GRIFFINCOAL
THE GRIFFIN COAL MINING COMPANY PTY. LIMITED

# Consultative Environmental Review

# Ewington Open-Cut Mine

## Volume 2

**Halpern**
**Glick**
**Maunsell**

GRIFFINCOAL
THE GRIFFIN COAL MINING COMPANY PTY. LIMITED

# Consultative Environmental Review

# Ewington Open-Cut Mine

## Volume 2

August 1991

**Halpern Glick Maunsell**

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## APPENDICES

# APPENDIX A
# EPA CONSULTATIVE ENVIRONMENTAL REVIEW GUIDELINES

# DRAFT GUIDELINES FOR THE CONSULTATIVE ENVIRONMENTAL REVIEW (CER) ON THE EWINGTON COAL MINE PROPOSAL AT COLLIE

The CER should be comprehensive enough to allow assessment authorities to fully understand the proposal, the environment it impacts upon, the short and long term impacts and the proposed management methods to address those impacts. The attached guidelines are as comprehensive as possible but it is the proponent's responsibility to consult with all relevant authorities and to identify the issues and compile an appropriate report on the proposal. Maps and diagrams should be used to illustrate the report where appropriate.

The CER should facilitate review of the key environmental issues but is intended to be a brief document. Its purpose should be explained in the introduction and the contents should be concise and accurate. It may be appropriate to include detailed, lengthy, technical information in appendices.

## 1. Summary

The CER should contain a brief summary of the proposal, surrounding environment, impacts/major issues, management programmes and the proposed safeguards and environmental commitments.

## 2. Introduction

- identify the proponent, including contact names and addresses;
- briefly describe the objectives of the proposal, the location and the basic outline of the proposal including the scope and timing;
- identify the responsible government authorities and the assessment and approval processes that are required and the aims of the CER.

## 3. The Proposal

- the CER should examine the need for the proposal and the alternatives considered for the various components of the preferred proposal; the relationship of government policy on such matters as energy policy, the Greenhouse effect, south-west development, etc, should be examined;
- the costs and benefits at local and regional levels should be discussed;
- the important components of the entire proposal (from mining to transport of the product) should be described including construction and operational phases, infrastructure requirements, anticipated impacts (noise, wastewater, air emissions), management procedures, rehabilitation, decommissioning and contingency planning;
- quantify the various aspects of the proposal as much as possible, particularly those aspects which relate to potential environmental impacts.

## 4. Existing Environment

- describe the biological and physical environment of the area and also the region; but particularly the project area, which should be described in sufficient detail so that the specific biological and physical parameters of the area can be understood in the regional context;

- describe the cultural and heritage values of the area including any archaeological or ethnographical interest in the area;
- other aspects of the human environment (local communities, nearest residents, background noise levels, landscape values, etc) should be described;
- describe the present and any proposed land uses and any other aspects of the environment which are important in relation to the proposal.

## 5. Environmental Impacts and Management

- identify the direct and indirect impacts arising from all phases and components of the proposal, quantification, if possible and necessary, any criteria used for making conclusions about the significance of the impacts should be described;
- identify the social impacts related to the proposal;
- describe the management techniques, operational constraints and other methods proposed to address the impacts;
- indicate the consultation and negotiation agreements reached with relevant regulatory and management authorities;
- particular assessment of the impacts related to surface drainage control, overburden management, groundwater drawdown, noise, wastewater, air emissions, hazard/risk management, dieback control and effect on the forest values should be made;
- summarise the overall environmental impact of the proposal;
- detail the environmental management and rehabilitation methods proposed to address and monitor the impacts;
- specific commitments should be made to manage the impacts and a numbered list of these commitments provided in the CER, possibly as an appendix.

## 6. Public Consultation

The public consultation activities that occurred during the planning of the proposal and preparation of the report should be described. This should outline the activities, the objectives of the activities and the groups and individuals involved. A summary of concerns raised should be documented along with how each of these concerns has been addressed.

## 7. Additional Information

- references; list and provide appropriate documentation of authorities consulted, literature referred to in the text and whatever maps and figures are used;
- guidelines; a copy of the guidelines should be included in the CER;
- appendices; any detailed, technical information which is essential to the proposal and the assessment process should be appended.

# APPENDIX B
# PUBLIC NOTICE TO RESIDENTS

GRIFFINCOAL
THE GRIFFIN COAL MINING COMPANY PTY. LIMITED
A MEMBER OF THE GRIFFIN GROUP INCLUDING:
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LEG/012
GAM:cr

29 January 1991

**TO THE OCCUPANTS**

**PUBLIC NOTICE**

**PROPOSED EWINGTON OPEN–CUT MINE**

**INFORMATION FOR RESIDENTS**

As part of its continuing plans for future development, The Griffin Coal Mining Company Pty Limited (Griffin) is currently evaluating the coal reserves of its Ewington deposit for the development of an open–cut mine.

It is proposed to develop the Ewington deposit as a staged open–cut strip mining operation. Continuous dewatering is necessary to provide safe working conditions, as with Griffin's current mining operations in Muja and Chicken Creek.

The mining operations are scheduled to commence during 1995 but the initial dewatering operations will begin two years prior, in 1993. The expected life of the Ewington mine is 30 years, delivering up to 2.3 million tonnes of coal per year.

The majority of the land under which the Ewington deposit occurs is either State Forest, or private properties owned freehold by Griffin. The area proposed to be mined is zoned for mining.

Planning for the Ewington mine is currently in its early stages. It is, however, recognised that the north–west extremity of the proposed mine is located approximately 2km east of the Collie township, as indicated in the accompanying sketch.

As potential environmental and social impacts are identified, mine planning will be further refined to ameliorate or minimise such impacts. Issues addressed to date include noise, dust, visual aesthetics, traffic, water supplies, aboriginal sites, vegetation and fauna.

The Collie Shire Council has been briefed concerning the proposed mine and has had the opportunity to comment on the development. All input from the Shire has been taken into account during the mine planning phase.

Environmental assessment of the proposal has been underway since November 1990. This will be reported on in a Consultative Environmental Review (CER) document to be released by the Environmental Protection Authority (EPA) to the public. The release date is anticipated to be early March 1991.

The emphasis of the CER will be the identification of potential environmental impacts associated with the proposed mining operations, and the presentation of Griffin's proposed environmental management plans and commitments.

Further, this CER will facilitate EPA's assessment of potential environmental impacts and allow affected and concerned parties to comment on the proposal.

The public will be given a review period of four weeks following release of the CER to submit comments on the proposal.

The purpose of the notice is to give residents, particularly those living in the vicinity of the proposed mine, the opportunity to express any concerns they may have.

If you would like further details, please contact any of the persons below:

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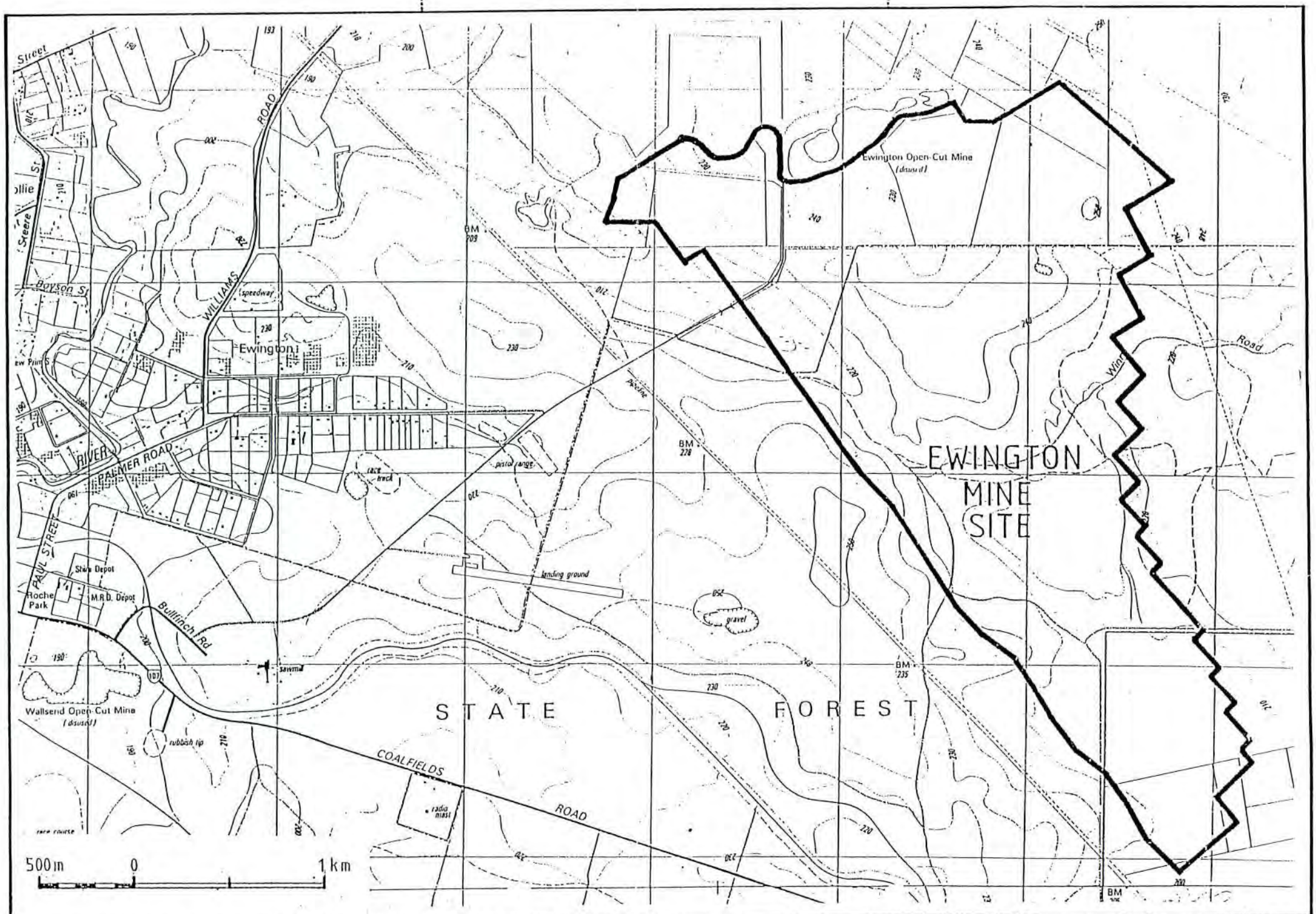
Yours faithfully,
**THE GRIFFIN COAL MINING COMPANY PTY LIMITED**

Graham Mathieson

**G.A. MATHIESON**
**GENERAL MANAGER – DEVELOPMENT**


EWINGTON
MINE
SITE
STATE
FOREST
Ewington Open-Cut Mine
(disused)
Wallsend Open-Cut Mine
(disused)
Ewington
WILLIAMS ROAD
PALMER ROAD
PAUL STREET
Bayson St
Steere St
RIVER
Bullfinch Rd
COALFIELDS ROAD
Roche Park
M.R.D. Depot
Stock Depot
speedway
pistol range
landing ground
gravel
rubbish tip
radio mast
race course
BM 209
BM 228
BM 235
BM 332
500m
0
1km

# APPENDIX C
# HYDROGEOLOGY AND GROUNDWATER REPORT

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# CONSULTATIVE ENVIRONMENTAL REVIEW

# EWINGTON COAL MINE

# EFFECTS OF DEWATERING

JANUARY 1991

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EFFECTS OF DEWATERING

JANUARY 1991

## 1. INTRODUCTION

Open pit mining at the Ewington Coal Deposit will require the dewatering of overburden and coal seams and depressurisation of underlying strata. This report summarises the hydrogeology of the area and predicts the effects of dewatering based on the previous studies outlined below.

### 1.1 AVAILABLE INFORMATION

Groundwater monitoring data for the Collie Basin collected by the State Energy Commission of Western Australia (SECWA), Western Collieries Ltd, and The Griffin Coal Mining Company Pty Limited (Griffin), were reviewed for the period July 1986 - June 1988 (AGC, 1989A); this followed an earlier review completed in 1986. The impact on surface water quality of Griffin's mining and water management operations in the Collie Basin were the subject of a second report (AGC, 1989B). This report was particularly aimed at the impacts of waste-water discharge on flow into the Wellington Reservoir.

The dewatering and depressurisation requirements at Ewington have been determined by GRC-Dames & Moore (GRC, 1990A) using a numerical groundwater model. That company has also assessed water disposal and treatment options for the Ewington Mine (GRC, 1990B).

The Geological Survey of Western Australia (Moncrieff, 1987) reported on variations in water table levels at Collie-Cardiff (Fig. 1), following concern by a resident that bore water levels had declined. That Department has since installed a series of shallow, water table monitoring bores so that the effects of mining can be assessed in the future.

## 2. HYDROGEOLOGICAL SETTING

The Ewington Mine is situated in an embayment at the northern end of the Shotts Sub-Basin of the Collie Basin (Fig. 1). In this area, the basin contains up to 213 m thickness of the Collie Coal Measures (of Permian age), overlain by up to 18 m thickness of weakly cemented sands, gravels and clays of Cretaceous to Tertiary age (Nakina Formation), and a thin veneer (up to 10 m) of laterite and Quaternary alluvium.

The Stockton Formation, of Early Permian age, underlies the coal measures, and is about 50 m thick at the Ewington Deposit. It consists of siltstone, sandstone and claystone and is tillitic in part.

The Ewington Deposit occurs within the basal Ewington Member of the Collie Coal Measures. This Member consists of beds of sandstone, siltstone, shale, carbonaceous shale and coal, with lenticular bedding. The sandstones are typically poorly sorted with varying feldspar content.

The Ewington Member occupies a syncline which dips gently to the east south-east at about three degrees. Beds dip towards the axis at 4.5 degrees on the northern side and 3.6 degrees on the southern side of the syncline.

The sub-basin is cut by a large number of normal faults that are generally parallel to the sub-basin orientation. Beds dip more steeply near the faults. There is little information on the position or throw of minor faults.

The sandstones of the Collie Coal Measures form a complex multilayered aquifer system. GRC (1990A) have identified 6 or 7 aquifers in the sequence. These are separated by shales, siltstones and coal seams that are of low permeability, and confine groundwater in the sandstone. Although restricted, there is flow between the aquifers, as faults, the discontinuity of confining beds, washouts, mine workings and poorly constructed bores provide vertical pathways for groundwater movement.

Unconfined groundwater occurs in the overlying Nakina Formation and Quaternary alluvium ("superficial sediments"). It is recharged by the direct infiltration of rainfall, and from flows in branches of the Collie River. In dry periods, groundwater discharges to creeks and rivers from the shallow aquifer. Hydraulic heads generally decrease with depth in the basin, indicating that recharge to aquifers in the Coal Measures occurs by infiltration from the Nakina Formation and Quaternary alluvium.

Groundwater in the Coal Measures and the overlying superficial sediments is generally fresh, with salinities mostly less than 500 mg/L TDS. There is some water of higher salinity near the basin margins, and in the basal Stockton Formation. Groundwater quality is discussed in more detail in Section 4.3.

## 3. HISTORICAL EFFECTS OF GROUNDWATER EXTRACTION

### 3.1 PERMIAN AQUIFERS

Groundwater extraction for water supply and mine dewatering has lowered water levels in the Basin, particularly in the Permian sandstone aquifers. There has been groundwater extraction to dewater the Muja and Chicken Creek open-cut mines in the Muja Sub-Basin, the WO3 and WO5 open-cut mines in the Cardiff Sub-Basin, and the WD2, WD6 and WD7 underground mines in the Cardiff Sub-Basin (Fig. 1). Also, water is drawn from the Shotts and Cardiff South borefields for cooling the Muja Power Station and to improve the quality of water discharged from the power station to the Collie River.

These borefields and dewatered mines are all remote (more than 5 km) from the abandoned Ewington mine, although the Shotts borefield is close to the southern boundary of the proposed Ewington open-cut mine.

#### 3.1.1 Cardiff Sub-Basin

The monitoring results presented by AGC (1989A) show that there has been extensive depressurisation (heads lowered more than 50 m) around the WD7 underground mine, and that drawdowns of more than 10 metres extend along more than 5 km of the basin. It is believed that similarly extensive regions of depressurisation occur around the WD2 and WD6 mines, although there are few monitoring bores in these areas to detect changes in head.

There are smaller drawdowns of 5 to 10 metres around the WO3 and WO5 mines, particularly along strike.

Extraction from the Cardiff South borefields may have lowered heads locally by up to 10 to 15 metres, with larger drawdowns (up to 50 m) in the production bores themselves.

#### 3.1.2 Muja Sub-Basin

There have been drawdowns of up to 160 m or more in the roof and floor aquifers of the Muja open-cut, and smaller drawdowns in the Chicken Creek open-cut; there are only small or indistinguishable drawdowns in other aquifers that are not in direct connection with mine workings or dewatering bores.

The lateral extent of drawdowns in aquifers of the Coal Measures is not given in the AGC report.

### 3.1.3 Shotts Sub-Basin

The only major groundwater extraction in this sub-basin is from the Shotts Borefield. There appear to be drawdowns of between 7 m and 33 m in the borefield, and smaller drawdowns in deep aquifers around the borefield, although this is unclear from the AGC report.

## 3.2 SUPERFICIAL AQUIFER

Drawdowns induced in the superficial aquifer as a result of groundwater extraction from the Permian sandstones are difficult to distinguish from seasonal fluctuations, and long term trends caused by, for example, a number of years with lower-than-average rainfall.

Monitoring bore SX8 is situated in the Shotts Sub-Basin, in the area of the proposed Ewington open-cut mine, and is unaffected by current groundwater extraction. Data for the period mid 1980 to mid 1988 indicate the following:

(i) seasonal fluctuations are in the range of 0.5 to 1.5 m

(ii) water levels rose by about 2.5 m between 1980 and 1984 as a result of higher rainfall after a period of very low rainfalls (although annual falls were still below average in 1980, 1981, 1982 and 1984).

(iii) water levels declined by about 3 m between the beginning of 1986 and mid 1988 in response to low rainfalls in 1985 to 1987, and early 1988.

Water levels in the superficial sediments may have fallen by 5 m or more as a result of the 1984 - 87 drought period (AGC, 1989A).

Some drawdowns in the shallow aquifer have been distinguished from these seasonal effects. Moncrieff (in prep.) shows a drawdown of about 2 m over one year in the superficial sediments (Bore CBS 17A) above the WD7 underground mine at Collie-Cardiff. The drawdown shows a good correlation with drawdowns of about 12 m in bore CBS 17B which intersects the Coal Measures. There is a vertical separation of about 29 m between the screened sections of these bores. Also, it is likely that the drawdown in CBS 17A was attenuated by infiltration from the Collie River South Branch.

AGC (1989A) report there is no evidence of extensive dewatering of the shallow aquifer around the Cardiff South borefield and that there has been only minimal dewatering, even close to the major open cut mining areas in the Cardiff Sub-Basin.

In the Muja Sub-Basin, AGC (1989A) state that there has been little or no effect on the shallow aquifer from groundwater extraction from the Permian aquifers and that, although some dewatering may have occurred close to the Muja and Chicken Creek mines, it is minor in comparison to the effects of recent below-average rainfall.

It is implied that up to 2 m of dewatering may have occurred in bores MX1 and MX2, close to the Chicken Creek open-cut mine.

In the Shotts Sub-Basin, the AGC review indicates possibly 5 to 6 m of dewatering in the shallow aquifer above the Shotts borefield, over several square kilometres, even allowing for climatic-induced variations in water levels.

### 3.3 WATER QUALITY

The monitoring assessment (AGC, 1989A) presents no specific evaluation of water quality data because the data are "somewhat limited in value by comparison with the water level records". It is stated that there is no clear evidence that extraction has affected groundwater quality, and that mining has a much greater effect, particularly where sulphides are oxidised in the mine workings.

Changes in quality have been reported by GRC (1990A,B), and these are discussed in Section 4.3.

## 4. POTENTIAL EFFECTS OF DEWATERING, EWINGTON MINE

### 4.1 PLANNED DEWATERING SCHEME

The planned dewatering scheme can be summarised as follows, from the report by GRC (1990A).

Dewatering will require pumping at rates of 10,000 to 35,000 cu m/day, depending on the final mining schedule and mine plan used. There will be up to 65 - 75 production bores in three groups: distributed along the western wall, the central fault and northwest corner of the deposit, and along the eastern (highwall) of the open-cut.

Water levels/heads will need to be lowered by up to 120 m.

### 4.2 WATER LEVEL CHANGES

Predicted drawdowns in water level around the proposed open-cut mine are not presented in the GRC report, as the numerical modelling was carried out to determine dewatering and depressurisation requirements rather than the effects of dewatering. Estimates of the extent of drawdown are given below.

### 4.2.1 Permian Sediments

Based on observed changes in hydraulic head around the WD7 (Collie-Cardiff) underground mine, water level drawdowns of more than 10 metres are likely to extend to at least 2 kilometres from the pit, particularly to the east and south of the mine. Smaller drawdowns will extend to greater distances, and will probably increase total drawdowns in the Shotts Borefield.

### 4.2.2 Superficial Sediments

A simple numerical groundwater model was constructed as part of the present study, to assess the potential effects of dewatering on water levels in the shallow aquifer. It utilises the aquifer parameters adopted in the dewatering model (GRC 1990A), including:

hydraulic conductivity = 1.8 m/day
specific yield = 0.1
average saturated thickness = 10 m

A rectangular finite-difference grid of 16 columns and 12 rows was superimposed over the north-eastern part of the Collie Basin (Fig. 2), including the proposed Ewington open-cut mine. It was assumed that the superficial sediments will be completely dewatered over the planned mining area, and drawdowns were calculated in the model for the surrounding area.

The results (Fig. 2) indicate that after a long period (10 years), there will be drawdowns of 3 m or more within a few hundred metres of the mine, decreasing to about 1 m at between 500 m and 1,000 m, and to 0.1 m at about 2.5 km from the mine.

