charter, CALM is likely to conclude that many mining developments within existing or proposed conservation reserves would be environmentally unacceptable. There are also occasions when environmental and aesthetic values may not be unduly disturbed by mining. In such cases CALM may not oppose the project. However, in the case of the Hill River Project, CALM concludes there will be major impacts on an area of the very highest conservation values. If the project goes ahead, it would be to the significant detriment of nature conservation and of the proposed conservation reserve.

We conclude that, from a nature conservation, landscape and recreation point of view, the project is environmentally unacceptable.

Chapter 9

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Chapter 11

Appendices

Appendix 1

Executive Summary of Calm's 1989 Report to the EPA

EXECUTIVE SUMMARY

1. BACKGROUND

The Lesueur Area of 27 493 ha is near Jurien Bay, some 220 km to the north of Perth. It has long been recognised as an area of outstanding flora conservation values, complex geological features and unusually rugged terrain in the subdued landforms of the northern kwongan region.

Its exceptionally diverse flora of 821 species represents 10 per cent of the State's known flora. Seven species are declared rare and endangered, and several more may warrant similar status. Lesueur is comparable with the Stirling Range and Fitzgerald River National Parks as one of the three most significant areas for flora conservation in southwestern Australia, but it is currently only a collection of unvested reserves and vacant Crown land. It is especially important because it is largely free of dieback disease.

The fauna is diverse, with at least 15 mammal, 124 bird, 48 reptile and 9 frog species. The area is critically important to the survival of hole-nesting birds such as Carnaby's Black Cockatoo, and is rich in birds of the kwongan.

It has been recommended for reservation by botanists, the Australian Academy of Science, the Conservation Through Reserves Committee and the Environmental Protection Authority. These recommendations were endorsed by State Cabinet in 1976 and again in 1983, but the presence of coal deposits at the eastern end of the proposed conservation reserve has prevented reservation to the present day.

The National Parks and Nature Conservation Authority has recommended that the Lesueur Area be declared a national park.

In 1989, the Environmental Protection Authority (EPA) sought from the Department of Conservation and Land Management (CALM) a detailed evaluation of the nature conservation, landscape and recreation values of the Lesueur Area. This publication is CALM's submission to the EPA.

It should be emphasised that this report only covers technical areas within CALM's responsibility (i.e. nature conservation, landscapes and recreational use in a proposed conservation reserve context). Other Government agencies will address aspects such as mineral resources, energy supply, economic and social issues, hydrology, air pollution, etc., in their own submissions to the EPA.

2. EUROPEAN EXPLORATION

Mount Lesueur was first observed and named from the sea by French explorers on the corvette *Naturaliste* in June 1801. Charles-Alexandre Lesueur was a topographical and natural history artist on the expedition. Europeans first traversed the Lesueur Area in 1839, and a party led by A.C. Gregory ascended Mt Lesueur in 1849. From 1850 onwards, Lesueur was avoided by travellers and pastoralists because of its rugged terrain and the abundance of poisonous plants (*Gastrolobium* spp.). 1850 was also the year that the Lesueur Area was first explored by a botanist, James Drummond, who delighted in finding a rich flora with many plants new to science. Neglected by all but a few bushmen and botanists for 100 years, the Lesueur Area was prominently featured in a Ph.D. study by N.H. Speck written in 1958. Since the early 1970s, the area has been visited by an increasing number of botanists, naturalists and bushwalkers, as well as employees of mining and petroleum exploration companies.

3. DESCRIPTION OF THE LESUEUR AREA

3.1 Geology

Permian to Mesozoic sedimentary rocks are overlain by thin layers of Triassic and Jurassic sandstones in the Lesueur uplands and by Quaternary and Recent

sediments on the coastal plain. The ancient sediments have been distorted by a series of roughly north-south trending fault lines, exposing examples of Triassic and Jurassic rocks. Thus the rugged uplands have a variety of interbedded rock types, including sandstones, siltstones, shales and coal. Laterite formed as a fossil soil horizon over undulating land surfaces during the Tertiary and Quaternary. These land surfaces have been eroded leaving lateritic upland residuals, some in the form of flat-topped mesas (e.g. Mt Lesueur, Mt Michaud). The Coastal Belt has a series of dunes of varying ages, some underlain by limestone, and with a chain of salt lakes and freshwater springs parallel to the coast.