Drawdowns where the Collie River East Branch crosses The Basin in and south of Collie will be less than one centimetre. In practice, drawdowns of less than 1 m will probably be indistinguishable from seasonal or long-term climatic effects. Also, additional recharge may be induced by lowering the water-table, thereby reducing drawdowns.

East and north-west of the proposed Ewington mine, the Collie River East Branch is within basement granitic and gneissic rocks and so in these areas there is no possibility that dewatering will affect streamflows.

There are small tributaries to the Collie River East and South branches in the vicinity of the proposed open-cut. In the present relatively undisturbed conditions, it is likely that these tributaries are effluent, i.e. shallow groundwater discharges to the streams, particularly at times of high groundwater levels. If the water table is lowered, these tributaries will become influent, with streamflow infiltrating to the groundwater.

## 4.3 WATER QUALITY

### 4.3.1 Chemistry

As discussed in Section 3.3, there has been no rigorous assessment of water quality changes resulting from mining in the Collie Basin. In the Ewington area, the limited water quality data have been assessed by GRC (1990B), and these are discussed below.

Groundwater was sampled by airlifting monitoring bores during 1984 and in April 1990. Also, four samples were collected from a production bore during test-pumping in 1984.

The 20 bores sampled in 1984 ranged in salinity from 125 to 832 mg/L TDS, and only three salinities were higher than the limit that is likely to be imposed for discharged water (550 mg/L TDS). The average salinity was 368 mg/L TDS, and during the 10 day pumping test, the salinity of water from the production bore decreased from 388 to 282 mg/L TDS.

The 8 bores sampled in April 1990 ranged in salinity from 52 to 400 mg/L TDS and averaged 273 mg/L TDS. Seven of these bores had also been sampled in 1984 and all showed significantly lower salinity in 1990 than in 1984, including two of the bores that had previously had a salinity in excess of 550 mg/L TDS. EW415 salinity had decreased from 598 to 335 mg/L TDS and EW431 salinity had decreased from 659 to 390 mg/L TDS.

The pH of water from 6 of the 7 bores re-sampled in 1990 had declined by between 1.1 and 2.5 pH units, from 4.6 to 7.5, to between 2.8 and 5.5. Also, bicarbonate and total iron concentrations had decreased. In most of the holes there was also a significant increase or decrease in sulphate concentrations.

It is likely that the hydrochemistry of groundwater around the monitoring bores has been modified by the action of iron or sulphate bacteria, by degradation of cement, or by oxidation of sulphides in the water and coal seams. Water in mine workings in the Collie Basin commonly becomes acidic because of the oxidation of sulphides.

Total iron concentrations ranged from <0.1 to 7 mg/L in the 1990 samples and 0.05 to 13.5 mg/L in the 1984 samples. In 3 of the 1990 samples and 6 of the 1984 samples the concentration exceeded 3 mg/L, the likely limit for water discharged to the Collie River.

Based on the data presently available, iron concentrations may need to be reduced and pH increased before groundwater from the Ewington mine or dewatering bores can be discharged to the Collie River. Average salinity is likely to remain below 400 mg/L TDS, within Water Authority limits.

### 4.3.2 Groundwater Temperature

There are no known data on groundwater temperatures in the Collie Basin. Based on geothermal gradients in the adjacent Perth Basin, temperature at the water-table is likely to be about 18°C and the geothermal gradient will probably be about 2°C per 100 m depth.

## 5. RECOMMENDED MONITORING PROGRAMME

The following groundwater monitoring programme is recommended to allow meaningful assessment of the effects of mining, in the future.

### 5.1 WATER LEVELS

#### 5.1.1 Superficial Sediments

Water-table levels should be monitored monthly in bores SX2, 3, and 8, SE1-1, and the new GSWA bores CBS 10, 11, 13, 14, 19, 20 and 21. Ultimately, bores SX8 and CBS14 will be mined-out.

#### 5.1.2 Permian Sediments

Water levels should be monitored at least monthly, and preferably weekly, in all dewatering bores and associated monitoring bores. This will provide information on whether dewatering is progressing at the required rate, as well as showing the effects of dewatering.

Monitoring bores SE1 (a test-production bore), SX1, and 4, EW404, 405, 409, 430, 464 and 467 should be monitored monthly. Some of these will also be mined-out.

### 5.2 STREAMFLOW

Sites should be selected on the small tributaries to the Collie River that drain north-westwards and southwards from the proposed open-cut mine. Stream flow measurements should commence as soon as possible, then be continued at monthly intervals once dewatering begins.

## 5.3 GROUNDWATER QUALITY

All dewatering bores should be sampled monthly (field measurements) for temperature, electrical conductivity and pH. Approximately 10 representative bores should be selected for monthly sampling and laboratory analysis of:

- pH
- Total Dissolved Solids (by evaporation)
- Sulphate
- Total Iron
- Total manganese
- Magnesium

Every six months, water samples should be taken and analysed for all major ions.

Water discharged from the mine, including water from dewatering bores and in-pit sumps should also be analysed monthly for all the above parameters, as well as suspended solids, oil and grease, and dissolved oxygen.

DATED: 18 FEBRUARY 1991

ROCKWATER PTY LTD

P. H. WHARTON
PRINCIPAL HYDROGEOLOGIST

REFERENCES

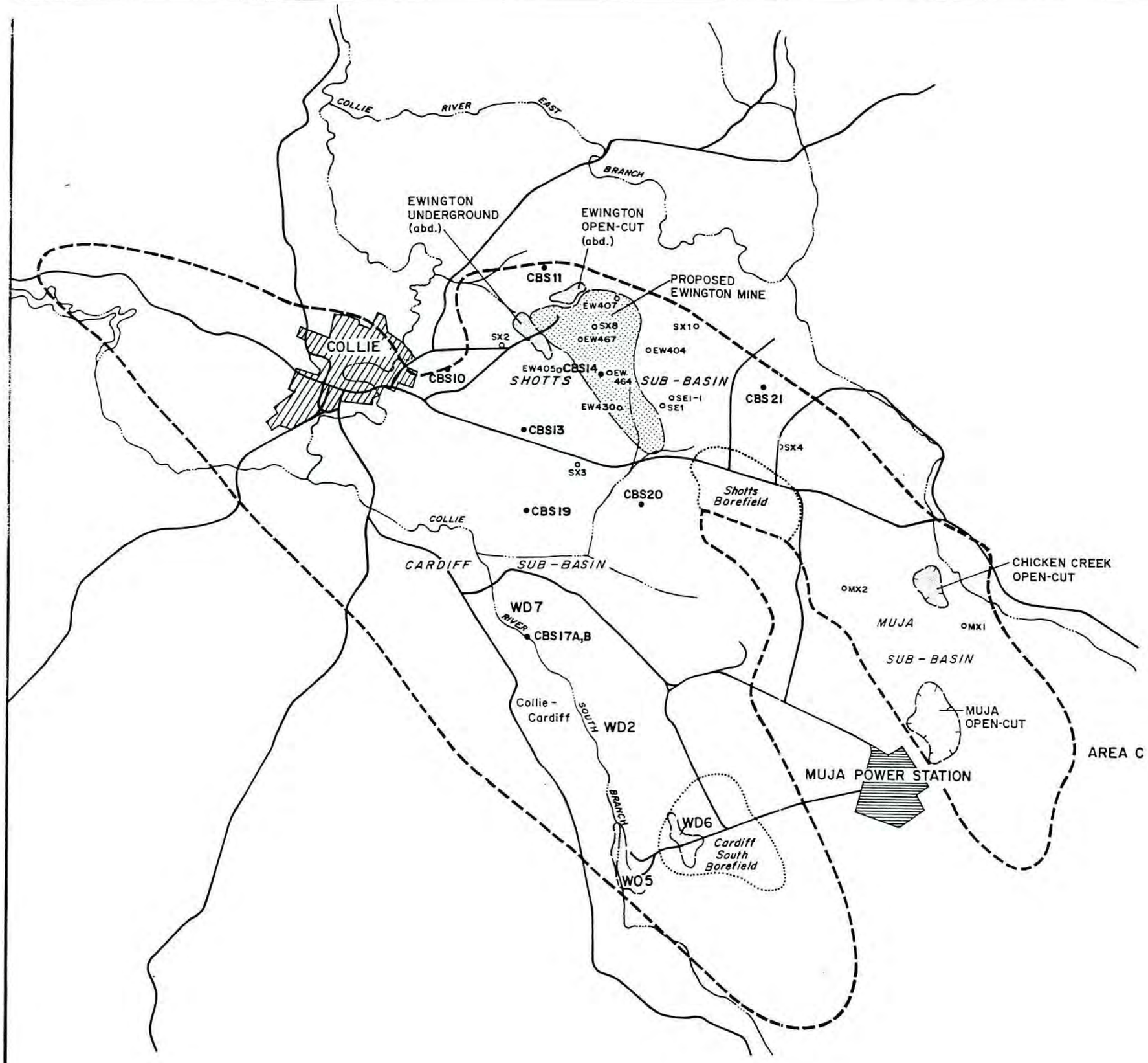
AGC, 1989A, Collie Basin groundwater monitoring review, July 1986 - June 1988. Unpub. report to SECWA.

AGC, 1989B, Collie Basin water quality impact assessment. Unpub. report to The Griffin Coal Mining Co. Ltd.

GRC, 1990A, Estimated dewatering/depressurisation requirements, Ewington Deposit. Unpub. report to The Griffin Coal Mining Co. Ltd.

GRC, 1990B, Assessment of water disposal and treatment options, Ewington Deposit. Unpub. report to The Griffin Coal Mining Co. Ltd.

Moncrieff, J.S., 1987, Variation in water table levels at Collie-Cardiff. Geol. Surv. of W.A. Hydrogeology Report No. 2776 (unpub).

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LEGEND

- Collie Basin Boundary.
- WD2, WO5 Western Collieries underground & open-cut mines.
- CBS 19 GSWA monitoring bore
- SX2 / EW405 Collie Basin monitoring bores (positions approximate).

0 1 2 3 4 5km

Scale 1:100 000(approx.)

FIGURE 1

Client : THE GRIFFIN COAL MINING CO. LTD.

Project : EWINGTON C.E.R.

# LOCALITY MAP

Date : January 1991 Dwg. No. 15·17/91/1-1

ROCKWATER PTY LTD

# APPENDIX D
# NOISE REPORT

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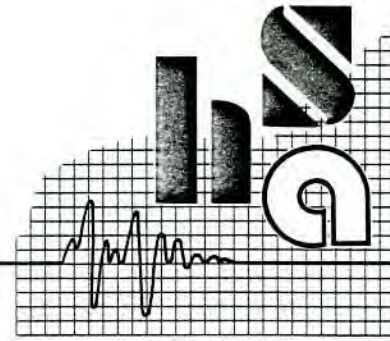


ALLAN HERRING M.I.E. AUST. M.A.A.S.
LYNTON STORER M.A.I.E.A., M.A.A.S.

# NOISE LEVEL ASSESSMENT & IMPACT STUDY

on behalf of

THE GRIFFIN COAL MINING COMPANY PTY LIMITED

for the

PROPOSED EWINGTON OPEN-CUT COAL MINE

COLLIE, W.A.

FEBRUARY 1991

(Our ref.0567-90106)

## 1.0 INTRODUCTION AND OBJECTIVE

A study has been undertaken of likely noise emissions from a proposed open-cut coal mining operation at Ewington, Collie, W.A. on behalf of The Griffin Coal Mining Company Pty Limited. The objectives of the study were to determine the noise propagation from the proposed operations to the surrounding area and assess the impact to any residential locations.

This report covers the process of determination of likely noise emissions, the calculation of noise level propagation and hence the resultant noise levels at the nearest residential areas, assessment of noise characteristics and assessment of likely impact upon residents in accordance with the Environmental Protection Act 1986 Regulations and other directives issued by that body.

## 2.0 CONCLUSIONS

It is the findings of this study that:

A. The most critical area for receival of plant noise will be the eastern end of the Collie township.

B. An acceptable noise emission level to the townsite is likely to be 40 dB(A) between the hours of 0700 to 2200 hours providing tonal or other characteristics do not exist.

C. Under normal atmospheric conditions resultant noise levels at the nearest location is predicted to be 33-34 dB(A). Under maximum propagation conditions (down wind) the level is predicted to be 43-45 dB(A).

D. It is considered the limited time of maximum propagation conditions (light NE breeze) will be such that noise complaints would not occur or would be sporadic.

E. Contingency plans should be made to use overburden to create a barrier at the western end of the northern haul road, should the down wind propagation prove excessive.

F. Noise level monitoring is recommended during the initial phases of the operation to flag any problems that may arise due to down wind propagation.

## 3.0 METHOD

### 3.1 Determination of Acceptable Noise Levels

The Environmental Protection Authority's document "Environmental Noise Management Procedure" establishes noise environments considered "to be the maximum acceptable in Western Australia for both residential and commercial/ industrial premises where these premises are influenced by intrusive noise emissions from other premises". Compliance with this procedure shall be deemed to result in noise emissions that are not unreasonable for the purposes of the Environmental Protection Act 1987.

A summary of the Procedure's acceptable maximum noise levels at any residential premises is as follows:

| | | |
|---|---|---|
| Monday to Saturday | 0700 to 1900 hours | 50 dBA |
| Any Day | 2200 to 0700 hours | 40 dBA |
| Any other time | | 45 dBA |

The above results are providing no tonal, impulsive or other annoying characteristics exist.

To assist with the determination of acceptable levels, measurements of the ambient noise levels were taken in the vicinity of the proposed mine site and residential area boundary. Percentile levels were recorded over a 24 hour period with printouts on an hourly basis. The results of these measurements would be compared with the maximum acceptable levels discussed above.

### 3.2 Determination of Plant Emission

A combination of measurements of noise levels from the existing Muja open cut operations and file data was used to establish sound power levels of various proposed equipment.

### 3.3 Determination of Resultant Noise Levels Surrounding the Operators

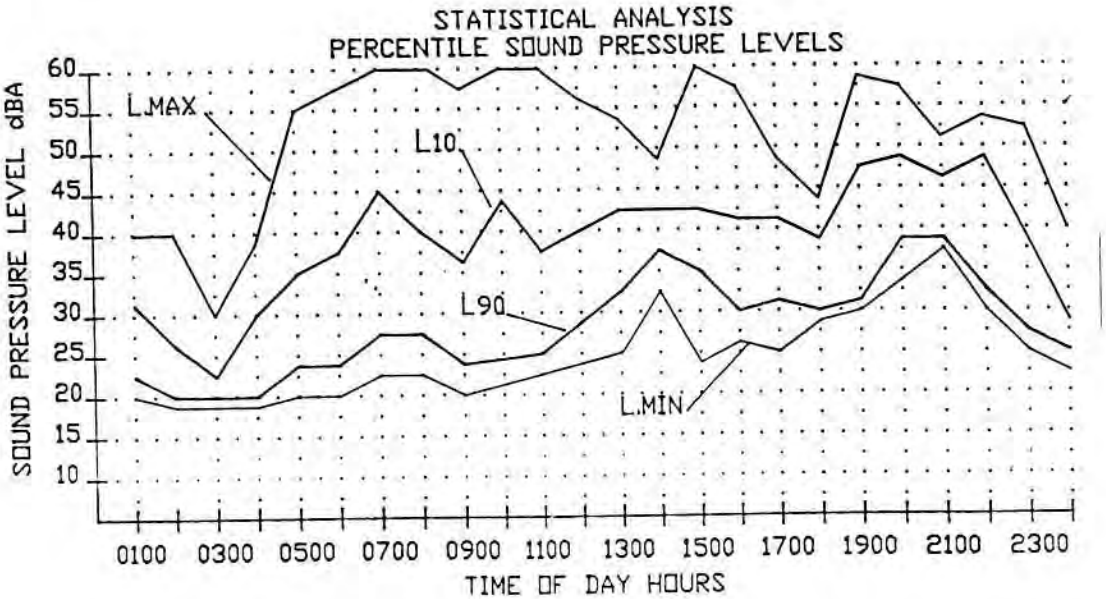
Computer modelling, specifically program E.N.M was used to predict noise level propagation. The program, based on the determined sound power levels in octave bands, topographical and atmospheric conditions calculates noise level contours to the surrounding areas.

## 4.0 RESULTS

### 4.1 Background and Acceptable Noise Levels

The results of 24 hour percentile measurements taken at the North East corner of the town boundary are presented in graphical form hereunder.

FIGURE 1




For the worst case period (2200 - 0700 hours) the arithmetic average of L90 levels (the nose level in dB(A) that is exceeded of 90% of the time and recognized as the measure of background level) is 27 dB(A).

It is generally accepted that levels up to 5 dB(A) above the background level will not cause annoyance providing tonal or other characteristics do not exist. From this criteria, levels up to 32 dB(A) would be acceptable.

From the EPA Procedural document previously discussed, 40 dB(A) would be the worst case acceptable level. As tonal components would exist this must be adjusted by -5 dBA resulting in 35 dB(A).

It is therefore recommended that 40 dB(A) be set as the "acceptable level" for broad band noise and 35 dB(A) for noise with tonal characteristics.

## 4.2 Plant Noise Emissions

Measurements of existing open cut operations were taken with the most reliable data being that recorded at a location down wind at approximately 500m as follows:

| Frequency Hz | 31.5 | 63 | 125 | 250 | 500 | 1K | 2K | 4K | 8K | dBA |
|---|---|---|---|---|---|---|---|---|---|---|
| SPL dB | 62 | 62 | 65 | 67 | 65 | 56 | 49 | 31 | 20 | 65 |

This data was used as a guide only as the noise sources were varied including at least several haul trucks, 3 hydraulic shovels, dozer and sundry vehicles and hence difficult to attribute individual levels. It was also used to assess the accuracy of model predictions. Due to the different layout of the proposed mine, the noise sources needed to be separated, particularly haul trucks so as these could be modelled at various worst case locations under both flat haul and uphill haul conditions.

To this end, file data for various equipment was used as follows:

HYDRAULIC SHOVEL / DRAG LINE / SUNDRY EQUIPMENT (Combined)

| Frequency Hz | 31.5 | 63 | 125 | 250 | 500 | 1K | 2K | 4K | 8K | dBA |
|---|---|---|---|---|---|---|---|---|---|---|
| SPL dB | 12 | 116 | 124 | 126 | 122 | 118 | 113 | 109 | 103 | 124 |

HAUL TRUCK 85 TONNE - ON FLAT ROAD

| Frequency Hz | 31.5 | 63 | 125 | 250 | 500 | 1K | 2K | 4K | 8K | dBA |
|---|---|---|---|---|---|---|---|---|---|---|
| SPL dB | 110 | 123 | 132 | 118 | 119 | 113 | 107 | 103 | 102 | 121 |

HAUL TRUCK 85 TONNE - HAUL UP INCLINE

| Frequency Hz | 31.5 | 63 | 125 | 250 | 500 | 1K | 2K | 4K | 8K | dBA |
|---|---|---|---|---|---|---|---|---|---|---|
| SPL dB | 113 | 133 | 134 | 128 | 122 | 109 | 108 | 101 | 102 | 124 |

Generally noises were tonal, typically in the octave bands of 125 or 250 Hz, being engine firing frequencies.

## 4.3 Determination of Noise Propagation

Using the ENM program, two basic scenarios were modelled. In each case, the ground type and contours were input along with the above equipment sound power levels. The two scenarios involved different noise source locations, the first being for the worst case conditions of the north western most operations (closest to Collie townsite), and the second for the southern extent of operations. In both cases relatively cool calm conditions were simulated.

The final results in the form of noise level contours (dBA) are shown in Figures 2 & 3.

FIGURE 2

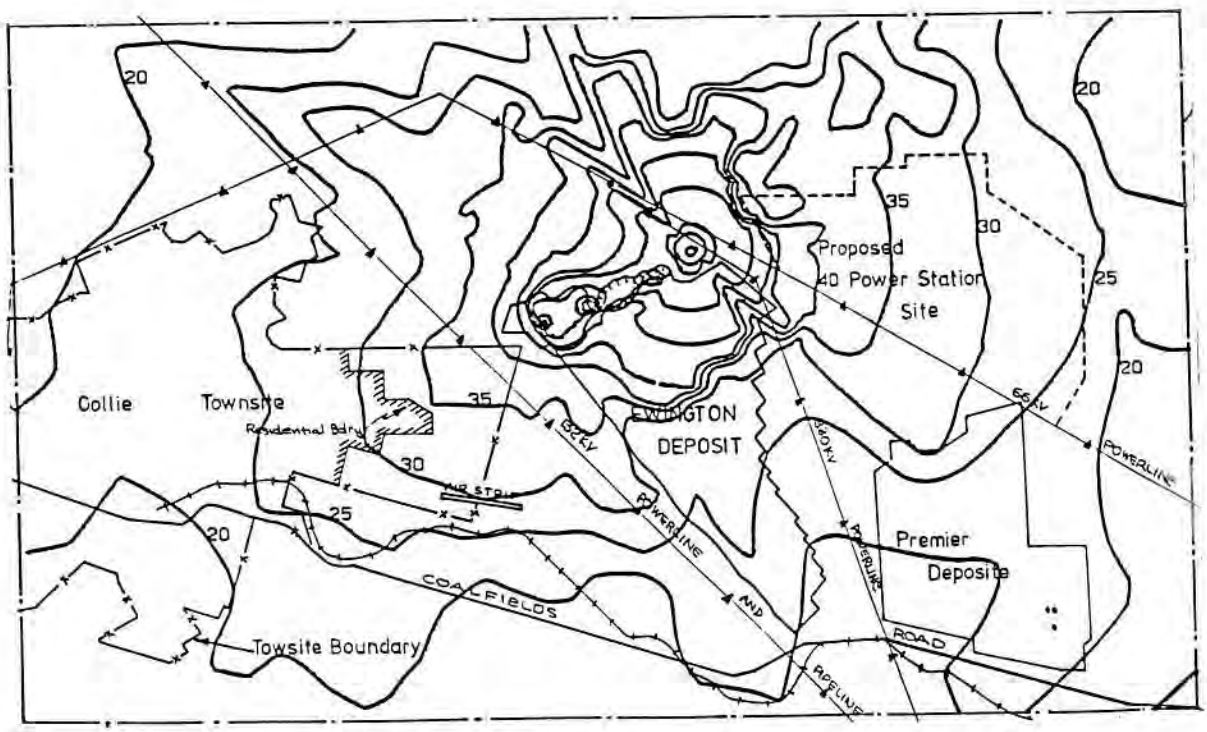
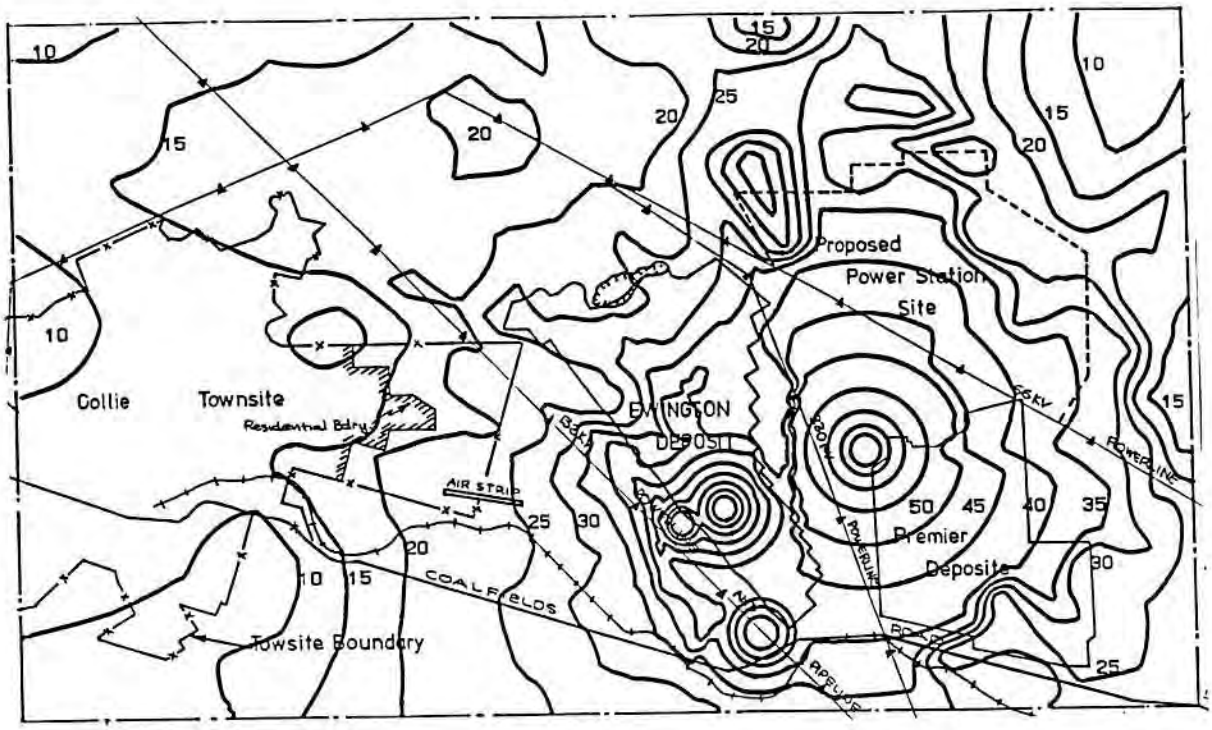
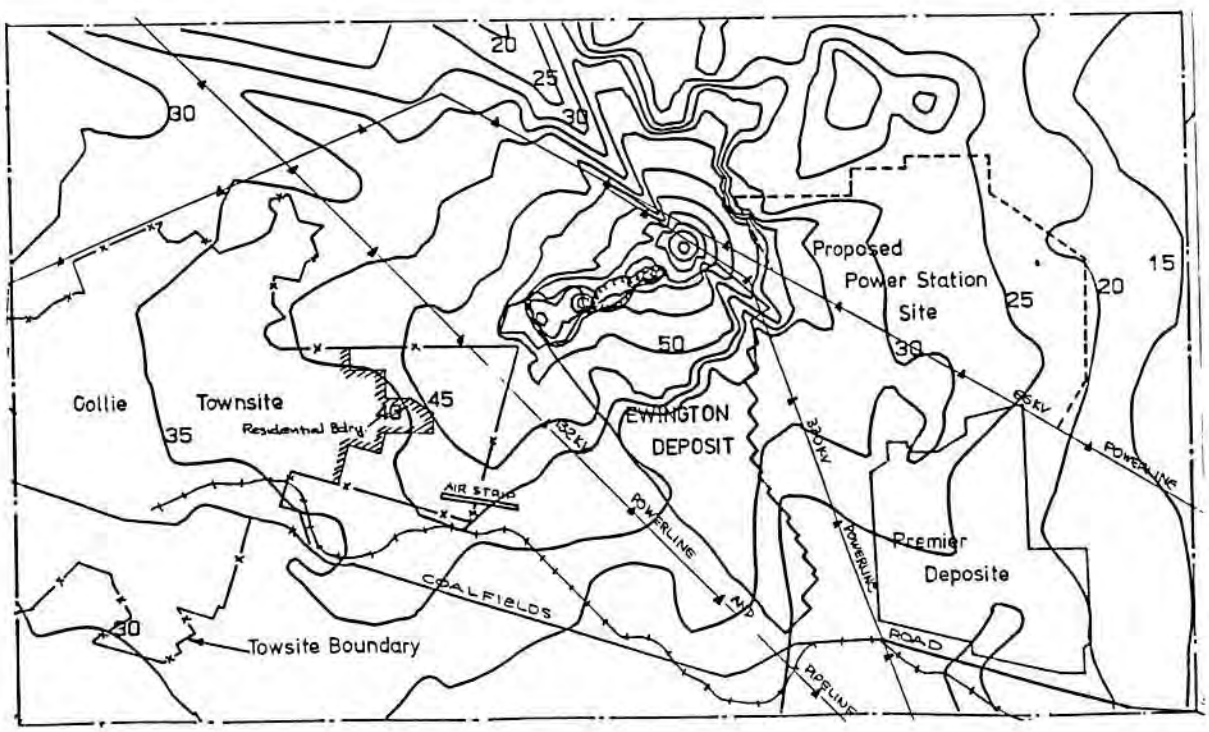


FIGURE 3




The critical north western 3 location was also modelled under considered worst case conditions of dominant propagation towards Collie, i.e. north easterly light breeze of 2-3 m/s was considered. The results are shown in Figure 4.

FIGURE 4



# APPENDIX E
# VEGETATION AND FLORA REPORT

# FLORA AND VEGETATION

## EWINGTON DEPOSIT - COLLIE

Prepared For: Halpern Glick Maunsell Pty Ltd

Prepared By : E M Mattiske & Associates

January 1991

TABLE OF CONTENTS

## 1. SUMMARY

A total of 52 families, 143 genera and 252 species were recorded on the Ewington Deposit survey area, Collie. Of these 252 species, 12 were introduced weed species. Dominant families were Myrtaceae (29 species), Proteaceae (24 species), Papilionaceae (24 species), Cyperaceae (16 species), Epacridaceae (14 species),Asteraceae (12 species), Poaceae (11 species), Dilleniaceae (10 species), Dasypogonaceae (10 species), Restionaceae (9 species), Haemodoraceae (9 species) and Mimosaceae (8 species).

No gazetted rare species were recorded on the Ewington Deposit survey area, Collie. A range of potentially rare and restricted species were defined for the Collie area. Only two of these was recorded near the Ewington Deposit, Collie (namely - *Restio ustulatus* and *Hibbertia silvestris*). In addition, a range of species were of particular interest as they manifested different patterns of distribution in the Collie Basin from the adjacent forest areas on the Darling Ranges.

In the vegetation studies associated with this review of natural resources in the Collie Basin, three vegetation complexes were defined by Heddle et al. (1980). The three vegetation complexes defined were - Collie, Cardiff and Muja. All these vegetation complexes occurred within the Ewington Deposit survey area. On the basis of defining the site-vegetation types for the Ewington Deposit survey area, it was possible to subdivide these vegetation complexes into 11 site-vegetation types. This level of definition is similar to that achieved for other areas within the northern Jarrah forest. The critical determinants of the site-vegetation types are the underlying topographical, soils and moisture regimes within the survey area. In most cases, it was possible to relate the type defined and mapped to similar communities in the adjacent northern Jarrah forest. The exception to this was site-vegetation type $A_3$ which was restricted to the clay soils over exposed secondary laterization in the southern section of the survey area. The latter community had greater affinities with the swamp communities on some of the swamps on the Swan Coastal Plain.

A significant level of stress was recorded in the Ewington Deposit survey area, Collie. The stress related to the damage of previous fires (mainly on *Allocasuarina fraseriana*), the presence of insects (mainly on *Eucalyptus marginata*) and the apparent regular presence of the dieback fungal disease - *Phytophthora cinnamomi* in the plant communities on the lower to mid slopes. The dieback disease was concentrated in the plant communities on the lower valley slopes. Management strategies for disease control and minimization of the effects of the proposed development on the flora and vegetation were summarized.

# 2. BACKGROUND

## 2.1 Location

The Ewington Deposit is located east of Collie in the south-west of Western Australia on the Collie Basin. E.M. Mattiske & Associates were commissioned by Halpern Glick Maunsell Pty Ltd to summarize the flora and vegetation on The Griffin Coal Mining Company Pty Limited coal deposit at Ewington.

The Ewington Deposit survey area is bounded in the east by a powerline and in the west by a water pipeline and powerline. The majority of the survey area is located within State Forest managed by the Department of Conservation and Land Management. The northern and southern extremities of the survey area have been cleared for agriculture and mining (the former Ewington coal mine in the north).

## 2.2 Flora and Vegetation

The flora and vegetation of the Collie Basin reflect the underlying geology, landforms and soils as summarized in the natural resources study by the Department of Conservation and Environment (1980). In the vegetation studies associated with this review of natural resources in the Collie Basin, three vegetation complexes were defined by Heddle et al. (1980). These studies supported the overlap in distribution of some plant species with adjacent regions, but also reflected the significance of the local soils and site conditions on the distribution of plant species. The three vegetation complexes defined were - Collie, Cardiff and Muja. These are discussed in further detail in the results and discussion sections of this report.

The vegetation on the Darling Ranges consists primarily of an open forest of *Eucalyptus marginata - Eucalyptus calophylla* on the drier sites and open woodlands of *Melaleuca preissiana* on the seasonally moist and wet swamps (Havel, 1975a and 1975b; Heddle et al., 1980). The studies by Havel defined the continuum nature of the plant communities with species varying in their distribution. These patterns were noted earlier by Diels (1906), who observed the association of Marri (*Eucalyptus calophylla* with moist, fertile sites, Sheoak (*Allocasuarina fraseriana*) on sandy soils, Bull Banksia (*Banksia grandis*) on gravelly uplands and *Melaleuca preissiana* and *Banksia littoralis* with seasonally wet swamps.

These relationships between site, soils and vegetation have been confirmed further in later studies by Williams (1932, 1945), Gardner (1942), Holland (1953), Speck (1958) and Lange (1960). The vegetation mapping by Smith (1974) for the Collie area, Beard (1979a, 1979b) for the Perth and Pinjarra areas depended largely on the structural and dominant floristic characteristics of the communities. In 1975 with the definition of the site-vegetation types for the northern Jarrah forest it was possible to incorporate site conditions and understorey species which reflected specific local site conditions. This level of mapping was incorporated at a regional scale by Heddle et al. (1980) and in a range of botanical studies by the authors within the Darling Ranges (e.g. mapping for Worsley Alumina Pty Ltd, 1985).

## 2.3 Aims and Objectives

The objectives of the botanical studies on the Ewington Deposit were:

- to collect and record the vascular plant species on the Ewington Deposit survey area, Collie;
- to review the conservation status of the vascular plant species on the Ewington Deposit survey area, Collie;
- to define and map the plant communities on the Ewington Deposit, Collie, utilizing the site-vegetation types as defined by Havel (1975a and 1975b);
- to review the local and regional significance of the plant communities on the Ewington Deposit survey area, Collie;
- to review the physiological stress evident in the plant communities on the Ewington Deposit survey area, Collie;
- to review the logging history of the forests on the Ewington Deposit survey area, Collie; and
- to assess the impacts of exploration and mining on the plant communities within the local area.

# 3. METHODS

## 3.1 Flora

Flora studies were undertaken in conjunction with reconnaissance, detailed site recordings and opportunistic collecting on the Ewington Deposit survey area in January 1991. The timing of the survey was related to the request by the Company to proceed in November 1990 and the availability of botanists to undertake the survey work.

Specimens of all new plant species recorded were collected, dried and fumigated, and identified by reference to the State Herbarium collections and relevant literature (Green, 1981; Marchant et al., 1987).

## 3.2 Vegetation

The vegetation survey was based on data recorded at 272 sites located regularly (c.100m) along 13 transects (250m apart). The sites are located on the maps enclosed. Each species present was ranked at each site using the scales of 0 to 5 as developed by Havel (1975a). Tree species were recorded in a radius of 20m from the recording site and understorey species were recorded in a radius of 5m from the recording site. Additional opportunistic observations were undertaken on accessible tracks on the edges of the survey area.

Each site was then classified into a site-vegetation type using the system developed by Havel (1975a and 1975b) for the northern Jarrah forest. These site types were then transferred to the map and the boundaries interpreted using the aerial photograph mosaic and photographs supplied by The Griffin Coal Mining Company Pty Limited.

## 3.3 Other Site Parameters

Additional observations were recorded at each site on topography, position in the landscape, soils, outcropping and drainage patterns. These were utilized in defining the site-vegetation types and delineating type boundaries for the vegetation map.

## 3.4 Physiological Stress

The forests in the south-west have been subjected to a variety of influences which have resulted in physiological stress in the

plant communities. Stress or dieback can be caused by a large variety of influences, but generally the term is used in relation to the presence of the dieback fungal disease - *Phytophthora cinnamomi* (Shearer and Tippett, 1989). In this report the emphasis was placed on this fungal disease, although at each site observations were made also on the impacts of fire (particularly on *Allocasuarina fraseriana*), insects (particularly on *Eucalyptus marginata*) and age (all older trees) on the resulting vigour of respective species. The degree of physiological stress apparent in the tree and understorey species was ranked as follows for each species:

| RANK | | PHYSIOLOGICAL STRESS LEVEL |
|---|---|---|
| 0 | - | No evidence of stress |
| 1 | - | Odd plant showing signs of stress, none dead |
| 2 | - | One or two stressed plants, usually under severe stress, near death |
| 3 | - | Scattered stressed and dead plants around plot |
| 4 | - | Susceptible plants dying or dead |
| 5 | - | "Graveyard" death - most trees logged and salvaged |

The stress apparently caused by the dieback fungal disease - *Phytophthora cinnamomi* was extracted from observations at the 272 recording sites and mapped. No sampling of plant material was undertaken to confirm these observations. Interpretations were based on 15 years of previous observations in the northern Jarrah forest by the authors.

### 3.5 Logging and Burning History

The logging history was assessed by ranking the degree of logging at each of the 272 recording sites, as follows:

| RANK | | LOGGING HISTORY |
|---|---|---|
| 0 | - | No evidence of logging (absence of stumps) |
| 1 | - | Very old logging - one cut only (age of stumps all old) |
| 2 | - | Recent logging only - light logging rate |
| 3 | - | Old and recent logging - area cut over twice at light rate |
| 4 | - | Logged intensively - heavy logging rate |
| 5 | - | "Graveyard" salvage logging |

Additional records were also undertaken on the number of stumps at each recording site (within a radius of 20m). The findings on the logging ranking are discussed in the text and the number of stumps are mapped.

The burning history was assessed by undertaking observations on the time since the last fire at each recording site. Findings are discussed in the text.

## 4. RESULTS

### 4.1 Flora

A total of 52 families, 143 genera and 252 species were recorded on the Ewington Deposit survey area, Collie (Appendix A) . Of these 252 species, 12 were introduced weed species. In view of the time of the field work several groups of plant species (e.g. members of the family - Orchidaceae) were not recorded in January 1991, due to seasonal conditions. It is estimated that some 70% of the total range of flora species were recorded in January, 1991.

Dominant families were Myrtaceae (29 species), Proteaceae (24 species), Papilionaceae (24 species), Cyperaceae (16 species), Epacridaceae (14 species), Asteraceae (12 species), Poaceae (11 species), Dilleniaceae (10 species), Dasypogonaceae (10 species), Restionaceae (9 species), Haemodoraceae (9 species) and Mimosaceae (8 species).

#### 4.1.1 Rare or Restricted Flora

No gazetted rare species were recorded on the Ewington Deposit survey area, Collie (Department of Conservation and Land Management, 1990; Hopper et al., 1990).

The following potentially rare and restricted species are in the Collie area near the Ewington Deposit, Collie (Department of Conservation and Land Management, 1990), Table 1.

**Table 1**
**Summary of Potentially Rare and Restricted Species in the Collie Area**

| | |
|---|---|
| *Drosera marchantii* | *Pultenaea skinneri* |
| *Hibbertia silvestris* | *Restio ustulatus* |
| *Leucopogon alternifolius* | *Stylidium rhipidium* |
| *Phyllota gracilis* | |

*Hibbertia silvestris* occurred on the lower and mid sandy-loam to sandy-clays with some gravels on the Ewington Deposit survey area (Appendices B and C). This species occurs from Waroona to Collie (Department of Conservation and Land Management, 1990). Under current listings this species is vulnerable and included in the group of species which are known from several localities, some of which are on lands not under immediate threat. This species is under consideration for declaration as rare flora but in need of further survey.

*Restio ustulatus* occurred on the valley floors in the southern extensive clay swamps (Appendices B and C). This species in the central forest area from Busselton to Scott River (Department of Conservation and Land Management, 1990). Under current listings this species is vulnerable and included in the group of species which are known from several localities, some of which are on lands not under immediate threat. This species is under consideration for declaration as rare flora but in need of further survey.

### 4.1.2 Species of Interest

A range of species are of particular interest as they manifest different patterns of distribution in the Collie Basin from the adjacent forest areas on the Darling Ranges. These species include:

*Adenanthos obovatus* - a species normally restricted to moist sandy soils on the lower slopes of broad Yarragil valley systems in the northern Jarrah forest. On the Ewington Deposit survey area this species extends upslope onto a greater range of topographical conditions.

*Baeckea camphorosmae* - a species normally restricted to moist sandy-loams and clay-loams on the lower slopes of broad Yarragil valley systems in the northern Jarrah forest. On the Ewington Deposit survey area this species extends upslope onto a greater range of topographical conditions.

*Hypocalymma angustifolium* - a species normally restricted to moist and wet sandy-loams and sandy-peat soils on the lower slopes and floors of broad Yarragil valley systems in the northern Jarrah forest. On the Ewington Deposit survey area this species extends upslope onto a greater range of topographical conditions.

These species reflect the predominance of sandy soils and moist soils in the Collie Basin and more specifically the Ewington Deposit survey area, Collie.

A range of species are of particular interest as they reflect local extremes in site conditions, and in many respects reflect similar conditions in the adjacent forest areas on the Darling Ranges and Swan Coastal Plain. These species include:

*Allocasuarina humilis* - a species normally restricted to shallow soils over outcrops (granitic and lateritic) in the northern Jarrah forest. On the Ewington Deposit survey area this species occurred on several pockets of shallow lateritic outcropping.

*Actinostrobus pyramidalis* and *Allocasuarina microstachya* - a species normally restricted to seasonally inundated swamps and wetlands on clay soils. In the Ewington Deposit survey area, this species was restricted to a small area on the southern section of the survey area of grey clays over shallow exposed secondary laterization outcropping.

A range of species are of particular interest as they appear to be of geographical or taxonomic interest. These species include:

*Baeckea aff. preissiana*, *Restio ustulatus*, *Calytrix ?similis* and *Lachnostachya albicans*. Further studies are required within the Collie region to clarify the significance of these collections.

In the vegetation studies associated with this review of natural resources in the Collie Basin, three vegetation complexes were defined by Heddle et al. (1980). These studies supported the overlap in distribution of some plant species with adjacent regions, but also reflected the significance of the local soils and site conditions on the distribution of plant species. The three vegetation complexes defined were - Collie, Cardiff and Muja. These are discussed in further detail in the results and discussion sections of this report.

## 4.2 Vegetation

The vegetation of the Collie Basin was subdivided into three vegetation complexes by Heddle et al. (1980), as follows:

"**Collie Complex** consists of an open-forest of jarrah-marri-sheoak with a range of understorey species which reflect the relative proportion of sand and gravel in the soils... The species which reflect the gravelly soils include *Banksia grandis*, *Persoonia longifolia*, *Hibbertia hypericoides*, *Leucopogon capitellatus*, *Bossiaea ornata*, *Acacia browniana*, *Hakea lissocarpha* and *Astroloma pallidum*. On the sandier soils common plant species are *Xylomelum occidentale*, *Daviesia incrassata*, *Bossiaea eriocarpa*, *Lyginia tenax*, *Dasypogon bromeliifolius* and species of *Calytrix*". (Note:*Acacia browniana* now *Acacia preissiana*; *Lyginia tenax* now *Lyginia barbata*).

"**Cardiff Complex** consists of an open-woodland of *B. attenuata* - *B. ilicifolia* and *Nuytsia floribunda* with a distinctive understorey with a range of species that reflects the levels of soil moisture... On the drier soils the understorey plant species include *Kunzea vestita*, *Banksia meissneri*, *Calothamnus* spp., *Lepidosperma angustatum*, *Xylomelum occidentale*, *Leucopogon glabellus*, *Jacksonia furcellata*, *Bossiaea eriocarpa* and *Daviesia incrassata*. On the moister soils common understorey species include *Leptospermum ellipticum*, *Adenanthos obovatus*, *Hypocalymma angustifolium* and *Schoenus brevifolius*. (Note:*Kunzea vestita* now *Kunzea ericifolia*; *Leptospermum ellipticum* now *Pericalymma ellipticum*).