3.2 Landforms

A sequence of landforms in the Lesueur Area may be recognised from the coast inland: Quindalup Dunes bounded by a Salt Lake Complex, Spearwood Dunes, Bassendean Dunes bounded by the Gingin Scarp, Peron Slopes, Lesueur Dissected Uplands, Gairdner Dissected Uplands, Banovich Uplands, and Bitter Pool Rises.

3.3 Soils

Soils on the uplands are an extremely complex mixture of siliceous sands, lateritic gravels, yellow duplexes, yellow massive earths and brown mottled cracking clays. The Coastal Belt has yellow and brown siliceous sand, sometimes over aeolinite, with shallow calcareous and gypsiferous soils on the salt lakes.

3.4 Climate

Lesueur has a typically Mediterranean climate of hot, dry summers and cool wet winters, with a moderately reliable rainfall (550 mm at Jurien, 620 mm at Mt Lesueur).

3.5 Drainage

Three major youthful drainage systems have their headwaters in the Lesueur Area - the Hill River (with Munbinea Creek as the major tributary), Cockleshell Gully and Stockyard Gully. In addition, one arm of Coomallo Creek (also a tributary of the Hill River) has mature tributaries arising in the eastern end of the Lesueur. The Lesueur Area protects the upper sections of these catchments in a natural state, allowing them to be used for "bench mark" studies applicable to catchment management issues. Flow in the drainage lines is seasonally intermittent, but permanent water occurs in some pools.

4. VEGETATION

The vegetation of the Lesueur Area is shown to be structurally diverse, consisting mainly of shrublands and woodlands interspersed in a complex mosaic. Even greater complexity is evident when communities are identified on a floristic basis. Major vegetation units are numerous, they form an intricate mosaic, and they show a close relationship to landforms. Moreover, within the one vegetation type studied in greatest detail (heath on lateritic uplands), there are 11 distinct floristic sub-types within the Lesueur Area which are geographically identifiable and can be related to specific geological substrates and soil erosional processes.

The great diversity of communities reflects the complexity of underlying strata and unusually large array of habitats found in the Lesueur Area, particularly in the eastern parts. Detailed mapping by Martinick and Associates (1988) identified a very fine-scale mosaic in the eastern landforms. Some communities in the eastern uplands are not found elsewhere.

5. FLORA

James Drummond in 1850 noted the exceptional richness of the flora, particularly of proteaceous genera and of locally endemic species. Subsequent work this century commencing with C.A. Gardner and N.H. Speck reaffirmed Drummond's observations. A.J.M. Hopkins and E.A. Griffin started a comprehensive study of the flora and vegetation in the late 1970s, providing much of the data on which the present review is based.

The present study supports earlier views on plant diversity in the Lesueur Area. It has 821 taxa of vascular plants, representing approximately 10% of the State's known flora, and a third of the taxa found in the Irwin Botanical District. Moreover, the Lesueur Area has seven species of Declared Rare Flora, nine endemic taxa, 111 regionally endemic taxa, and 81 taxa at their northern or southern limits in the Lesueur Area. The numbers of Declared Rare Flora, endemics and taxa at the end of their geographical ranges are the highest of any area in the Irwin Botanical District. The Lesueur Area has been and will continue to be an important refugium for species from wetter climates.

A rapid replacement of species is notable. Even within the same vegetation type, moving as little as 0.5 km may reduce the number of species in common to less than 40%. When species richness is measured at the scales of landscape unit or within stands, diversity in the Lesueur Area is comparable with that in the Fitzgerald River and Stirling Range National Parks. Lesueur ranks as one of the three most important areas for flora conservation in southern Western Australia.

6. FAUNA

Although not studied in detail, the fauna of the Lesueur Area is known to be rich in species of

vertebrates, with 15 indigenous mammal species, 124 bird species, 48 reptile species and 9 frog species. In comparison with other existing conservation reserves in south western Australia, it is richer in species than all except a few, much larger areas.

Among birds, Lesueur is rich in species of the kwongan and species that depend on nest hollows in the wandoo woodlands, e.g. Carnaby's Black Cockatoo and the Regent Parrot. The reptile fauna is particularly rich in geckoes and legless lizards.

Terrestrial and aquatic invertebrates have not been studied in detail. However, the little that is known suggests that it is rich in species, e.g. 104 species of macro-invertebrates were sampled in a brief survey of aquatic sites. Lesueur includes some invertebrate species not known from elsewhere.