"**Muja Complex** consists of an open-woodland of *M. preissiana* - *B. littoralis* with some admixture of yarri (*E. patens*) dominating the moister areas, and replaced by a woodland of *Banksia* spp. on the drier sites... The understorey species reflect the level of soil moisture. On the drier soils common plant species include *Lepidosperma angustatum*, *Dasypogon bromeliifolius*, *Lyginia tenax* and *Xylomelum occidentale*. Common plant species on the moister soils include *Hakea ceratophylla*, *Agonis linearifolia*, *Leptospermum ellipticum*, *Hypocalymma angustifolium*, *Adenanthos obovatus* and *Leptocarpus scariosus*. (Note:*Dasypogon bromeliaefolius* now *Dasypogon bromeliifolius*; *Lyginia tenax* now *Lyginia barbata*; *Leptospermum ellipticum* now *Pericalymma ellipticum*).

All these vegetation complexes occurred within the Ewington Deposit survey area. On the basis of defining the site-vegetation types for the Ewington Deposit survey area, it was possible to subdivide these vegetation complexes into 11 site-vegetation types, as follows:

**Collie** vegetation complex was subdivided into 5 site-vegetation types D, P, S, $S_2$ and $S_3$. This subdivision was based on local variations in structural and floristic compositions and site conditions (Appendices B and C).

**Cardiff** vegetation complex was subdivided into 2 site-vegetation types B and J. This subdivision was based on local variations in structural and floristic compositions and site conditions (Appendices B and C).

**Muja** vegetation complex was subdivided into 4 site-vegetation types $A_1$, $A_2$, $A_3$ and C. This subdivision was based on local variations in structural and floristic compositions and site conditions (Appendices B and C).

The occurrence of the species recorded on the Ewington Deposit survey area are summarized in, Appendix B. Detailed summaries of each site-vegetation type are provided on the following pages of the text and in Appendix C. The vegetation map enclosed illustrates the aerial distribution of the respective site-vegetation types.

**Site-vegetation Type:** $A_1$

$A_1$ consists of a low open woodland of *Melaleuca preissiana - Banksia littoralis* over dense understorey of shrubs and sedges. Understorey species include *Astartea fascicularis*, *Agonis linearifolia*, *Boronia molloyae*, *Callistemon phoeniceus*, *Gahnia trifida*, *Hakea ceratophylla*, *Hakea varia*, *Juncus pallidus*, *Leptocarpus scariosus*, *Leptocarpus coangustatus*, *Melaleuca viminea*, *Melaleuca lateritia* and *Pericalymma ellipticum*. This plant community is closely related to the A type as defined by Havel (1975a) for the northern Jarrah forest, which is regionally widespread on the Yarragil, Pindalup, Goonaping and Swamp vegetation complexes as defined by Heddle et al.(1980). This type occurs in restricted localized areas within the Ewington Deposit survey area, where local sandy-peat swamps occur (see Vegetation Map enclosed).

**Site-vegetation Type: $A_2$**

$A_2$ consists of an open woodland of *Melaleuca preissiana - Eucalyptus rudis - Banksia littoralis* over dense understorey of shrubs and sedges. Understorey species include *Astartea fascicularis*, *Callistemon phoeniceus*, *Calothamnus lateralis*, *Aotus gracillima*, *Hakea ceratophylla*, *Hakea varia*, *Kunzea recurva*, *Leptocarpus scariosus*,*Leptocarpus coangustatus*, *Melaleuca polygaloides*, *Pericalymma ellipticum*, *Restio tremulus*, *Schoenus rodwayanus* and *Viminaria juncea*. This plant community is closely related to a variant of the A type as defined by Havel (1975a) for the northern Jarrah forest. This community has been recorded previously by the authors in the northern Jarrah forest, although the type was defined in the original studies by Havel (1975a). The type occurs mainly on clay-loam soils in seasonally moist to wet swamps. The type is more common on the eastern areas of the Yarragil complex and in particular the Pindalup and Swamp vegetation complexes as defined by Heddle et al.(1980). This type is widespread within the southern section of the Ewington Deposit survey area, on soils dominated by clays which are water-logged in winter (see Vegetation Map enclosed).

**Site-vegetation Type: $A_3$**

$A_3$ consists of a low open woodland of *Melaleuca preissiana - Banksia littoralis* over open understorey of shrubs and low sedges. Understorey species include *Actinostrobus pyramidalis*, *Allocasuarina microstachya*, *Hakea prostrata* and *Jacksonia furcellata*. This community is similar to the extensive clay swamps that occur on the Swan Coastal Plain (e.g. near Bullsbrook). This type is restricted within the Ewington Deposit survey area and is not typical of the northern Jarrah forest. This type is restricted within the Ewington Deposit survey area to a small pocket on the southern extremities of the survey area (see Vegetation Map enclosed).

**Site-vegetation Type: B**

B consists of an open woodland of *Eucalyptus marginata - Melaleuca preissiana - Nuytsia floribunda - Xylomelum occidentale* with occasional stands of *Banksia ilicifolia* and *Banksia attenuata* over low shrubs and sedges. Understorey species include *Adenanthos cygnorum*, *Adenanthos obovatus*, *Baeckea camphorosmae*, *Bossiaea eriocarpa*, *Calytrix flavescens*, *Calytrix ?similis*, *Dasypogon bromeliifolius*, *Eremaea pauciflora*, *Hypocalymma angustifolium*, *Kunzea recurva*, *Lyginia barbata*, *Melaleuca scabra*, *Mesomelaena tetragona*, *Petrophile linearis*, *Phlebocarya ciliata*, *Scholtzia involucrata* and *Verticordia* var. *densiflora*. This plant community is closely related to the B type as defined by Havel (1975a) for the northern Jarrah forest, which is regionally widespread on the

lower slopes of the Goonaping and Yarragil vegetation complexes as defined by Heddle et al.(1980). This type occurs on the valley systems within the Ewington Deposit survey area, where local sandy soils are seasonally moist (see Vegetation Map enclosed). The type differs slightly from the B type defined by Havel ( 1975a) for the northern Jarrah forest due to slight changes in floristic composition which reflect the sandier and wetter soils on the Collie Basin.

**Site-vegetation Type: C**

**C** consists of a low open woodland of *Melaleuca preissiana - Banksia littoralis* over dense understorey of shrubs and sedges. Understorey species include *Agonis linearifolia*, *Astartea fascicularis*, *Baumea articulata*, *Callistemon phoeniceus*, *Gahnia trifida*, *Hakea ceratophylla*, *Hakea varia*, *Hypocalymma angustifolium*, *Juncus pallidus*, *Lepidosperma tetraquetrum*, *Leptocarpus* spp., *Melaleuca lateritia* and *Pericalymma ellipticum.* This plant community is closely related to the C type as defined by Havel (1975a) for the northern Jarrah forest, which is regionally widespread on the Murray and Yarragil vegetation complexes as defined by Heddle et al.(1980). This type occurs on the main creek-lines within the Ewington Deposit survey area (see Vegetation Map enclosed).

**Site-vegetation Type: D**

**D** consists of a woodland of *Eucalyptus marginata - Eucalyptus calophylla*, with scattered *Banksia grandis* and *Persoonia longifolia* over mixed shrub layer. Understorey species include *Adenanthos obovatus*, *Baeckea camphorosmae*, *Boronia fastigiata*, *Bossiaea ornata*, *Dasypogon bromeliifolius*, *Daviesia decurrens*, *Daviesia incrassata*, *Daviesia preissi*, *Dryandra nivea*, *Hakea lissocarpha*, *Hakea prostrata*, *Hibbertia rhadinopoda*, *Hypocalymma angustifolium*,*Kingia australis* (although restricted to only several pockets), *Macrozamia riedlei* and *Xanthorrhoea preissii*.This plant community is closely related to the D type as defined by Havel (1975a) for the northern Jarrah forest, which is regionally widespread on the Yarragil and Murray vegetation complexes as defined by Heddle et al.(1980). This type occurs on the lower valley slopes and is associated with sandy-loams to sand-clays within the Ewington Deposit survey area (see Vegetation Map enclosed).

**Site-vegetation Type: J**

**J** consists of an open woodland to open forest of *Eucalyptus marginata - Eucalyptus calophylla - Banksia attenuata - Banksia ilicifolia* with some *Allocasuarina fraseriana*, *Xylomelum occidentale* and *Nuytsia floribunda* over low understorey of shrubs and sedges. Understorey species include *Adenanthos obovatus*, *Baeckea camphorosmae*, *Bossiaea eriocarpa*, *Calytrix flavescens*, *Calytrix ?similis*, *Conostylis aculeata*, *Dasypogon bromeliifolius*, *Eremaea pauciflora*, *Hibbertia huegelii*, *Hypolaena exsulca*, *Lyginia barbata*, *Mesomelaena tetragona*, *Petrophile linearis*, *Phlebocarya ciliata*, *Scholtzia involucrata* and *Synaphea petiolaris*. This plant community is closely related to the J type as defined by Havel (1975a) for the northern Jarrah forest, which is regionally widespread on the lower and mid slopes of the Goonaping and Yarragil vegetation complexes as defined by Heddle et al.(1980). This type occurs within the Ewington Deposit survey area, where local deep sandy soils dominate (see Vegetation Map enclosed). The type differs slightly from the J type defined by Havel ( 1975a) for the northern Jarrah forest due to slight changes in floristic composition which reflect the sandier and wetter soils on the Collie Basin.

**Site-vegetation Type: P**

**P** consists of an open forest of *Eucalyptus marginata - Allocasuarina fraseriana* with scattered *Banksia grandis* and *Persoonia longifolia* over mixed shrub layer. Understorey species include *Boronia crenulata*, *Boronia fastigiata*, *Bossiaea eriocarpa*, *Conostylis setigera*, *Hypolaena exsulca*, *Lechenaultia biloba*, *Leucopogon nutans* and *Loxocarya fasciculata*. This plant community is closely related to the P type as defined by Havel (1975a) for the northern Jarrah forest, which is regionally widespread on the slopes of the Dwellingup vegetation complexes as defined by Heddle et al.(1980). This type occurs within the Ewington Deposit survey area, where soils are dominated by deep sands (see Vegetation Map enclosed). The type differs slightly from the P type defined by Havel (1975a) for the northern Jarrah forest due to slight changes in floristic composition which reflect the sandier and wetter soils on the Collie Basin.

**Site-vegetation Type: $S_1$**

**$S_1$** consists of an open forest of *Eucalyptus marginata - Eucalyptus calophylla - Allocasuarina fraseriana* with some *Banksia grandis* and *Persoonia longifolia* over low understorey of shrubs and sedges. Understorey species include *Acacia preissiana*, *Bossiaea ornata*, *Hakea lissocarpha*, *Hibbertia commutata*, *Hibbertia hypericoides*, *Hovea chorizemifolia*, *Styphelia tenuiflora* and *Xanthorrhoea preissii*. This plant community is closely related to the S type as defined by Havel (1975a) for the northern Jarrah forest, which is regionally widespread on the slopes of the Dwellingup

vegetation complexes as defined by Heddle et al.(1980). This type occurs within the Ewington Deposit survey area, where soils on valley slopes and ridges are dominated by sandy-gravels (see Vegetation Map enclosed). The type differs slightly from the S type defined by Havel (1975a) for the northern Jarrah forest due to slight changes in floristic composition which reflect the sandier and wetter soils on the Collie Basin.

**Site-vegetation Type: $S_2$**

$S_2$ consists of an open forest of *Eucalyptus marginata - Eucalyptus calophylla* with some *Banksia grandis* and *Persoonia longifolia* over low understorey of shrubs and sedges. Understorey species include *Acacia drummondii*, *Acacia preissiana*, *Bossiaea ornata*, *Hakea lissocarpha*, *Hibbertia commutata*, *Hibbertia hypericoides*, *Hovea chorizemifolia*, *Lasiopetalum floribundum*, *Leucopogon capitellatus*, *Trymalium ledifolium* and *Xanthorrhoea gracilis*. This plant community is closely related to the S type as defined by Havel (1975a) for the northern Jarrah forest, which is regionally widespread on the slopes of the Dwellingup vegetation complexes as defined by Heddle et al.(1980). This type occurs within the Ewington Deposit survey area, where soils on upper valley slopes and ridges are dominated by sandy-gravels and shallow lateritic outcropping (see Vegetation Map enclosed). The type differs slightly from the S type defined by Havel (1975a) for the northern Jarrah forest due to slight changes in floristic composition which reflect the sandier and wetter soils on the Collie Basin.

**Site-vegetation Type: $S_3$**

$S_3$ consists of an open forest of *Eucalyptus marginata - Allocasuarina fraseriana* over shrubs and sedges. Understorey species include *Allocasuarina humilis*, *Bossiaea eriocarpa*, *Hibbertia amplexicaulis*, *Loxocarya fasciculata*, *Petrophile linearis* and *Xanthorrhoea preissii*. This variant of S is restricted in occurrence on the Ewington Deposit survey area to a localized pocket in the south-west corner due to the presence of shallow outcropping which has results in the occurrence of species such as *Allocasuarina humilis* which elsewhere in the northern Jarrah forest are associated with shallow soils. This type is restricted also in the northern Jarrah forest to similar site conditions.

## 4.3 Physiological Stress

A significant level of stress was recorded in the Ewington Deposit survey area, Collie. The stress related to the damage of previous fires (mainly on *Allocasuarina fraseriana*), the presence of insects (mainly on *Eucalyptus marginata*) and the apparent presence of the dieback fungal disease. The latter disease was reflected in the loss of vigour and death of *Eucalyptus marginata*, *Banksia grandis*, *Persoonia longifolia*, *Banksia attenuata*, *Banksia ilicifolia*, *Banksia littoralis*, *Xylomelum occidentale*, *Xanthorrhoea preissii*, *Macrozamia riedlei* and a selection of other species from the families - Proteaceae and Epacridaceae. Results are presented for the 272 recording sites on the enclosed map summarizing the apparent presence of the dieback fungal disease - *Phytophthora cinnamomi*. No sampling of plant material was undertaken to confirm these observations. Interpretations were based on 15 years of previous observations in the northern Jarrah forest by the authors.

The dieback disease was concentrated in the plant communities on the lower valley slopes. As many species in the swamp communities are not susceptible to the dieback disease - *Phytophthora cinnamomi*, the results for these communities do not reflect the obvious presence of the species in these areas.

## 4.4 Logging and Burning History

The majority of the forested areas have been logged at least twice in the Ewington Deposit survey area. The number of stumps recorded at each site are summarized on the attached map. These results reflect the degree of logging on the mid and upper slopes in the plant communities on these areas.

On the basis of field observations, the majority of the area has been burnt within the last four year.

# 5. DISCUSSION

A total of 52 families, 143 genera and 252 species were recorded on the Ewington Deposit survey area, Collie (Appendix A). Of these 252 species, 12 were introduced weed species.

Dominant families were Myrtaceae (29 species), Proteaceae (24 species), Papilionaceae (24 species), Cyperaceae (16 species), Epacridaceae (14 species), Asteraceae (12 species), Poaceae (11 species), Dilleniaceae (10 species), Dasypogonaceae (10 species), Restionaceae (9 species), Haemodoraceae (9 species) and Mimosaceae (8 species).

No gazetted rare species were recorded on the Ewington Deposit survey area, Collie. A range of potentially rare and restricted species were defined for the Collie area. Only one of these was recorded near the Ewington Deposit, Collie (namely - *Restio ustulatus* and *Hibbertia silvestris*). In addition, a range of species were of particular interest as they manifested different patterns of distribution in the Collie Basin from the adjacent forest areas on the Darling Ranges. These trends supported similar patterns at the plant community level.

In the vegetation studies associated with this review of natural resources in the Collie Basin, three vegetation complexes were defined by Heddle et al. (1980). These studies supported the overlap in distribution of some plant species with adjacent regions, but also reflected the significance of the local soils and site conditions on the distribution of plant species. The three vegetation complexes defined were - Collie, Cardiff and Muja. All these vegetation complexes occurred within the Ewington Deposit survey area. On the basis of defining the site-vegetation types for the Ewington Deposit survey area, it was possible to subdivide these vegetation complexes into 11 site-vegetation types. This level of definition is similar to that achieved for other areas within the northern Jarrah forest by Havel (1975a and 1975b) and the authors. The critical determinants of the site-vegetation types are the underlying topographical, soils and moisture regimes within the survey area. In most cases, it was possible to relate the type defined and mapped to similar communities in the adjacent northern Jarrah forest. The exception to this was site-vegetation type $A_3$ which was restricted to the clay soils over exposed secondary laterization in the southern section of the survey area. The latter community had greater affinities with the swamp communities on some of the swamps on the Swan Coastal Plain.

A significant level of stress was recorded in the Ewington Deposit survey area, Collie. The stress related to the damage of previous fires (mainly on *Allocasuarina fraseriana*), the presence of insects (mainly on *Eucalyptus marginata*) and the apparent regular presence of the dieback fungal disease - *Phytophthora cinnamomi* in the plant communities on the lower to mid slopes. The dieback disease was concentrated in the plant communities on the lower valley slopes. Management strategies for disease control should be developed in conjunction with the Department of Conservation and Land Management to restrict further spread of the disease both within the Ewington Deposit survey area and to adjacent forest areas which are under the management of the Department of Conservation and Land Management (and vested in the Lands and Forest Commission).

The majority of the forested areas have been logged at least twice in the Ewington Deposit survey area. These results reflected the degree of logging on the mid and upper slopes in the plant communities on these areas. On the basis of field observations, the majority of the area has been burnt within the last four year.

Potential impacts of the Ewington Deposit development on the flora and vegetation of the area could be minimized by developing management strategies:

- to restrict clearing requirements to a minimum,
- to re-establish local native species on disturbed and modified environment,
- to regulate drainage into already disturbed areas instead of uncleared forested areas,
- to maintain hygiene measures in the area to minimize any further spread of the dieback fungal disease (*Phytophthora cinnamomi*) both within and outside the Ewington Deposit survey area.

The latter measures should be undertaken in consultation with the Environmental Protection and District branches of the Department of Conservation and Land Management.

In summary, the plant species and communities (with the exception of the $A_3$ swamp community) are representative of the Collie Basin. In addition, although the species distributions and patterns differ slightly from the adjacent northern Jarrah forest there are distinct overlaps due to the underlying determinants of topography, soils and moisture regimes. The main management issues should be addressed in consultation with the Department of Conservation and Land Management.

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**APPENDIX A: SUMMARY OF VASCULAR SPECIES ON THE EWINGTON DEPOSIT, COLLIE**

| FAMILIES | SPECIES |
|---|---|
| DENNSTAEDTIACEAE | |
| | Pteridium esculentum |
| LINDSAEACEAE | |
| | Lindsaea linearis |
| ZAMIACEAE | |
| | Macrozamia riedlei |
| CUPPRESSACEAE | |
| | Actinostrobus pyramidalis |
| POACEAE | |
| | *Aira caryophyllea |
| | Amphipogon amphipogonoides |
| | Amphipogon avenaceus |
| | *Avena fatua |
| | *Briza maxima |
| | *Briza minor |
| | Danthonia ?caespitosa |
| | Neurachne alopecuroidea |
| | Stipa semibarbata |
| | Tetrarrhena laevis |
| | *Vulpia myuros |
| CYPERACEAE | |
| | Baumea articulata |
| | Cyathochaeta avenacea |
| | Gahnia trifida |
| | Lepidosperma angustatum |
| | Lepidosperma scabrum |
| | Lepidosperma tenue |
| | Lepidosperma tetraquetrum |
| | Mesomelaena graciliceps |
| | Mesomelaena tetragona |
| | Schoenus curvifolius |
| | Schoenus lanatus |
| | Schoenus rodwayanus |
| | Schoenus subbulbosus |
| | Schoenus subflavus |
| | Tetraria capillaris |
| | Tetraria octandra |

**APPENDIX A: SUMMARY OF VASCULAR SPECIES ON THE EWINGTON DEPOSIT, COLLIE**

| FAMILIES | SPECIES |
|---|---|
| RESTIONACEAE | |
| | Hypolaena exsulca |
| | Leptocarpus coangustatus |
| | Leptocarpus scariosus |
| | Lepyrodia macra |
| | Loxocarya cinerea |
| | Loxocarya fasciculata |
| | Lyginia barbata |
| | Restio tremulus |
| | Restio ustulatus |
| JUNCACEAE | |
| | Juncus pallidus |
| DASYPOGONACEAE | |
| | Dasypogon bromeliifolius |
| | Kingia australis |
| | Lomandra caespitosa |
| | Lomandra effusa |
| | Lomandra hermaphrodita |
| | Lomandra nigricans |
| | Lomandra purpurea |
| | Lomandra sericea |
| | Lomandra sonderi |
| | Lomandra spartea |
| XANTHORRHOEACEAE | |
| | Xanthorrhoea gracilis |
| | Xanthorrhoea preissii |
| PHORMIACEAE | |
| | Dianella revoluta |
| ANTHERICACEAE | |
| | Agrostocrinum scabrum |
| | Thysanotus ?sparteus |
| | Thysanotus teretifolius |
| | Tricoryne elatior |
| COLCHICACEAE | |
| | Burchardia umbellata |

## APPENDIX A: SUMMARY OF VASCULAR SPECIES ON THE EWINGTON DEPOSIT, COLLIE

| FAMILIES | SPECIES |
|---|---|
| HAEMODORACEAE | |
| | Anigozanthos humilis |
| | Anigozanthos manglesii |
| | Conostylis aculeata |
| | Conostylis setigera |
| | Conostylis setosa |
| | Haemodorum laxum |
| | Haemodorum paniculatum |
| | Haemodorum spicatum |
| | Phlebocarya ciliata |
| IRIDACEAE | |
| | Orthrosanthus laxus |
| | Patersonia occidentalis |
| | Patersonia rudis |
| CASUARINACEAE | |
| | Allocasuarina fraseriana |
| | Allocasuarina humilis |
| | Allocasuarina microstachya |
| PROTEACEAE | |
| | Adenanthos cygnorum |
| | Adenanthos obovatus |
| | Banksia attenuata |
| | Banksia grandis |
| | Banksia ilicifolia |
| | Banksia littoralis |
| | Conospermum capitatum |
| | Dryandra bipinnatifida |
| | Dryandra nivea |
| | Hakea amplexicaulis |
| | Hakea ceratophylla |
| | Hakea lissocarpha |
| | Hakea marginata |
| | Hakea prostrata |
| | Hakea ruscifolia |
| | Hakea sulcata |
| | Hakea varia |
| | Persoonia longifolia |
| | Petrophile linearis |
| | Petrophile striata |
| | Stirlingia simplex |
| | Synaphea petiolaris |
| | Synaphea reticulata |
| | Xylomelum occidentale |