7. INTER-RELATIONSHIPS OF PLANTS AND ANIMALS

The Lesueur Area provides an opportunity for essential ecological inter-relationships between plants and animals to continue. Two recent studies highlight relationships between rare plants in the Lesueur Area and the wide-ranging birds on which they are dependent.

Banksia tricuspis is a Declared Rare species endemic to the Lesueur Area. It shows a strong preference for microclimatically favourable sites, and may be a relict species from wetter times. Pollinators, including birds, mammals and insects, are essential for seed set in this outbreeding species. Moth larvae and cockatoos reduce the reproductive success of *Banksia tricuspis* through predation. However, because cockatoos destroy more moth larvae than flower heads, the latter which they damage 'in error', the cockatoos have a positive effect. The ability of *B. tricuspis* to cope with fire is influenced by fire frequency, which influences plant survivorship, and seasonality, which in turn influences seedling recruitment. Management of *B. tricuspis* should ensure that all organisms involved in its inter-relationships are catered for. In the cockatoos' case this is extremely important and will require protection of wandoo woodlands, kwongan and freshwater sources throughout the Lesueur - Coomallo region.

Black Kangaroo Paws (*Macropidia fuliginosa*) are dependent on honeyeaters for pollination and sustain some nectar loss from the introduced honey bee.

The ecological links that exist between these plants and animals in the Lesueur Area highlight the need to not only manage and conserve rare and restricted species but also to conserve the organisms that interact with them. To achieve this, a larger area of native vegetation than that occupied by a rare plant is often required.

8. DIEBACK DISEASES

Phytophthora cinnamomi and other *Phytophthora* species are having a major detrimental effect on the vegetation and associated fauna of many national parks and other conservation reserves in southern Australia. In the northern kwongan, studies on the extent of these plant diseases commenced only recently, but it is known that five types of *Phytophthora* occur there, with *P. cinnamomi* having been found recently near Eneabba. One infection of *Phytophthora citricola* has been found within the Lesueur Area, beside Cockleshell Gully Road.

Dieback disease caused by *Phytophthora* species would have a major impact if introduced because of the suitable climate, the abundance of susceptible plant species and vegetation types and the type of soils present. The probability of introduction of *Phytophthora* is high when extensive use of earth-moving equipment and vehicles takes place in a highly susceptible area, even if high standards of hygiene are maintained. If introduced, the impact of *Phytophthora* could be extensive, because of the high proportion of susceptible vegetation types and plant species.

9. LANDSCAPE VALUES

The Lesueur Area encompasses some of the most attractive countryside to be found in the northern kwongan. The Gairdner Range, with its distinctive mesa landforms, is an area of high scenic appeal. Within the Range, one is confronted by ever-changing vistas of steep breakaways, low hills and gullies with eucalypt woodlands set amongst heath-covered slopes. The heathlands themselves, when viewed more closely, reveal a rich tapestry of plant forms, colours and textures.

10. RECREATION AND EDUCATION VALUES

Recreational and educational values, while not well documented, are nevertheless of major regional importance. Although the Lesueur Area has not been widely promoted and is relatively distant from major population centres, it presently attracts a wide range of recreational use, including nature study, sightseeing, photography, bushwalking, camping and four-wheel driving. Indications are that visitation levels have increased in recent times. This trend is likely to continue, particularly as the area becomes better known. Given adequate protection through reservation and management, the Lesueur Area has the capacity to attract and sustain a much higher level of public use than at present. Opportunities for

interpretation of the natural environment are also numerous.

11. STATUS OF CURRENT KNOWLEDGE

The flora and fauna of the northern kwongan are very rich in species and studies on it are inadequate for a detailed analysis of the possible impact of any development on the Lesueur Area. With regard to the flora, more research is needed into local endemics, impacts of dieback disease, cryptogams, regional plant communities, community processes and population biology. Considerable research is required into rehabilitation techniques for many plant groups that cannot be regenerated at present. In the fauna, vertebrate surveys are at present inadequate to understand either the habitat requirements or the minimum area required by most species. Data on terrestrial invertebrates are lacking for most of the area and data on aquatic invertebrates need to be upgraded by conducting surveys throughout the wet season. Because of lack of information this report has not dealt with possible effects on groundwater levels and quality or possible effects on the area's freshwater springs.