APPENDIX A: SUMMARY OF VASCULAR SPECIES ON THE EWINGTON DEPOSIT, COLLIE

| FAMILIES | SPECIES |
|---|---|
| SANTALACEAE | Leptomeria cunninghamii |
| LORANTHACEAE | Nuytsia floribunda |
| AMARANTHACEAE | Ptilotus manglesii |
| CARYOPHYLLACEAE | Polycarpaea longiflora |
| RANUNCULACEAE | Clematis pubescens |
| LAURACEAE | Cassytha glabella |
| DROSERACEAE | Drosera platystigma |
| PITTOSPORACEAE | Billardiera drummondiana |
| | Billardiera ?floribunda |
| | Billardiera variifolia |
| | Sollya heterophylla |
| MIMOSACEAE | Acacia alata |
| | Acacia drummondii |
| | Acacia extensa |
| | Acacia huegelii |
| | Acacia nervosa |
| | Acacia preissiana |
| | Acacia pulchella |
| | Acacia stenoptera |
| CAESALPINIACEAE | Labichea punctata |
| PAPILIONACEAE | Aotus gracillima |
| | Bossiaea eriocarpa |
| | Bossiaea ornata |
| | Burtonia conferta |
| | Daviesia costata |
| | Daviesia decurrens |

APPENDIX A: SUMMARY OF VASCULAR SPECIES ON THE EWINGTON DEPOSIT, COLLIE

| FAMILIES | SPECIES |
|---|---|
| PAPILIONACEAE (Continued) | Daviesia hakeoides |
| | Daviesia incrassata |
| | Daviesia preissii |
| | Euchilopsis linearis |
| | Gompholobium knightianum |
| | Gompholobium marginatum |
| | Gompholobium ovatum |
| | Gompholobium polymorphum |
| | Gompholobium tomentosum |
| | Hovea chorizemifolia |
| | Hovea trisperma |
| | Jacksonia furcellata |
| | Kennedia carinata |
| | Kennedia coccinea |
| | Latrobea tenella |
| | Nemcia capitata |
| | *Trifolium angustifolium |
| | Viminaria juncea |
| RUTACEAE | Boronia crenulata |
| | Boronia fastigiata |
| | Boronia molloyae |
| TREMANDRACEAE | Tetratheca hirsuta |
| POLYGALACEAE | Comesperma flavum |
| | Comesperma virgatum |
| EUPHORBIACEAE | Monotaxis ?occidentalis |
| STACKHOUSIACEAE | Stackhousia huegelii |
| | Stackhousia pubescens |
| | Tripterococcus brunonis |
| RHAMNACEAE | Cryptandra sp. |
| | Trymalium ledifolium |
| STERCULIACEAE | Lasiopetalum floribundum |
| | Thomasia pauciflora |
| | Thomasia aff. purpurea |

APPENDIX A: SUMMARY OF VASCULAR SPECIES ON THE EWINGTON DEPOSIT, COLLIE

| FAMILIES | SPECIES |
|---|---|
| DILLENIACEAE | |
| | Hibbertia amplexicaulis |
| | Hibbertia commutata |
| | Hibbertia ferruginea |
| | Hibbertia huegelii |
| | Hibbertia hypericoides |
| | Hibbertia racemosa |
| | Hibbertia rhadinopoda |
| | Hibbertia silvestris |
| | Hibbertia stellaris |
| | Hibbertia vaginata |
| THYMELAEACEAE | |
| | Pimelea ?angustifolia |
| | Pimelea ciliata |
| | Pimelea lehmanniana var. nervosa |
| MYRTACEAE | |
| | Actinodium cunninghamii |
| | Agonis linearifolia |
| | Astartea fascicularis |
| | Baeckea camphorosmae |
| | Baeckea aff. preissiana |
| | Callistemon phoeniceus |
| | Calothamnus lateralis |
| | Calothamnus planifolius |
| | Calothamnus sanguineus |
| | Calytrix flavescens |
| | Calytrix ?similis |
| | Eremaea pauciflora |
| | Eucalyptus calophylla |
| | Eucalyptus marginata |
| | Eucalyptus rudis |
| | Homalospermum firmum |
| | Hypocalymma angustifolium |
| | Hypocalymma cordifolium |
| | Kunzea ericifolia |
| | Kunzea recurva |
| | Melaleuca lateritia |
| | Melaleuca ?pauciflora |
| | Melaleuca polygaloides |
| | Melaleuca preissiana |
| | Melaleuca scabra |
| | Melaleuca viminea |
| | Pericalymma ellipticum |
| | Scholtzia involucrata |
| | Verticordia var. densiflora |

**APPENDIX A: SUMMARY OF VASCULAR SPECIES ON THE EWINGTON DEPOSIT, COLLIE**

| FAMILIES | SPECIES |
|---|---|
| HALORAGACEAE | |
| | Glischrocaryon aureum |
| | Gonocarpus cordiger |
| APIACEAE | |
| | Pentapeltis peltigera |
| | Xanthosia atkinsoniana |
| | Xanthosia huegelii |
| EPACRIDACEAE | |
| | Andersonia involucrata |
| | Astroloma ciliatum |
| | Astroloma drummondii |
| | Astroloma pallidum |
| | Leucopogon australis |
| | Leucopogon capitellatus |
| | Leucopogon conostephioides |
| | Leucopogon nutans |
| | Leucopogon ?oxycedrus |
| | Leucopogon propinquus |
| | Leucopgon aff. pulchellus |
| | Lysinema ciliatum |
| | Sphenotoma gracile |
| | Styphelia tenuiflora |
| LOGANIACEAE | |
| | Logania serpyllifolia |
| GENTIANACEAE | |
| | *Centaurium erythraea |
| MENYANTHACEAE | |
| | Villarsia sp. |
| CHLOANTHACEAE | |
| | Lachnostachys albicans |
| LAMIACEAE | |
| | Hemiandra pungens |
| | Hemigenia pritzelii |
| OROBANCHACEAE | |
| | *Orobanche minor |
| RUBIACEAE | |
| | Opercularia apiciflora |

**APPENDIX A: SUMMARY OF VASCULAR SPECIES ON THE EWINGTON DEPOSIT, COLLIE**

| FAMILIES | SPECIES |
|---|---|
| LOBELIACEAE | |
| | Isotoma hypocrateriformis |
| | Lobelia tenuior |
| GOODENIACEAE | |
| | Dampiera cuneata |
| | Dampiera linearis |
| | Goodenia filiformis |
| | Lechenaultia biloba |
| | Scaevola calliptera |
| | Velleia sp. |
| STYLIDIACEAE | |
| | Levenhookia pusilla |
| | Stylidium amoenum |
| | Stylidium brunonianum |
| | Stylidium bulbiferum |
| | Stylidium junceum |
| | Stylidium piliferum |
| ASTERACEAE | |
| | *Dittrichia graveolens |
| | Hyalosperma cotula |
| | *Hypochaeris glabra |
| | Olearia paucidentata |
| | Podolepis gracilis |
| | Podotheca ?angustifolia |
| | *Pseudognaphalium luteo-album |
| | Senecio hispidulus |
| | Trichocline spathulata |
| | *Ursinia anthemoides |
| | Waitzia citrina |
| | Waitzia paniculata |

## APPENDIX B: SUMMARY OF SPECIES OCCURRENCE IN RESPECTIVE SITE-VEGETATION TYPES ON THE EWINGTON DEPOSIT, COLLIE

| | SITE-VEGETATION TYPES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $A_1$ | $A_2$ | $A_3$ | B | C | D | J | P | $S_1$ | $S_2$ | $S_3$ |
| Acacia alata | - | - | - | + | - | - | - | - | - | - | - |
| Acacia drummondii | - | - | - | - | - | - | - | - | - | + | - |
| Acacia extensa | - | - | + | + | + | + | + | + | + | + | + |
| Acacia huegelii | - | - | - | + | - | - | - | + | - | - | - |
| Acacia nervosa | - | - | - | - | - | - | - | - | + | + | - |
| Acacia preissiana | - | - | - | - | - | + | + | - | + | + | - |
| Acacia pulchella | - | + | + | + | - | + | + | + | + | + | - |
| Acacia stenoptera | - | + | - | - | + | - | - | - | - | - | - |
| Actinodium cunninghamii | - | + | - | - | - | - | - | - | - | - | - |
| Actinostrobus pyramidalis | - | - | + | - | - | - | - | - | - | - | - |
| Adenanthos cygnorum | + | - | - | + | - | + | + | - | - | - | - |
| Adenanthos obovatus | + | + | - | + | + | + | + | + | + | - | - |
| Agonis linearifolia | + | + | + | + | + | - | - | - | - | - | - |
| Agrostocrinum scabrum | - | - | - | - | - | - | - | + | + | + | - |
| *Aira caryophyllea | - | - | + | + | - | + | + | + | + | + | - |
| Allocasuarina fraseriana | - | - | - | + | - | + | + | + | + | + | + |
| Allocasuarina humilis | - | - | - | - | - | - | + | - | - | - | + |
| Allocasuarina microstachya | - | - | + | - | - | - | - | - | - | - | - |
| Amphipogon amphipogonoides | - | + | - | + | + | + | + | + | + | + | - |
| Amphipogon avenaceus | - | + | - | + | + | + | + | + | + | + | - |
| Andersonia involucrata | - | + | - | - | - | - | - | - | - | - | - |
| Anigozanthos humilis | - | - | - | + | - | - | + | + | + | - | - |
| Anigozanthos manglesii | - | - | - | + | - | - | + | + | + | - | - |
| Aotus gracillima | + | + | + | + | - | - | - | - | - | - | - |
| Astartea fascicularis | + | + | + | + | + | - | - | - | - | - | - |
| Astroloma ciliatum | - | - | - | + | - | + | - | - | - | + | - |
| Astroloma drummondii | - | - | - | - | - | - | - | - | + | + | - |
| Astroloma pallidum | - | - | - | + | - | + | - | - | + | + | - |
| *Avena fatua | + | + | + | + | + | + | + | + | + | - | - |
| Baeckea camphorosmae | + | + | - | + | - | + | + | + | + | + | + |
| Baeckea aff. preissiana | - | - | - | + | - | - | + | - | - | - | - |
| Banksia attenuata | - | - | - | + | - | - | + | - | - | - | - |
| Banksia grandis | - | - | - | + | - | + | - | - | + | + | - |
| Banksia ilicifolia | - | - | - | + | - | - | + | - | - | - | - |
| Banksia littoralis | + | + | + | - | + | - | - | - | - | - | - |
| Baumea articulata | - | + | - | - | + | - | - | - | - | - | - |
| Billardiera drummondiana | - | - | - | - | + | + | - | + | + | + | - |
| Billardiera ?floribunda | - | - | - | - | - | - | - | - | + | + | - |
| Billardiera variifolia | - | - | - | - | + | + | + | + | + | + | - |
| Boronia crenulata | - | - | - | + | - | + | + | + | + | + | - |
| Boronia fastigiata | - | - | - | + | - | + | + | + | - | - | - |
| Boronia molloyae | + | + | - | - | + | - | - | - | - | - | - |
| Bossiaea eriocarpa | - | - | - | + | + | + | + | + | + | + | + |
| Bossiaea ornata | - | - | - | + | - | + | + | + | + | + | - |

**APPENDIX B: SUMMARY OF SPECIES OCCURRENCE IN RESPECTIVE SITE-VEGETATION TYPES ON THE EWINGTON DEPOSIT, COLLIE**

| | SITE-VEGETATION TYPES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $A_1$ | $A_2$ | $A_3$ | B | C | D | J | P | $S_1$ | $S_2$ | $S_3$ |
| *Briza maxima | - | - | + | + | - | - | + | - | + | + | - |
| *Briza minor | - | - | + | + | - | - | + | - | + | + | + |
| Burchardia umbellata | - | - | - | + | - | + | + | + | + | + | - |
| Burtonia conferta | - | - | - | + | - | - | + | + | + | + | - |
| Callistemon phoeniceus | + | + | + | - | + | - | - | - | - | - | - |
| Calothamnus lateralis | - | + | - | + | + | - | - | - | - | - | - |
| Calothamnus planifolius | - | - | - | - | - | - | - | - | + | + | + |
| Calothamnus sanguineus | - | - | - | - | - | - | - | - | + | - | - |
| Calytrix flavescens | - | - | - | + | - | + | + | + | - | - | + |
| Calytrix ?similis | - | - | - | + | - | - | + | - | - | - | - |
| Cassytha glabella | - | + | - | - | - | - | + | - | - | - | - |
| *Centaurium erythraea | - | - | - | + | - | - | - | - | - | - | - |
| Clematis pubescens | - | - | - | - | - | - | - | - | - | + | - |
| Comesperma flavum | + | + | - | - | + | - | - | - | - | - | - |
| Comesperma virgatum | - | - | + | + | + | + | + | + | + | + | - |
| Conospermum capitatum | - | - | - | - | - | + | - | - | - | - | - |
| Conostylis aculeata | - | - | - | + | - | + | + | + | + | + | + |
| Conostylis setigera | - | - | + | + | - | + | + | + | + | + | - |
| Conostylis setosa | - | - | - | + | - | - | - | + | + | + | - |
| Cryptandra sp. | - | - | - | + | - | - | - | - | - | - | - |
| Cyathochaeta avenacea | - | + | - | + | + | + | + | - | + | + | - |
| Dampiera cuneata | - | - | - | + | + | + | + | + | + | + | + |
| Dampiera linearis | - | - | - | - | + | + | + | + | + | - | - |
| Danthonia ?caespitosa | - | - | - | + | - | + | - | - | + | + | - |
| Dasypogon bromeliifolius | - | + | - | + | + | + | + | + | + | + | + |
| Daviesia costata | - | - | - | - | - | - | - | - | + | + | - |
| Daviesia decurrens | - | - | - | - | - | + | + | + | + | + | - |
| Daviesia hakeoides | - | - | - | + | - | + | + | + | + | - | + |
| Daviesia incrassata | - | - | - | + | - | + | + | + | - | - | + |
| Daviesia preissii | - | - | - | + | - | + | + | + | + | + | - |
| Dianella revoluta | - | - | - | - | - | - | - | - | + | + | - |
| *Dittrichia graveolens | + | - | + | + | - | - | - | - | - | - | - |
| Drosera platystigma | - | - | - | - | + | - | - | - | - | - | - |
| Dryandra bipinnatifida | - | - | - | + | - | + | + | - | + | + | + |
| Dryandra nivea | - | - | - | + | - | + | + | - | + | + | - |
| Eremaea pauciflora | - | - | - | + | - | - | + | - | - | - | - |
| Eucalyptus calophylla | + | + | - | + | - | + | + | + | + | + | + |
| Eucalyptus marginata | + | + | - | + | - | + | + | + | + | + | + |
| Eucalyptus rudis | - | + | - | - | - | - | - | - | - | - | - |
| Euchilopsis linearis | - | + | - | + | - | - | - | - | - | - | - |
| Gahnia trifida | + | + | - | + | + | - | - | - | - | - | - |
| Glischrocaryon aureum | - | - | - | - | - | - | - | - | - | + | - |

**APPENDIX B: SUMMARY OF SPECIES OCCURRENCE IN RESPECTIVE SITE-VEGETATION TYPES ON THE EWINGTON DEPOSIT, COLLIE**

| | SITE-VEGETATION TYPES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $A_1$ | $A_2$ | $A_3$ | B | C | D | J | P | $S_1$ | $S_2$ | $S_3$ |
| Gompholobium knightiantum | - | - | - | - | - | - | - | - | - | + | - |
| Gompholobium marginatum | - | - | - | - | - | - | + | - | - | - | - |
| Gompholobium ovatum | - | - | - | - | - | - | - | - | + | + | - |
| Gompholobium polymorphum | - | - | - | - | - | - | + | - | + | + | - |
| Gompholobium tomentosum | - | - | - | + | - | - | + | + | - | - | - |
| Gonocarpus cordiger | - | - | - | - | - | - | - | - | + | + | - |
| Goodenia filiformis | - | + | - | - | + | - | - | - | - | - | - |
| Haemodorum laxum | - | - | - | + | - | + | - | - | - | - | - |
| Haemodorum paniculatum | - | - | - | - | - | - | - | + | + | + | - |
| Haemodorum spicatum | - | - | - | + | - | + | - | - | - | - | - |
| Hakea amplexicaulis | - | - | - | - | + | - | - | - | - | - | - |
| Hakea ceratophylla | + | + | + | + | + | - | - | - | - | - | - |
| Hakea lissocarpha | - | - | - | + | - | + | + | - | + | + | - |
| Hakea marginata | - | - | + | - | - | - | - | - | - | - | - |
| Hakea prostrata | - | - | + | - | - | + | - | - | - | - | - |
| Hakea ruscifolia | - | - | - | - | - | - | + | + | + | - | - |
| Hakea sulcata | + | + | + | - | - | + | - | - | - | - | - |
| Hakea varia | + | + | + | - | + | - | - | - | - | - | - |
| Hemiandra pungens | - | - | + | + | - | + | + | + | + | + | - |
| Hemigenia pritzelii | - | - | - | - | - | - | - | - | + | + | - |
| Hibbertia amplexicaulis | - | - | - | - | - | + | + | + | + | + | + |
| Hibbertia commutata | - | - | - | - | - | - | - | + | + | + | - |
| Hibbertia ferruginea | - | - | - | - | - | - | + | + | + | - | - |
| Hibbertia huegelii | - | - | - | + | - | - | + | + | - | - | - |
| Hibbertia hypericoides | - | - | - | - | - | + | - | + | + | + | - |
| Hibbertia racemosa | - | - | - | - | - | - | + | + | + | - | + |
| Hibbertia rhadinopoda | - | - | - | + | - | + | + | - | + | - | + |
| Hibbertia silvestris | - | - | - | - | - | + | - | - | + | - | - |
| Hibbertia stellaris | - | - | + | + | - | - | - | - | - | - | - |
| Hibbertia vaginata | - | - | - | + | - | - | + | + | + | + | - |
| Homalospermum firmum | - | + | - | + | - | - | - | - | - | - | - |
| Hovea chorizemifolia | - | - | - | + | - | + | - | + | + | + | - |
| Hovea trisperma | - | - | - | + | - | - | - | + | + | + | - |
| Hyalosperma cotula | - | - | - | + | - | - | + | - | - | - | - |
| Hypocalymma angustifolium | + | + | + | + | + | + | + | + | + | + | - |
| Hypocalymma cordifolium | - | - | - | + | - | - | - | - | - | - | - |
| *Hypochaeris glabra | - | - | + | + | - | + | + | + | - | - | - |
| Hypolaena exsulca | - | - | - | + | + | + | + | + | + | - | - |
| Isotoma hypocrateriformis | - | - | - | + | + | - | - | - | - | + | - |
| Jacksonia furcellata | - | + | + | + | + | + | - | + | - | - | - |
| Juncus pallidus | + | + | + | + | + | - | - | - | - | - | - |
| Kennedia carinata | - | - | - | + | - | + | + | - | + | - | - |
| Kennedia coccinea | - | - | - | + | - | + | + | - | - | - | - |
| Kingia australis | - | - | - | - | - | + | - | - | - | - | - |

**APPENDIX B: SUMMARY OF SPECIES OCCURRENCE IN RESPECTIVE SITE-VEGETATION TYPES ON THE EWINGTON DEPOSIT, COLLIE**

| | SITE-VEGETATION TYPES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $A_1$ | $A_2$ | $A_3$ | B | C | D | J | P | $S_1$ | $S_2$ | $S_3$ |
| Kunzea ericifolia | - | - | - | + | - | - | + | + | + | + | - |
| Kunzea recurva | + | + | - | + | + | + | + | - | - | - | - |
| Labichea punctata | - | - | - | - | - | + | - | + | - | + | - |
| Lachnostachya albicans | - | - | - | - | - | - | - | + | - | - | - |
| Lasiopetalum floribundum | - | - | - | + | - | + | + | - | + | + | - |
| Latrobea tenella | + | + | - | + | - | - | - | - | - | - | - |
| Lechenaultia biloba | - | - | - | + | - | + | + | + | + | + | - |
| Lepidosperma angustatum | - | + | - | + | - | + | + | + | + | + | - |
| Lepidosperma scabrum | - | + | + | - | + | - | - | - | - | - | - |
| Lepidosperma tenue | - | - | - | + | - | + | + | - | + | + | + |
| Lepidosperma tetraquetrum | - | - | - | - | + | - | - | - | - | - | - |
| Leptocarpus coangustatus | + | + | + | - | + | - | - | - | - | - | - |
| Leptocarpus scariosus | + | + | + | + | + | + | + | - | - | - | - |
| Leptomeria cunninghamii | - | - | - | - | - | - | - | - | + | + | - |
| Lepyrodia macra | - | - | - | + | - | - | - | - | - | - | - |
| Leucopogon australis | - | - | - | + | - | - | - | - | - | - | - |
| Leucopogon capitellatus | - | - | - | - | - | + | - | - | + | + | - |
| Leucopogon conostephioides | - | - | - | - | - | - | + | + | - | - | - |
| Leucopogon nutans | - | - | - | - | - | - | + | + | - | - | - |
| Leucopogon ?oxycedrus | - | + | - | + | - | - | + | + | - | - | - |
| Leucopogon propinquus | - | - | - | - | - | + | - | + | + | + | - |
| Leucopgon aff. pulchellus | - | + | - | + | - | - | - | - | - | - | - |
| Levenhookia pusilla | - | + | + | + | - | - | - | - | - | - | - |
| Lindsaea linearis | - | - | - | + | - | - | + | - | - | - | - |
| Lobelia tenuior | - | - | - | - | + | - | + | + | + | - | - |
| Logania serpyllifolia | - | - | - | - | - | - | - | - | - | + | + |
| Lomandra caespitosa | - | - | - | - | - | - | - | - | - | + | - |
| Lomandra effusa | - | - | - | - | - | + | + | + | + | - | - |
| Lomandra hermaphrodita | - | - | - | - | - | + | + | + | + | - | - |
| Lomandra nigricans | - | - | - | - | - | - | - | + | - | - | - |
| Lomandra purpurea | - | - | - | + | - | - | - | + | - | + | - |
| Lomandra sericea | - | - | - | - | - | - | + | + | + | - | - |
| Lomandra sonderi | - | - | - | - | - | + | + | + | + | + | - |
| Lomandra spartea | - | - | - | - | - | - | - | - | + | + | - |
| Loxocarya cinerea | - | - | - | - | - | - | - | + | + | + | - |
| Loxocarya fasciculata | + | + | + | + | - | + | + | + | + | + | + |
| Lyginia barbata | - | + | - | + | - | + | + | + | + | - | - |
| Lysinema ciliatum | - | - | - | - | - | + | + | + | + | - | - |
| Macrozamia riedlei | - | - | - | + | - | + | + | + | + | + | - |
| Melaleuca lateritia | + | + | - | - | + | - | - | - | - | - | - |
| Melaleuca ?pauciflora | - | + | - | - | - | - | - | - | - | - | - |
| Melaleuca polygaloides | - | + | + | - | + | - | - | - | - | - | - |
| Melaleuca preissiana | + | + | + | + | + | - | - | - | - | - | - |
| Melaleuca scabra | - | - | - | + | - | - | + | + | - | - | - |
| Melaleuca viminea | + | + | + | - | + | - | - | - | - | - | - |

**APPENDIX B: SUMMARY OF SPECIES OCCURRENCE IN RESPECTIVE SITE-VEGETATION TYPES ON THE EWINGTON DEPOSIT, COLLIE**

| | SITE-VEGETATION TYPES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $A_1$ | $A_2$ | $A_3$ | B | C | D | J | P | $S_1$ | $S_2$ | $S_3$ |
| Mesomelaena graciliceps | - | - | - | + | - | - | - | - | - | - | - |
| Mesomelaena tetragona | - | + | + | + | + | + | + | + | + | + | - |
| Monotaxis ?occidentalis | - | - | - | - | - | - | - | + | + | + | - |
| Nemcia capitata | - | - | - | + | - | - | - | - | - | - | - |
| Neurachne alopecuroidea | - | - | - | + | - | - | - | + | + | + | - |
| Nuytsia floribunda | + | + | - | + | + | + | + | + | + | + | - |
| Olearia pauciflora | - | - | - | - | - | - | - | - | + | - | - |
| Opercularia apicifolia | - | - | - | - | - | - | - | + | + | + | - |
| *Orobanche minor | - | - | - | + | - | - | - | + | - | - | - |
| Orthrosanthus laxus | - | - | - | - | - | - | - | + | - | - | - |
| Patersonia occidentalis | - | - | - | + | - | - | + | + | - | - | - |
| Patersonia rudis | - | - | - | + | - | - | + | + | + | - | - |
| Pentapeltis peltigera | - | - | - | - | - | - | - | - | + | + | - |
| Pericalymma ellipticum | + | + | - | + | + | + | + | + | + | - | - |
| Persoonia longifolia | - | - | - | + | - | + | + | + | + | + | - |
| Petrophile linearis | - | - | - | + | - | - | + | + | + | + | + |
| Petrophile striata | - | - | - | - | - | - | - | - | + | - | - |
| Phlebocarya ciliata | - | + | - | + | + | - | + | + | + | + | + |
| Pimelea ?angustifolia | - | - | - | + | - | - | - | - | - | - | - |
| Pimelea ciliata | - | - | - | - | - | + | - | - | + | + | - |
| Pimelea lehmanniana var. nervosa | - | - | - | - | - | + | + | + | + | + | - |
| Podolepis gracilis | - | - | + | + | - | - | - | - | - | + | - |
| Podotheca ?angustifolia | - | - | + | - | - | - | - | - | - | - | - |
| Polycarpaea longiflora | + | + | + | + | - | - | - | - | - | - | - |
| *Pseudognaphalium luteo-album | + | + | + | + | - | - | + | + | - | - | - |
| Pteridium esculentum | - | - | - | + | - | - | - | + | + | + | - |
| Ptilotus manglesii | + | + | + | + | - | + | + | + | - | - | - |
| Restio tremulus | - | + | - | - | - | - | - | - | - | - | - |
| Restio ustulatus | - | + | - | - | - | - | - | - | - | - | - |
| Scaevola calliptera | - | - | - | + | - | + | - | + | + | + | - |
| Schoenus curvifolius | - | - | - | + | - | - | + | - | - | - | - |
| Schoenus lanatus | + | + | - | + | - | - | - | - | - | - | - |
| Schoenus rodwayanus | + | + | - | + | + | - | - | - | - | - | - |
| Schoenus subbulbosus | + | + | + | + | - | - | - | - | - | - | - |
| Schoenus subflavus | + | + | - | + | - | - | - | - | - | - | - |
| Scholtzia involucrata | - | - | - | + | - | - | + | + | - | - | - |
| Senecio hispidulus | - | - | - | - | - | - | - | + | + | + | - |
| Sollya heterophylla | - | - | - | - | - | - | - | - | + | + | - |
| Sphenotoma gracile | - | + | - | + | + | - | - | - | - | - | - |
| Stackhousia huegelii | - | - | - | + | - | - | - | - | - | - | - |
| Stackhousia pubescens | - | + | - | + | + | - | - | - | - | - | - |
| Stipa semibarbata | - | - | - | - | - | + | - | + | + | + | - |
| Stirlingia simplex | - | - | - | + | - | - | + | + | - | - | - |

**APPENDIX B: SUMMARY OF SPECIES OCCURRENCE IN RESPECTIVE SITE-VEGETATION TYPES ON THE EWINGTON DEPOSIT, COLLIE**

| | SITE-VEGETATION TYPES | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $A_1$ | $A_2$ | $A_3$ | B | C | D | J | P | $S_1$ | $S_2$ | $S_3$ |
| Stylidium amoenum | - | + | - | - | - | + | - | + | + | + | - |
| Stylidium brunonianum | - | - | - | - | - | + | - | + | + | + | - |
| Stylidium bulbiferum | + | - | - | + | - | - | - | - | - | - | - |
| Stylidium junceum | - | - | - | + | - | - | - | + | + | + | - |
| Stylidium piliferum | - | - | - | + | - | + | + | + | + | + | - |
| Styphelia tenuiflora | - | - | - | - | - | + | + | + | + | + | - |
| Synaphea petiolaris | - | - | - | + | - | - | + | + | + | + | - |
| Synaphea reticulata | - | - | - | - | - | + | - | + | + | + | - |
| Tetraria capillaris | - | - | - | + | - | - | + | + | + | + | - |
| Tetraria octandra | - | - | - | + | - | + | + | + | + | + | - |
| Tetrarrhena laevis | - | - | - | - | - | + | - | + | - | + | - |
| Tetratheca hirsuta | - | - | - | - | - | - | - | - | + | + | - |
| Thomasia pauciflora | + | - | - | + | + | - | - | - | - | - | - |
| Thomasia aff. purpurea | - | - | - | + | - | + | + | - | + | + | - |
| Thysanotus ?sparteus | + | + | - | + | - | - | - | + | - | + | - |
| Thysanotus teretifolius | - | - | - | - | - | - | - | - | - | + | - |
| Trichocline spathulata | - | - | - | - | - | - | - | + | - | + | - |
| Tricoryne elatior | - | - | - | - | - | + | - | + | - | + | - |
| *Trifolium angustifolium | - | - | + | - | - | - | - | - | - | - | - |
| Tripterococcus brunonis | - | - | - | - | - | - | - | - | + | - | - |
| Trymalium ledifolium | - | - | - | - | - | + | - | - | - | + | - |
| *Ursinia anthemoides | + | - | - | + | - | - | + | + | - | - | - |
| Velleia sp. | - | + | - | - | - | - | - | - | - | - | - |
| Verticordia var.densiflora | - | + | - | + | - | - | + | - | - | - | - |
| Villarsia sp. | + | - | - | - | + | - | - | - | - | - | - |
| Viminaria juncea | - | + | - | - | - | - | - | - | - | - | - |
| *Vulpia myuros | - | - | - | + | - | - | + | + | - | - | - |
| Waitzia citrina | - | - | + | + | - | + | + | + | - | - | - |
| Waitzia paniculata | - | - | + | + | - | + | + | + | - | - | - |
| Xanthorrhoea gracilis | - | - | - | - | - | + | + | + | + | + | + |
| Xanthorrhoea preissii | - | + | + | + | - | + | + | + | + | + | + |
| Xanthosia atkinsoniana | - | - | - | - | - | - | - | + | + | + | + |
| Xanthosia huegelii | - | - | - | - | - | - | - | - | + | + | - |
| Xylomelum occidentale | - | - | - | + | - | + | + | + | + | - | + |

## APPENDIX C: SUMMARY OF SITE-VEGETATION TYPES ON THE EWINGTON DEPOSIT, COLLIE

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**SITE-VEGETATION TYPE: $A_1$**
**General Description:**

Low open woodland of *Melaleuca preissiana - Banksia littoralis* over dense understorey of shrubs and sedges.

**Indicator Species:**

Tree Species - *Melaleuca preissiana* and *Banksia littoralis*.

Understorey Species - *Astartea fascicularis*, *Agonis linearifolia*, *Boronia molloyae*, *Callistemon phoeniceus*, *Gahnia trifida*, *Hakea ceratophylla*, *Hakea varia*, *Juncus pallidus*, *Leptocarpus scariosus*, *Leptocarpus coangustatus*, *Melaleuca viminea*, *Melaleuca lateritia* and *Pericalymma ellipticum*.

**Topography & Soils:**

Water-gaining sites, seasonally wet swamps.
Grey sands to peaty soils, water-logged in winter.

---

**SITE-VEGETATION TYPE: $A_2$**
**General Description:**

Open woodland of *Melaleuca preissiana - Eucalyptus rudis - Banksia littoralis* over dense understorey of shrubs and sedges.

**Indicator Species:**

Tree Species - *Melaleuca preissiana*, *Eucalyptus rudis* and *Banksia littoralis*.

Understorey Species - *Aotus gracillima*,*Astartea fascicularis*, *Callistemon phoeniceus*, *Calothamnus lateralis*, *Hakea ceratophylla*, *Hakea varia*, *Kunzea recurva*, *Leptocarpus scariosus*, *Leptocarpus coangustatus*, *Melaleuca polygaloides*, *Pericalymma ellipticum*, *Restio tremulus*, *Schoenus rodwayanus* and *Viminaria juncea*.

**Topography & Soils:**

Water-gaining sites, seasonally moist to wet swamps.
Grey clays to red-brown clays, water-logged in winter.

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## APPENDIX C: SUMMARY OF SITE-VEGETATION TYPES ON THE EWINGTON DEPOSIT, COLLIE

---

**SITE-VEGETATION TYPE:** $A_3$

**General Description:**

Low open woodland of *Melaleuca preissiana - Banksia littoralis* over open understorey of shrubs and low sedges.

**Indicator Species:**

Tree Species - *Melaleuca preissiana* and *Banksia littoralis*.

Understorey Species - *Actinostrobus pyramidalis*, *Allocasuarina microstachya*, *Hakea prostrata* and *Jacksonia furcellata*.

**Topography & Soils:**

Water-gaining sites, seasonally wet swamps.
Grey clays over shallow exposed secondary laterization outcropping, water-logged in winter.

---

**SITE-VEGETATION TYPE:** B

**General Description:**

Open woodland of *Eucalyptus marginata - Melaleuca preissiana - Nuytsia floribunda - Xylomelum occidentale* with occasional stands of *Banksia ilicifolia* and *Banksia attenuata* over low shrubs and sedges.

**Indicator Species:**

Tree Species - *Eucalyptus marginata*, *Melaleuca preissiana*, *Nuytsia floribunda*, *Xylomelum occidentale*, *Banksia attenuata* and *Banksia ilicifolia*.

Understorey Species - *Adenanthos cygnorum*, *Adenanthos obovatus*, *Baeckea camphorosmae*, *Bossiaea eriocarpa*, *Calytrix flavescens*, *Calytrix ?similis*, *Dasypogon bromeliifolius*, *Eremaea pauciflora*, *Hypocalymma angustifolium*, *Kunzea recurva*, *Lyginia barbata*, *Melaleuca scabra*, *Mesomelaena tetragona*, *Petrophile linearis*, *Phlebocarya ciliata*, *Scholtzia involucrata* and *Verticordia* var. *densiflora*.

**Topography & Soils:**

Water-gaining sites, seasonally moist valley floors.
Grey sands, seasonally moist in winter.

---

**APPENDIX C: SUMMARY OF SITE-VEGETATION TYPES ON THE EWINGTON DEPOSIT, COLLIE**

---

**SITE-VEGETATION TYPE: C**
**General Description:**

Low open woodland of *Melaleuca preissiana - Banksia littoralis* over dense understorey of shrubs and sedges.

**Indicator Species:**

Tree Species - *Melaleuca preissiana* and *Banksia littoralis.*

Understorey Species - *Agonis linearifolia*, *Astartea fascicularis*, *Baumea articulata*, *Callistemon phoeniceus*, *Gahnia trifida*, *Hakea ceratophylla*, *Hakea varia*, *Hypocalymma angustifolium*, *Juncus pallidus*, *Lepidosperma tetraquetrum*, *Leptocarpus* spp., *Melaleuca lateritia* and *Pericalymma ellipticum.*

**Topography & Soils:**

Water-gaining creek-beds, seasonal flows.
Soils vary from sandy-peats to sandy-clays, water-logged in winter.

---

**SITE-VEGETATION TYPE: D**
**General Description:**

Woodland of *Eucalyptus marginata - Eucalyptus calophylla*, with scattered *Banksia grandis* and *Persoonia longifolia* over mixed shrub layer.

**Indicator Species:**

Tree Species - *Eucalyptus marginata*, *Eucalyptus calophylla*, *Banksia grandis* and *Persoonia longifolia.*

Understorey Species - *Adenanthos obovatus*, *Baeckea camphorosmae*, *Boronia fastigiata*, *Bossiaea ornata*, *Dasypogon bromeliifolius*, *Daviesia decurrens*, *Daviesia incrassata*, *Daviesia preissi*, *Dryandra nivea*, *Hakea lissocarpha*, *Hakea prostrata*, *Hibbertia rhadinopoda*, *Hypocalymma angustifolium*,*Kingia australis* (although restricted to only several pockets), *Macrozamia riedlei* and *Xanthorrhoea preissii.*

**Topography & Soils:**

Water-loss sites, seasonally moist valley lower slopes.
Grey sandy-loams to sandy-clays, seasonally moist in winter.

---

## APPENDIX C: SUMMARY OF SITE-VEGETATION TYPES ON THE EWINGTON DEPOSIT, COLLIE

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**SITE-VEGETATION TYPE: J**

**General Description:**

Open woodland to open forest of *Eucalyptus marginata - Eucalyptus calophylla - Banksia attenuata - Banksia ilicifolia* with some *Allocasuarina fraseriana*, *Xylomelum occidentale* and *Nuytsia floribunda* over low understorey of shrubs and sedges.

**Indicator Species:**

Tree Species - *Eucalyptus marginata*, *Eucalyptus calophylla*, *Banksia attenuata*, *Banksia ilicifolia*, *Nuytsia floribunda*, *Xylomelum occidentale* and *Allocasuarina fraseriana*

Understorey Species - *Adenanthos obovatus*, *Baeckea camphorosmae*, *Bossiaea eriocarpa*, *Calytrix flavescens*, *Calytrix ?similis*, *Conostylis aculeata*, *Dasypogon bromeliifolius*, *Eremaea pauciflora*, *Hibbertia huegelii*, *Hypolaena exsulca*, *Lyginia barbata*, *Mesomelaena tetragona*, *Petrophile linearis*, *Phlebocarya ciliata*, *Scholtzia involucrata* and *Synaphea petiolaris*.

**Topography & Soils:**

Water-loss, lower to mid valley slopes.
Soils dominated by deep grey leached sands.

---

**SITE-VEGETATION TYPE: P**

**General Description:**

Open forest of *Eucalyptus marginata - Allocasuarina fraseriana* with scattered *Banksia grandis* and *Persoonia longifolia* over mixed shrub layer.

**Indicator Species:**

Tree Species - *Eucalyptus marginata*, *Allocasuarina fraseriana*, *Banksia grandis* and *Persoonia longifolia*.

Understorey Species - *Boronia crenulata*, *Boronia fastigiata*, *Bossiaea eriocarpa*, *Conostylis setigera*, *Hypolaena exsulca*, *Lechenaultia biloba*, *Leucopogon nutans* and *Loxocarya fasciculata*.

**Topography & Soils:**

Water-loss, mid to upper valley slopes.
Soils dominated by deep grey leached sands.

---

426 000 E
427 000 E
428 000 E
429 000 E
6 311 000 N
6 310 000 N
6 309 000 N
6 308 000 N

EWINGTON MINE SITE

## SITE-VEGETATION TYPES

**$A_1$** Low open woodland of *Melaleuca preissiana - Banksia littoralis* over dense understorey of shrubs and sedges on seasonally wet sands and peaty soils.

**$A_2$** Open woodland of *Melaleuca preissiana - Eucalyptus rudis - Banksia littoralis* over dense understorey of shrubs and sedges on seasonally wet clay soils.

**$A_3$** Low open woodland of *Melaleuca preissiana - Banksia littoralis* over open understorey of shrubs and low sedges on clays over shallow exposed secondary laterization outcropping.

**B** Open woodland of *Eucalyptus marginata - Melaleuca preissiana - Nuytsia floribunda - Xylomelum occidentale* with occasional stands of *Banksia attenuata* over low shrubs and sedges on seasonally moist grey sands.

**C** Low open woodland of *Melaleuca preissiana - Banksia littoralis* over dense understorey of shrubs and sedges on creek-beds with variable soils (sandy-peats to sandy-clays).

**D** Woodland of *Eucalyptus marginata - Eucalyptus calophylla*, with scattered *Banksia grandis* and *Persoonia longifolia* over mixed shrub layer on seasonally moist grey sandy-loams to sandy-clays.

**J** Open woodland to open forest of *Eucalyptus marginata - Eucalyptus calophylla - Banksia sicifolia* with some *Allocasuarina fraseriana, Xylomelum occidentale* and *Nuytsia floribunda* over low understorey of shrubs and sedges on deep grey sands on lower to mid valley slopes.

**P** Open forest of *Eucalyptus marginata - Allocasuarina fraseriana* with scattered *Banksia grandis* and *Persoonia longifolia* over mixed shrub layer on deep grey sands on mid to upper valley slopes.

**$S_1$** Open forest of *Eucalyptus marginata - Eucalyptus calophylla - Allocasuarina fraseriana* with some *Banksia grandis* and *Persoonia longifolia* over low understorey of shrubs and sedges on sandy-gravels.

**$S_2$** Open forest of *Eucalyptus marginata - Eucalyptus calophylla* with some *Banksia grandis* and *Persoonia longifolia* over low understorey of shrubs and sedges on sandy gravels over lateritic outcropping.

**$S_3$** Open forest of *Eucalyptus marginata - Allocasuarina fraseriana* over shrubs and sedges on shallow sand-gravels over outcropping.