12. SIGNIFICANCE OF THE LESUEUR AREA

The Lesueur Area is an area of world, national, State and regional nature conservation significance. It has all the characteristics of an important conservation reserve and is the most important nature conservation area in the northern kwongan. Its major characteristics are uniqueness of many geological, landform and biological attributes, biodiversity, very high nature conservation values, representativeness for more common components of the northern kwongan flora and fauna, and scenic grandeur. Its size is not large for an important conservation reserve and, desirably, it should be larger. There are currently seven national parks and Class A nature reserves in the northern kwongan, totalling only 107 460 ha. The Lesueur Area includes a wider range of ecosystems than any other existing or proposed conservation reserve in the northern kwongan.

Appendix 2

Abstract of Unpublished Chapter 13 of a Draft of Calm's 1989 Report to the EPA

POSSIBLE IMPACT OF COAL MINE AND POWER STATION

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Abstract

This chapter identifies potential impacts of the proposed coal mine and power station on the proposed Lesueur National Park. It is not a full environmental impact statement.

Consultants to the mining Companies have identified a minimum impact area (the coal mines and batters alone) and a maximum impact area (an area within a line surrounding all possible mines, batters, the power station and infrastructure). They state that the actual area of impact lies somewhere between these figures. The minimum impact area within the proposed national park is about 934 ha and the maximum impact area is about 4 258 ha. An additional 3 406 ha outside the proposed national park boundaries is within the maximum impact zone, some of it bushland of high nature conservation value.

The four eastern landforms of the proposed national park will be affected to varying degrees, with Banovich Uplands (40% - 94%) and Bitter Pool Rises (8% - 100%) being most affected, and Gairdner Dissected Uplands (4% - 28%) and Lesueur Dissected Uplands (0% - 3%) being less affected. The upper portions of the four major catchments in the proposed national park will sustain high impact.

Some vegetation types are greatly affected, particularly lateritic heath dominated by an undescribed species of Dryandra, two other lateritic upland types of heath, the best stands of a particular type of wandoo woodland, and Calothamnus quadrifidus heath.

All seven species of Declared Rare Flora that occur in the proposed national park will be affected. Figures for total plants destroyed, both inside and outside the park, vary from 0% to 57% (minimum and maximum impact) of individuals for Acacia forrestiana to 6% to 79% for Hakea megalosperma, 11% to 22% for the sun orchid Thelymitra stellata and 12 to 49% for Banksia tricuspis. Figures for those plants inside the proposed park are higher, with 91% of Asterolasia drummondii and 100% of Thelymitra stellata being affected under maximum impact. Of the 111 regional endemics in the proposed national park, two thirds (65%) would be affected should mining affect all the maximum impact area. Twenty-six very geographically restricted plant taxa occur in the maximum impact zone.

Impact on animal species is difficult to quantify because of the lack of data. Particular concern is expressed for species that depend on the wandoo woodlands for nesting, especially Carnaby's Black Cockatoo and the Regent Parrot.

Dieback disease caused by Phytophthora species would have a major impact if introduced because of the suitable climate, the abundance of susceptible plant species and vegetation types and the type of soils present. The probability of introduction of Phytophthora is high when extensive use of earth-moving equipment and vehicles takes place in a highly susceptible area, even if high standards of hygiene are maintained. If introduced, the impact of Phytophthora could be extensive, because the development affects all catchments in the proposed national park, and because of the high proportion of susceptible vegetation types and plant species.

The most scenic parts of the proposed national park would not be mined. However, there will be a significant degree of impact on visual resource values if the mine goes ahead because the area that will be mined is a supporting landscape and important foreground to the eastern flank of the Gairdner Range. The viewsheds east and northeast from the eastern edge of the Gairdner Range would also be affected and the coal-fired power station, with its reported 200 metre high stack, would also be visible from a considerable distance, both from within and outside the reserve. The natural character and scenic beauty of what are some of the most attractive landscapes within the northern kwongan will be severely degraded should the project proceed.

Experience with attempted rehabilitation of somewhat similar kwongan vegetation at Eneabba suggests that rehabilitation at Lesueur would be extremely difficult, if not impossible. The Lesueur mining operation will have problems additional to those met by the sand mining Companies at Eneabba. The substrate is quite different and soils are much more complex, and the overburden is likely to be toxic to plant growth. Moreover, successful germination and establishment, either in cultivation or rehabilitation areas, of many species of Restionaceae, Cyperaceae, Orchidaceae and Epacridaceae has not been achieved, due to as yet unknown horticultural difficulties.