**M** Mined Areas

**CL** Cleared Areas

**LEGEND**

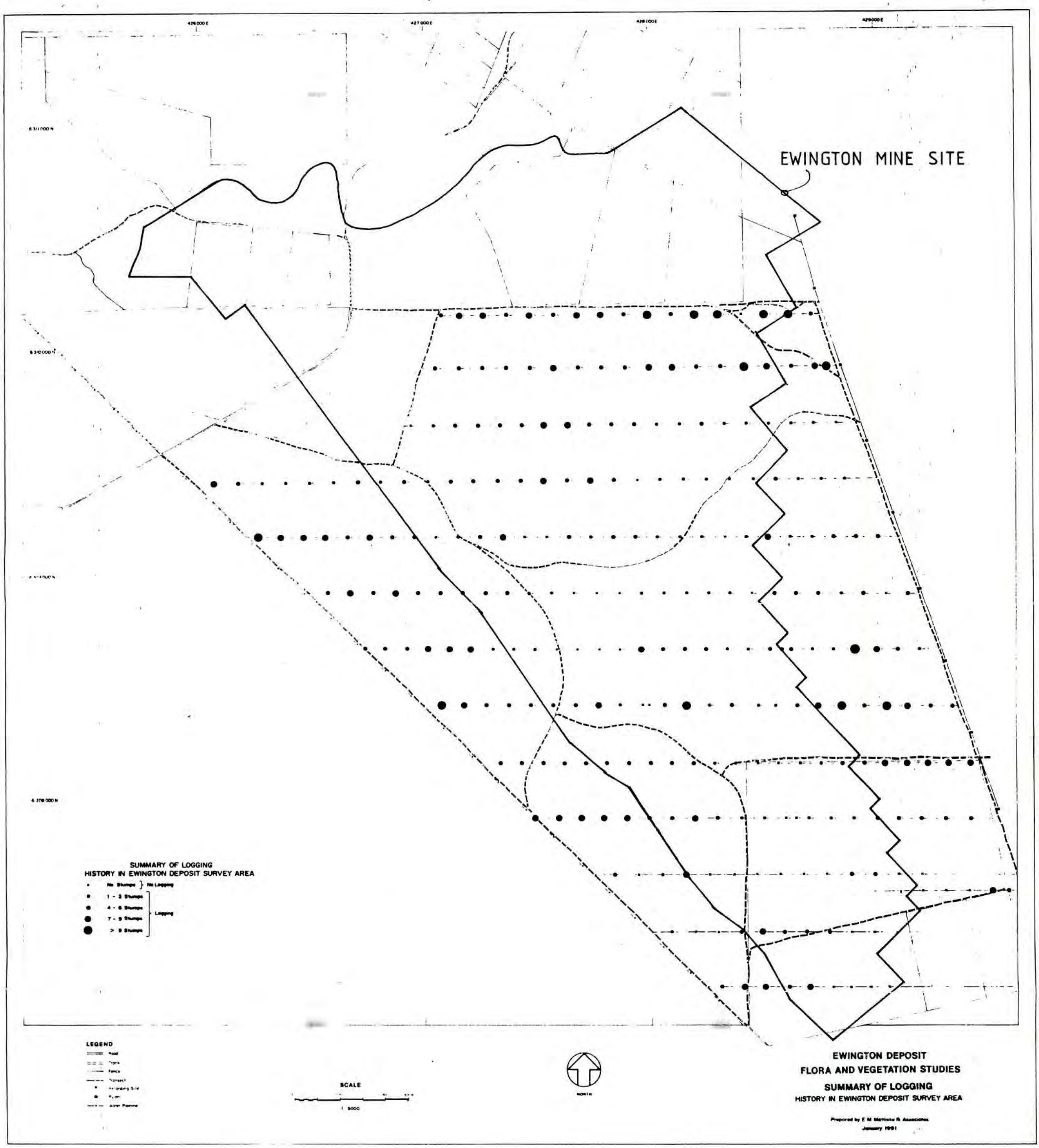
Road
Track
Fence
Transect
Recording Site
Pylon
Water Pipeline

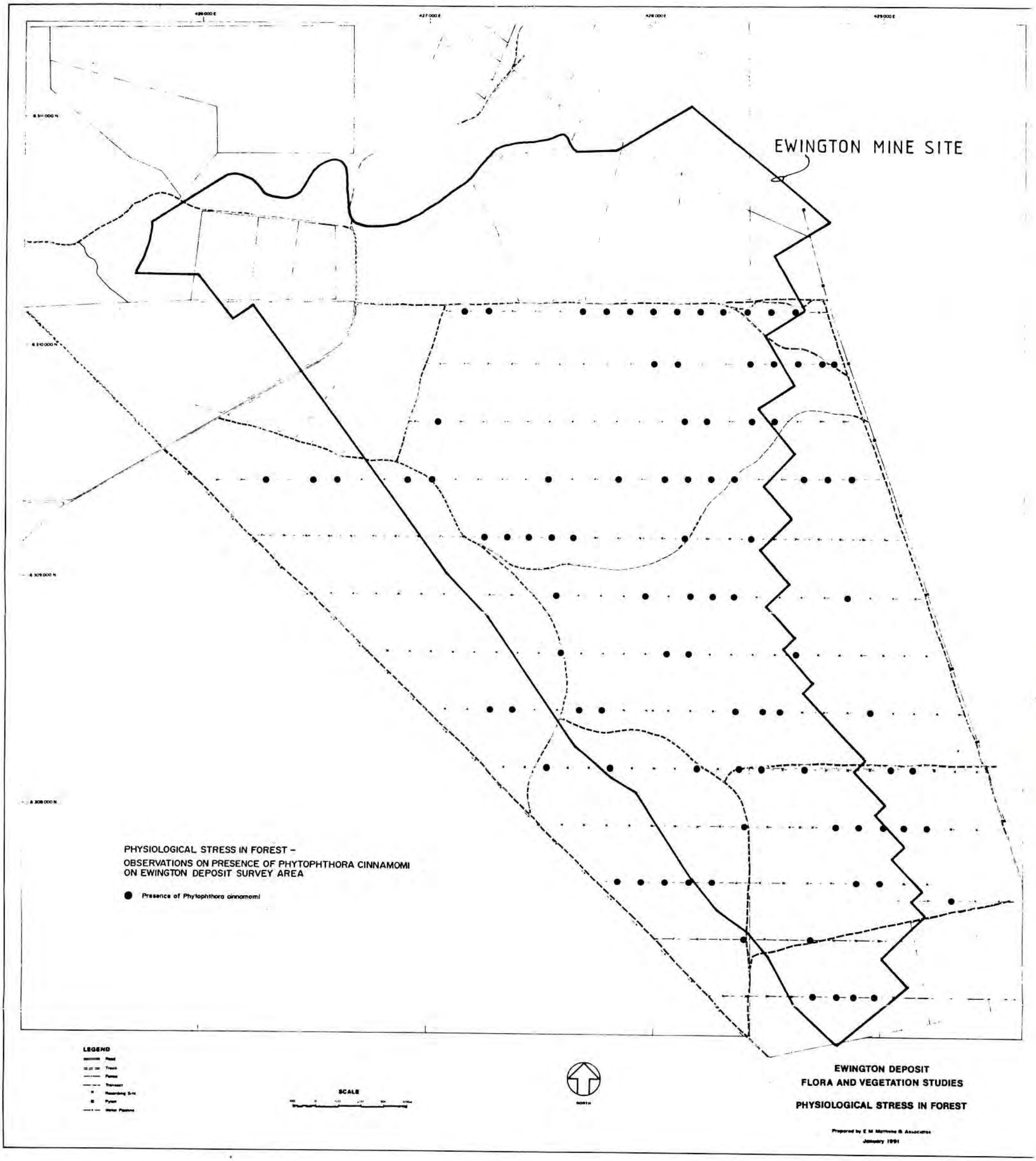
**SCALE**

NORTH

**EWINGTON DEPOSIT**
**FLORA AND VEGETATION STUDIES**
**SITE-VEGETATION TYPES**

Prepared by E M Mattiske & Associates
January 1991


426 000 E
427 000 E
428 000 E
429 000 E
6 311 000 N
6 310 000 N
6 309 000 N
EWINGTON MINE SITE
SUMMARY OF LOGGING
HISTORY IN EWINGTON DEPOSIT SURVEY AREA
No Stumps } No Logging
1 - 3 Stumps
4 - 6 Stumps
7 - 9 Stumps
> 9 Stumps
Logging
LEGEND
Road
Track
Fence
Transect
Sampling Site
Plot
Aster Parvus
SCALE
1 5000
NORTH
EWINGTON DEPOSIT
FLORA AND VEGETATION STUDIES
SUMMARY OF LOGGING
HISTORY IN EWINGTON DEPOSIT SURVEY AREA
Prepared by E M Mattiske & Associates
January 1991


428 000 E
427 000 E
426 000 E
429 000 E
6 311 000 N
6 310 000 N
6 309 000 N
6 308 000 N
EWINGTON MINE SITE
PHYSIOLOGICAL STRESS IN FOREST –
OBSERVATIONS ON PRESENCE OF PHYTOPHTHORA CINNAMOMI
ON EWINGTON DEPOSIT SURVEY AREA
Presence of Phytophthora cinnamomi
LEGEND
Road
Track
Fence
Transect
Recording Site
Pylon
Water Pipeline
SCALE
NORTH
EWINGTON DEPOSIT
FLORA AND VEGETATION STUDIES
PHYSIOLOGICAL STRESS IN FOREST
Prepared by E M Mattiske & Associates
January 1991

# APPENDIX F
# FAUNA REPORT

THE GRIFFIN COAL MINING COMPANY PTY. LIMITED

# EWINGTON OPEN CUT COAL MINE PROJECT

# CONSULTATIVE ENVIRONMENTAL REVIEW: FAUNA SURVEY

JANUARY 1991

Prepared by

*ecologia* ENVIRONMENTAL CONSULTANTS

**CONTENTS** 2

TABLES



FIGURES



PLATES

## SUMMARY

The project area encompasses landforms and vegetation associations which are widely distributed in the Collie basin. The area is characterised by Jarrah - Marri forests, Banksia and Melaleuca Woodlands and sedge - shrub wetlands.

Knowledge of the region's fauna, unlike that of the flora, remains very incomplete. Continued sporadic fauna information arises from Environmental Impact Assessment of proposed mining and industrial developments, CALM research projects and opportunistic collecting by amateur naturalists. The populations of numerous species of conservation significance, such as the Western Native Cat *Dasyurus geoffroii* and Southern Brown Bandicoot *Isoodon obesulus*, are poorly documented.

An intensive field survey of the project area was carried out by ***ecologia*** Environmental Consultants in early November 1990. The principal aim was to document the existing fauna, delineate the main faunal habitats, integrate previously published and unpublished information,develop appropriate recommendations and management stratagies.

The project area lies in the Collie Basin well within the major zoogeographic region of the mesic South-west Western Australia and the fauna present is typical of the Jarrah Forest of the Darling Range.The field survey recorded 34 species of bird, 6 native and 4 introduced mammals, 12 reptiles and 2 amphibians. On the basis of literature searches and species known habitat preferences the project area may support approximately 102 bird species, 30 native and 10 introduced mammal, 46 reptile and 12 amphibians.

Faunal habitats are closely aligned with landform - vegetation associations. Four major faunal habitats occur within the Ewington Project area, jarrah - marri forests with a variety of understoreys, Banksia woodlands and Melaleuca woodlands with varying degree of sedge and shrub understoreys and the sedge and shrub wetlands in drainage lines and swamps. Full descriptions of the site - vegetation types are contained within Mattiske & Associates (1991).

Fauna of significance which occur within the project area are the Southern Brown Bandicoot and the Tammar Wallaby, the population of which is of uncertain status and may require further investigation. With confirmation of status, these species may require special protection at specific localities within the area. It is considered that the only gazetted rare species which may be impacted by the Ewington Coal Mine Project are the Southern Brown Bandicoot *Isoodon obesulus* and possibly the Tammar Wallaby *Macropus eugenii.*

The principal impacts from the construction of the proposed developments will be the loss of vegetated area, reduction in area of forest and woodland habitat and the impositions on the swamp drainage system. The area loss from the developments (800 ha) is insignificant in comparison to the ecological habitat - vegetation units represented within the region. The area is already of a degraded nature due to historical forestry practices.

The impact on the fauna is generally secondary. There will be major local impacts initially with destruction of habitat and loss of sedentary species and relocation of mobile species into adjacent habitats. Impacts may be minimised by staging clearing, limiting clearing to absolute essential minimum, fencing off dangerous areas and limiting road and track development. Increased traffic may cause localised death of larger mobile species, predominately kangaroos, wallabys and monitor lizards.

# 1. INTRODUCTION

The Ewington Open Cut Coal Mine proposed by The Griffin Coal Mining Company Pty. Limited is located at (33°21' S,116°13'E) 5.5 km east of Collie, Western Australia (Fig. 1.). The proposed development includes an open-cut pit mine, mine facilities and infrastructure covering 14 $km^2$ , of which 60% is forested (Fig. 2.), within 20 mining tenements CML 633-636, 642-645, 648, 744-753, 756 . In accordance with Environmental Protection Authority requirements the project feasibility study will be formally assessed at the level of Consultative Environmental Review. The guidelines for the CER require the documentation of the existing biota of the project area, an assessment of the potential impacts with recommendations for management and rehabilitation. To fulfil these objectives ***ecologia*** Environmental Consultants carried out a fauna survey in November 1990 to provide baseline information on the vertebrate fauna of the project area. Additionally this report, which documents the survey undertaken, will detail;

A) An inventory of;

-vertebrate species list including recent published and unpublished records.
-valuable faunal habitats and critical resources.
-records of species which might be expected to occur but whose presence is as yet unrecorded.

B) A review of;

-biologically significant species including rare fauna.
-introduced exotic or declared pest species and their impact.
-environmental impacts and recommendations for management.

C) An assessment of;

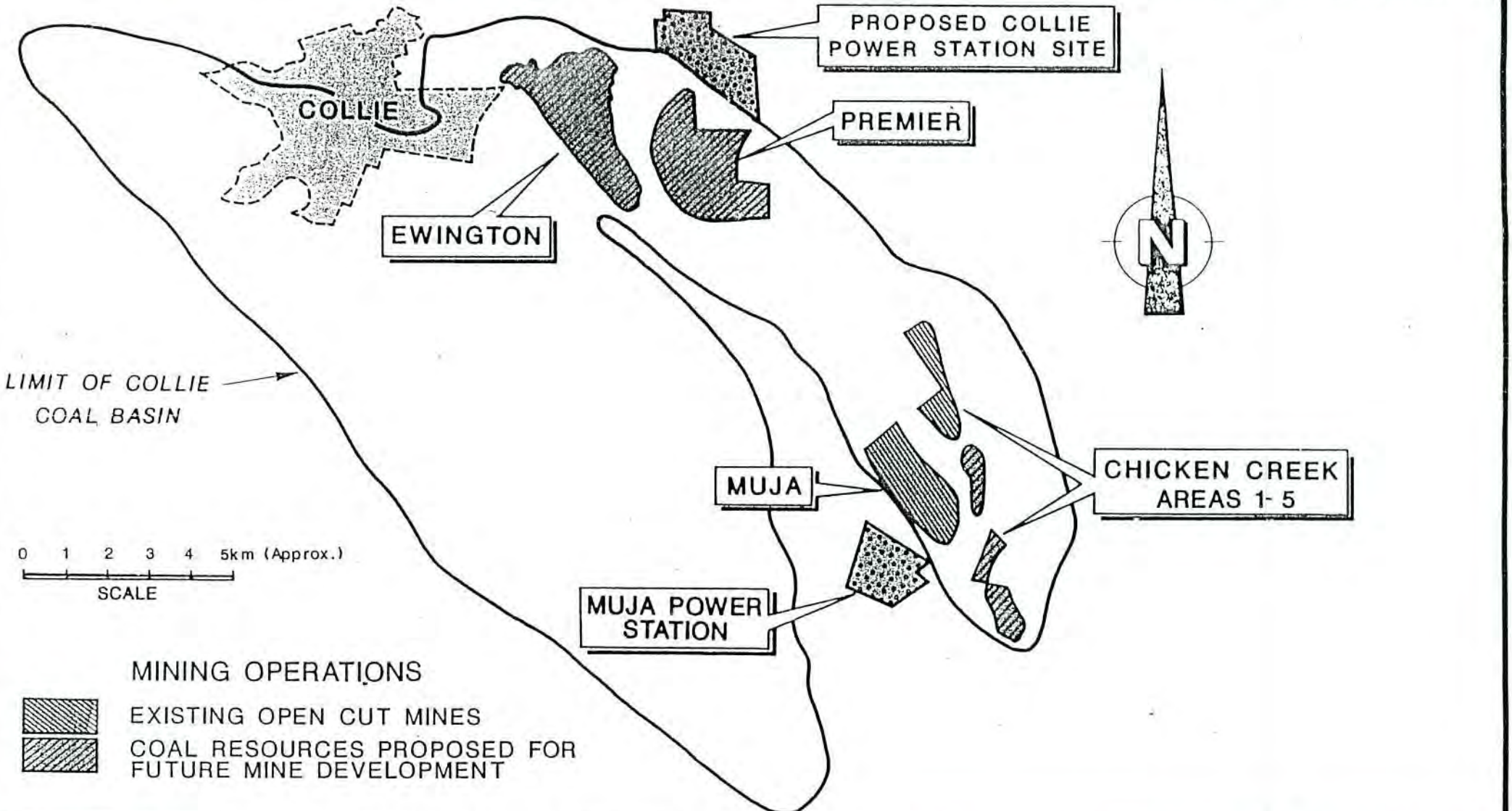
-the regional and local conservational value of the flora and fauna of the intended development area.

## 1.1 Previous Biological Studies

The South-West Region is of considerable environmental significance with a high degree of endemism as well as numerous species which are rare or with restricted geographic distributions. Extensive previous biological research has been carried out in the Darling Ranges resulting from its proximity to densely populated areas and intensive multiple landuses, including agriculture, timber production, mining, recreation and conservation (Forests Department, 1976). Early biological research centred on broad scale vegetation mapping by Diels (1906), Gardener (1942), Holland (1953) and Speck (1958) relating site characteristics to vegetation associations. Later mapping by Beard (1979) and Smith emphasised physiognomy and floristic dominants. Detailed site specific flora surveys began with Williams (1932, 1945) and were developed into the widely used "site-vegetation" system by Havel (1975a, b). The widespread forestry industry and bauxite mining has stimulated extensive botanical research within the Darling Ranges.

Knowledge of the region's fauna, unlike that of the flora, remains very incomplete. Continued sporadic fauna information arises from Environmental Impact Assessment of proposed mining and industrial developments, such as the Worsley Alumina Project (Worsley Alumina Pty Ltd,1985) and Harris River Dam (Harold, 1985), CALM research projects and opportunistic collecting by amateur naturalists (Nichols and Nichols, 1984). However given the diversity of landforms and the paucity of biological survey work, the region is undoubtedly richer in fauna than currently known. The populations of numerous species of conservation significance, such as the Western Native Cat *Dasyurus geoffroii* and Southern Brown Bandicoot *Isoodon obesulus*, are poorly documented.

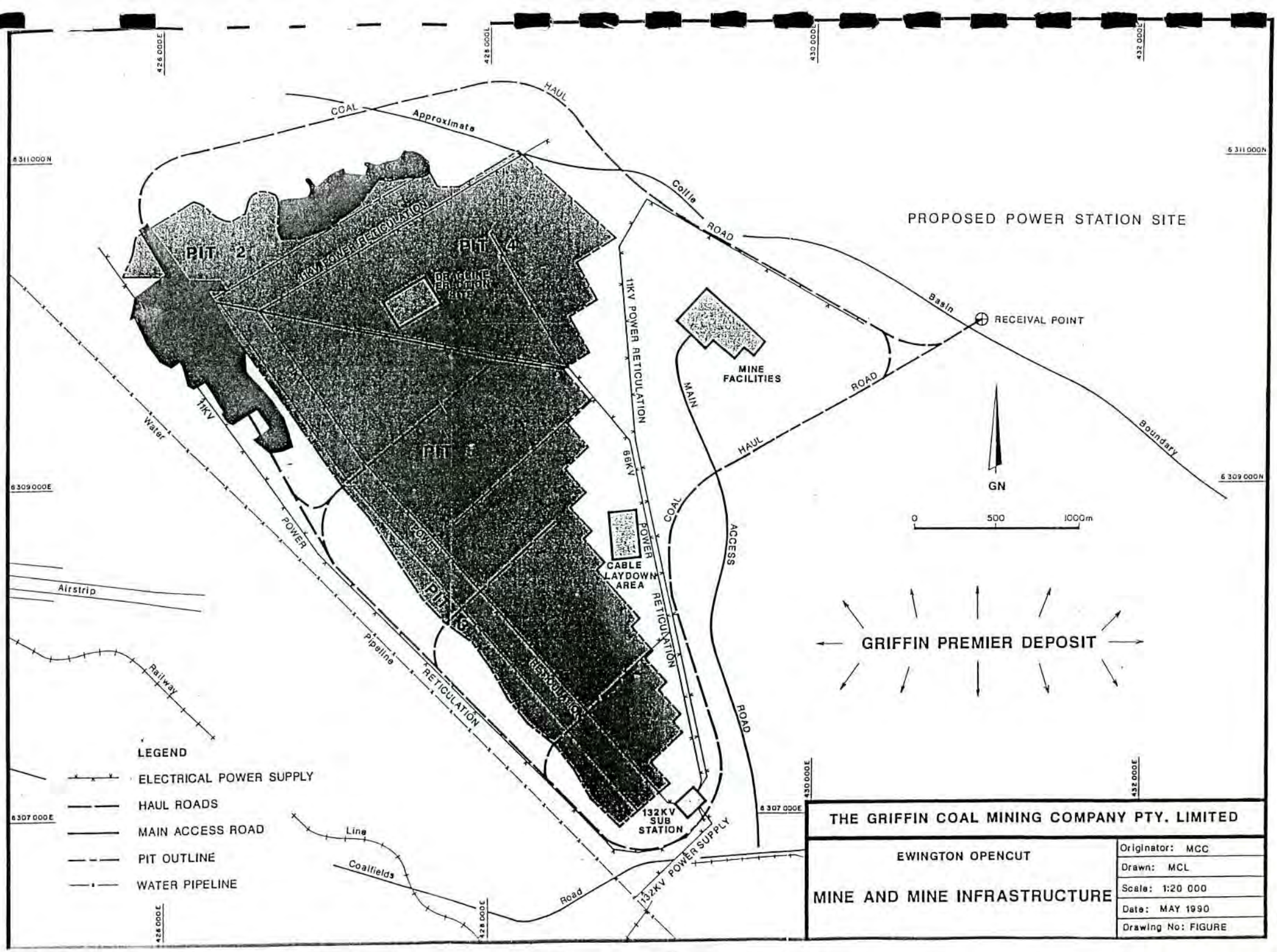
The vertebrate fauna of the Collie Basin was reviewed by Butler (Fuel and Power Commission of WA) and Forests Department Information Sheets (Christensen and Kimber, 1977; Kimber and Christensen, 1976). In all cases, virtually no details specific to the project area were available.




THE GRIFFIN COAL MINING COMPANY PTY. LIMITED

# DISPOSITION OF MAJOR COAL RESERVE AREAS COLLIE BASIN

| | |
|---|---|
| Originator: | DAM |
| Drawn: | |
| Scale: | |
| Date: | MAY 1990 |
| Drawing No: | FIGURE 1 |




THE GRIFFIN COAL MINING COMPANY PTY. LIMITED

EWINGTON OPENCUT

MINE AND MINE INFRASTRUCTURE

| | |
|---|---|
| Originator: | MCC |
| Drawn: | MCL |
| Scale: | 1:20 000 |
| Date: | MAY 1990 |
| Drawing No: | FIGURE |

# 2 BIOPHYSICAL ENVIRONMENT

## 2.1 Climate

The climate of the south-west of Western Australia is described as Mediterranean with cool wet winters and hot dry summers (Gentilli 1947, 1951). The strongly seasonal climate is reflected in the rainfall and temperature conditions. Greater than 80% of rainfall occurs between May to October with a yearly average of 1350 mm (Australian Bureau of Meteorology, 1965,1966).

## 2.2 Physiography, Geology and Soils

The Collie Basin lay within the Darling Plateau which is an uplifted plateau dissected by a major series of rivers and their tributaries. The dominant rock of the plateau is granite, in the form of batholiths ,dykes and sills over Precambrian greenstones, schists, whitestones and gneisses (Biggs *et al.*, 1980). Regional geology influences landform and soils. A mantle of weathered rock predominated by ferruginous and bauxite horizons overlies the plateau (Churchward and McArthur,1980). Soil distribution patterns have resulted from the effect of climate through erosional modification and drainage patterns (Stephens,1962; Northcote *et al*, 1967).

## 2.3 Vegetation associations and habitats

The vegetation of the Collie Basin is primarily jarrah - marri forests, banksia woodlands and paperbark woodlands comprising three vegetation complexes defined by Heddle *et al* (1980). The distribution of vegetation complexes reflects the pattern of the underlying geology, topography and soils (Department of Conservation and Environment,1980).The complexes defined were ;

**"Collie"**

An open forest of jarrah - marri - sheoak with an understorey varying with the proportion of sand and gravels in the soil. Understoreys on gravel substrates contain *Banksia grandis, Persoonia longifolia, Leucopogon capitellatus* and *Hakea lissocarpha.* Sandy substrates support understoreys of *Daviesia incrassata, Xylomelum occidentale* and *Dasypogon bromeliifolius.*

**"Cardiff"**

An open banksia woodland of *Banksia attenuata - B. ilicifolia* and *Nuytsia floribunda* with a variable understorey reflecting soil moisture. Drier soils accommodating *Kunzea ericifolia*, *Calothamnus* spp., *Jacksonia furcellata* and *Bossiaea eriocarpa*, while moister soils contain understoreys with *Pericalymma ellipticum, Adenanthos obovatus*, and *Hypocalymma angustifolium.*

**"Muja"**

An open - woodland of *Melaluca preissiana - Banksia littoralis.* Again similar to the Cardiff complex the understorey exhibits variation reflecting soil moisture variation. On drier areas common species include *Lepidosperma angustatum, Lyginia barbata* and *Dasypogon bromeliifolius* while wetter soils support *Hakea caratophylla, Agnois linearifolia* and *Adenanthos obovatus.*

The Ewington deposit area includes representatives of most of the Collie Basin vegetation and the three basic vegetation complexes have been subdivided into 11 site vegetation types and detailed in Mattiske & Associates (1991). The subdivision was based on local variations in structural and floristic compositions and site conditions.

## 3. SURVEY METHODOLOGY

An intensive five day field survey was carried out in the project area from 19 th to 23 rd November 1990. Assessment of the vertebrate fauna was carried out using a variety of trapping, searching and observation techniques. During the field work all fauna and secondary evidence of fauna, such as tracks, diggings and scats were recorded.

Ten trapping areas (Fig 3) were chosen as being; (i) representative of major habitat-vegetation units and (ii) areas of major environmental impact from proposed development.

Trapping methods employed were;

A) Pit-trap drift fence - 5 lines of five PVC (16 cm diam., 40 cm deep)pits, 30m apart with 10m flywire drift fence (30cm high) were dug in the ground and baited with universal bait (rolled oats, peanut paste, honey, sardines, bacon).

B) Elliot box traps - eight grids of 25 medium box traps 10m apart in 5 rows of 5 traps, baited with universal bait.

C) Possum traps - six lines of 5 Tomahawk cage traps, baited with universal bait.

All traps were checked and rebaited each morning during the study period.

Quantitative assessment of bird habitat utilization centred on 200m x 200m Bird Observation Quadrats located at ten sites (Fig 3). Bird observations were collected between 0700 hr and 1700 hr by systematic foot traversing through the Quadrats for 30 minutes.Total species and number of each species present were recorded for each quadrat.

Opportunistic fauna sightings were recorded while searching or travelling. All major habitats were searched for cryptic species and nocturnal species were assessed by spot-lighting and head-torch searching.

Nomenclature is based on; Birds - Pizzey (1983), Mammals - Strahan (1983), Amphibians - Tyler *et al* (1984), Reptiles - Storr *et al* (1981,1983,1986,1990).

## 4 FAUNA

The project area lies in the Collie Basin well within the major zoogeographic region of the mesic South West Western Australia and the fauna present is typical of the Jarrah Forest of the Darling Range.The field survey recorded 34 species of bird, 6 native and 4 introduced mammals, 12 reptiles and 2 amphibians. On the basis of literature searches and species known habitat preferences the project area may support approximately 102 bird species, 30 native and 10 introduced mammal, 46 reptils and 12 amphibians (Appendix A). The low species richness recorded during the field survey is indicative of the inclement weather experienced during 60% of the field time. It is widely known that within jarrah forest habitats spring is the optimal period for collecting vertebrate data, species richness and abundance is greatest at this time (Worsley Alumina Pty Ltd, 1985). Increased survey duration and appropriate seasonal timing would undoubtedly increase the number of species recorded from the project area. The number of reptile and amphibian species in particular would increase with further field survey.

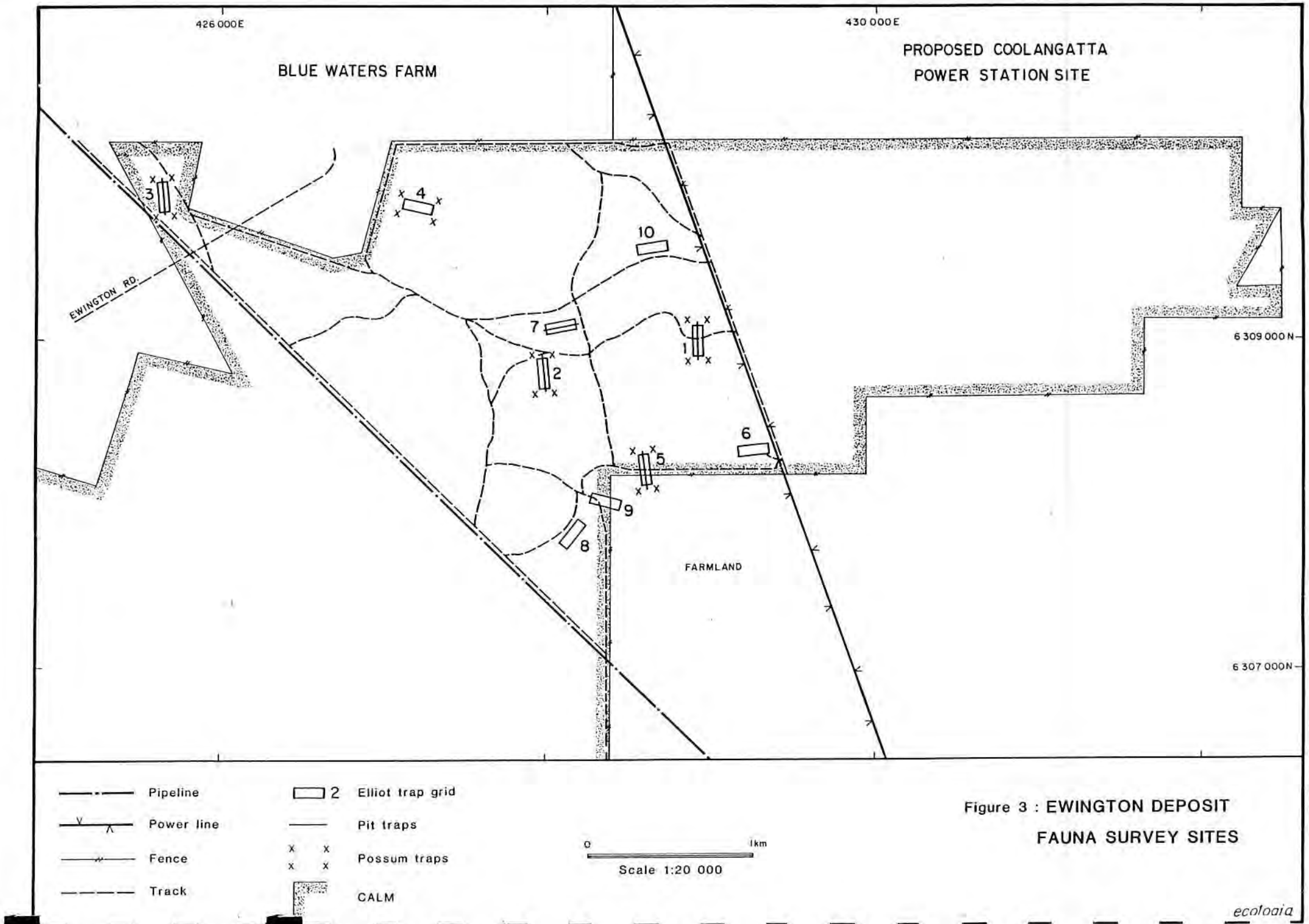



Figure 3 : EWINGTON DEPOSIT
FAUNA SURVEY SITES

ecologia

## 4.1 Rare or Restricted Fauna

Occurring or likely to occur, within the Collie Basin area are 6 vertebrate fauna species gazetted as "rare, or otherwise in need of special protection" They are the;

**Western Native Cat** *Dasyurus geoffroii*: - Gazetted Schedule 1 as "fauna that is likely to become extinct, or is rare". The species is "sparse to rare, scattered in southwestern Australia, possibly extinct in inland Australia" (Strahan,1983). Butler (Fuel and Power Commission WA,1974) listed the Western Native Cat as present in the Collie Basin, while Dames and Moore (1985) list the species as "probably present" at the Griffin lease areas. However there have been no confirmed records of the species within the immediate area of the project for more than twenty years. It is considered that the species is unlikely to be currently present within the Ewington project area.

**Red-tailed Wambenger** *Phascogale calura*: - Gazetted Schedule 1 as "fauna that is likely to become extinct, or is rare" The species is "common, limited, at risk" (Strahan,1983). The preferred habitat is Wandoo and Rock oak communities, neither of which are present in the Ewington project area. The species is probably not present within the Ewington Project area.

**Numbat** *Myrmecobius fasciatus:* - Gazetted Schedule 1 as "fauna that is likely to become extinct, or is rare". The species is "rare, scattered" (Strahan, 1983). While occurring in the northern jarrah forest, the numbat has not been recorded in the vicinity of the project area (Connell, 1985; Connell and Friend, 1985) and no indication of the species presence was noted despite extensive familiarity with the species. It is considered that the heavy past logging and degraded condition of the forest is not conducive to the species.

**Southern Brown Bandicoot** *Isoodon obesulus*: - Recently gazetted as "rare and endangered" (Government Gazette, WA, 16 November 1990). The species has undergone significant range contraction and local population extinctions in the last twenty years. Coupled with high risk from feral predators (Endersby, 1989) and habitat modification, the vulnerable conservation status of this once recently abundant species has prompted the current "rare" classification. The bandicoot population in Ewington is sizable; 6 individuals from approximately 4 hectares of suitable habitat, and currently experiencing a period of growth. Sixty percent of the individuals captured were sub adults, while the population density compares favourably with other documented populations from Jandakot Marsupial Reserve, 3 per hectare (Craven, 1981) and is significantly higher than a recently recorded population at the Serpentine River, Mandurah, 1 per 5 ha (*ecologia*, 1990). The size of the bandicoot population in Ewington is estimated to be in the order of 100 individuals.

**Tammar Wallaby** *Macropus eugenii*: - Gazetted Schedule 1 as "fauna that is likely to become extinct, or is rare". While the species was not recorded during the current survey, Dames and Moore (1985) list the species as "definitely" occurring in the Griffin leases within the Collie Basin. The project area contains limited suitable habitat of dense low vegetation for daytime shelter and open grassy areas for feeding (Christensen, 1980). The species may be present within the project area at low densities.

**Peregrine Falcon** *Falco peregrinus*: - Gazetted Schedule 2 as "in need of special protection". This species is widely distributed throughout Australia. It's status is considered to be "generally uncommon, probably declining in settled regions; still well established in remote areas (Pizzey,1983). This species has been recorded from mid-slope jarrah habitat at the Worsley Project area (Worsley Alumina Pty Ltd, 1985). While potentially occurring in the project area it is a wide ranging species and is not dependent on any habitat which is to be disturbed.

It is considered that the only gazetted rare species which may be impacted by the Ewington Coal Mine Project are the Southern Brown Bandicoot *Isoodon obesulus* and possibly the Tammar Wallaby *Macropus 0eugenii.*

## 4.2 Mammals

Ten species of mammal from 9 families were recorded during the field survey, of these 6 species were native and 4 introduced (Table 1). On the basis of known habitat preferences and species distributions the project area may support an additional 17 native species of which 10 are bats.This compares favourably with the Collie Basin as a whole for which a total of 38 species have been recorded, 30 native and 8 introduced. All species occurring in the project area are widely distributed within the Collie basin and the Darling Ranges. However as is typical of the region, population densities of most native species, excluding macropods, appear to be very low. In keeping with the known low densities of south-west populations of the Echidna *Tachyglossus aculeatus* (Strahan,1983), only a few scattered signs of this species presence were noted. Conversely the two macropods, the Western Grey Kangaroo and the Brush Wallaby, and the Mardo *Antechinus flavipes* were moderately common. A single Brush-tailed Possum *Trichosurus vulpecula* was recorded from Site 4 in the jarrah - marri forest overlying lateritic outcropping. The Southern Brown Bandicoot *Isoodon obesulus* population appears to be of moderate density and good condition. The species is confined to the Site - Vegetation types "C" and "B" of Mattiske and Associates (1991), where there is a dense understorey of shrubs and sedges on drainage lines and seasonally moist areas.

Forty percent of the native mammals which occur or are expected to occur in the project area are Bassian (humid) in biogeographic affinities with the major proportion of their distributions in the mesic south-west of Western Australia. The remainder, such as the Echidna and Brush-tailed Possum have Australia wide distributions.

The proximity of the project area to the township of Collie would facilitate the presence of introduced species. However very little evidence of the presence of feral predators were noted aside from the occasional fox scat or track. Surprisingly no evidence of cats was recorded, though this ubiquitous species would undoubtedly be present. Rabbits were uncommon and only occurring in open Banksia and Melaleuca woodland habitat with open understorey (Sites 2 and 10) in the central area. A single House Mouse *Mus musculus* was captured at Site 5, within the sedgeland swamp habitat. Horse tracks and scats resulting from recreational activities were confined to vehicle tracks. None of the introduced species, except the Fox *Vulpes vulpes*, is considered to have a significant impact on the native fauna community of the project area. The fox though seemingly low in density, would significantly impact the populations of small mammal fauna, particularly the bandicoots and mardos.

| | Habitats | F | S | W | Sdg |
|---|---|---|---|---|---|
| **MONOTREMATA** | | | | | |
| TACHYGLOSSIDAE | | | | | |
| *Tachyglossus aculeatus* | Echidna | X | X | | |
| **MARSUPIALIA** | | | | | |
| DASYURIDAE | | | | | |
| *Antechinus flavipes* | Mardo | 6 | | 1 | 4 |
| PETAURIDAE | | | | | |
| *Trichosurus vulpecula* | Brush-tailed Possum | 1 | | | |
| PERAMELIDAE | | | | | |
| *Isoodon obesulus* | Southern Brown Bandicoot | | 2 | X | 4 |
| MACROPODIDAE | | | | | |
| *Macropus fuliginosus* | Western Grey Kangaroo | 7 | X | | |
| *Macropus irma* | Brush Wallaby | 5 | X | | |
| **INTRODUCED MAMMALS** | | | | | |
| *Mus musculus* | House Mouse | | | | 1 |
| *Equs caballus* | Horse | X | X | | |
| *Oryctolagus cuniculus* | Rabbit | | X | | |
| *Vulpes vulpes* | Fox | X | X | X | X |
| | # species | 7 | 8 | 3 | 4 |

Key: F- Jarrah-Marri forest; S - Melaleuca woodlands; W - Low open Banksia woodlands; Sdg - Sedge/shrub wetlands.

**TABLE 1: Mammals recorded in Habitat-vegetation units of the proposed Ewington Project area.**

## 4.3 Birds

Bird surveys of the project area recorded 34 species, 17 non passerines and 17 passerines (Table 2). The area may support up to 102 species based on known habitat preferences and species distributions,51 non passerines and 45 passerines (Appendix A). The low number of field records reflects the short duration of the survey and seasonal influences with early summer being a sub-optimal period for biological surveys.The species lists for the Collie Basin, 121 species and the Worsley Alumina Project Refinery Lease area (62 species) represents data collected over much greater time period of which 34 species were rare or occasional vagrant visitors.

The project area is within the Bassian zoogeographic sub-region of Spencer (1896). Serventy and Whitell (1976) noted that much of the South-West contained and admixture of Bassian and Eremaean (arid) species, particularly the Wheatbelt. The bird fauna consist primarily of Bassian species with many widely distributed species, such as the Australian Raven, Grey Butcher Bird, and Brown Honeyeater. Species with a largely Eremaean distribution are absent.

Within the project area the passerines predominate in abundance (65%), particularly the honeyeaters, flycatchers, woodswallows and thornbills, with large numbers of Dusky Woodswallows and Western Spinebills being present. Among the non passerines the granivorous parrots make up 47% with the Red-capped Parrot and Red-tailed Black Cockatoo being the most common.

## 4.4 Reptiles and Amphibians

Pit trapping and opportunistic collecting yielded 12 reptile and 2 amphibian species from the project area (Table 3). With examination of known species distributions and habitat preferences it is expected that up to 46 reptile and 12 amphibians may occur in the area. However similar to the birds, the limited survey duration and seasonal timing resulted in a low number of records. It is expected that the actual species number is much higher.

The largely mesic Bassian component of the mammal and bird fauna is repeated in the herpetofauna. Twenty species (45%) have Bassian biogeographic affinities only, while a further 6 species (19%) such as *Diplodactylus granariensis, Underwoodisaurus milli, Rhinoplocephalus gouldii* and *Aprasia repens* are near their southwestern distribution limits. All amphibian species are Bassian in affinities. The herpetofauna is typical of the Darling Ranges jarrah - marri forest habitats and is widely represented throughout the south-west of Western Australia. Two species *Varanus gouldii* and *Pogona minor* have Australia wide distributions occurring mainly in arid and semi-arid habitats.

In terms of abundance, the skink *Egernia napoleonis* was common among dead logs and litter trunks in the jarrah - marri forest areas along with *Leiolopisma trilineatum* and *Ctenotus labillardieri.* Also widespread and common over the project area was the Bobtail *Tiliqua rugosa.* Numerous individuals were captured during the survey while scats and tracks were ubiquitous. Notably absent were the agamid dragons, only one *Pogona minor* , due in part to the absence of suitable habitats, such as rock outcrops.

| | Habitat Code | F | S | W | Sdg |
|---|---|---|---|---|---|
| TURNICIDAE | | | | | |
| *Turnix varia* | Painted Button-quail | | 1 | 1 | |
| COLUMBIDAE | | | | | |
| *Phas chalcoptera* | Common Bronzewing | 1 | 1 | | |
| PSITTACIDAE | | | | | |
| *Barnardius zonarius* | Port Lincoln Parrot | 2 | | | |
| *Calyptorhynchus baudini* | White-tailed Black Cockatoo | 1 | | | |
| *Calyptorhynchus magnificus* | Red-tailed Black Cockatoo | 8 | | | |
| *Neophema elegans* | Elegant Parrot | | 3 | | |
| *Platycercus spurius* | Red-capped Parrot | 5 | 5 | | |
| *Platycercus icterotis* | Western Rosella | | | 1 | |
| CUCULIDAE | | | | | |
| *Chrysococcyx basalis* | Horsefield's Bronze Cuckoo | | 1 | 3 | 1 |
| *Cuculus pallidus* | Pallid Cuckoo | | | 1 | |
| STRIGIDAE | | | | | |
| *Ninox novaeseelandiae* | Boobook Owl | 1 | | | |
| PODARGIDAE | | | | | |
| *Podargus strigoides* | Tawny Frogmouth | 4 | | | |
| ALCEDINIDAE | | | | | |
| Dacelo gigas | Laughing Kookaburra | 2 | | 1 | |
| CAMPEPHAGIDAE | | | | | |
| *Coracina novaehollandiae* | Black-faced Cuckoo-shrike | 1 | | 1 | |
| PACHYCEPHALIDAE | | | | | |
| *Colluricincla harmonica* | Grey Shrike-thrush | | | 4 | 2 |
| *Pachycephalus pectoralis* | Golden Whistler | 2 | | | |
| *Petroica goodenovii* | Red-capped Robin | | | 1 | |
| *Petroica multicolor* | Scarlet Robin | 3 | | 3 | |
| *Petroica cucullata* | Hooded Robin | | 1 | 1 | |
| MONARCHIDAE | | | | | |
| *Rhipidura fuliginosa* | Grey Fantail | 4 | 1 | | |
| ACANTHIZIDAE | | | | | |
| *Acanthiza apicalis* | Broad-tailed Thornbill | 2 | 3 | 6 | |
| *Acanthiza chrysorrhoa* | Yellow-rumped Thornbill | | | 1 | |
| *Sericornis frontalis* | White-browed Scrub-wren | | 2 | | 1 |
| MALURIDAE | | | | | |
| *Malurus elegans* | Red-winged Fairy Wren | 2 | | | |
| *Malurus splendens* | Splendid Fairy-wren | 6 | 1 | 5 | |
| DAPHOENOSITTIDAE | | | | | |
| *Daphoenositta chrysoptera* | Australian Sittella | 4 | | | |
| ZOSTEROPIDAE | | | | | |
| *Zosterops gouldi* | Silvereye | 3 | | | |
| MELIPHAGIDAE | | | | | |
| *Acanthorhynchus superciliosus* | Western Spinebill | 6 | 3 | 4 | 1 |
| *Lichmera indistincta* | Brown Honeyeater | | 3 | 3 | |
| *Phylidonyris melanops* | Tawny-crowned Honeyeater | | 2 | 1 | |
| ARTAMIDAE | | | | | |
| *Artamus cyanopterus* | Dusky Woodswallow | | 2 | 15 | |
| CRACTICIDAE | | | | | |
| *Cracticus torquatus* | Grey Butcherbird | 1 | | | |
| *Gymnorhina tibicen* | Black-backed Magpie | 4 | | | |
| CORVIDAE | | | | | |
| *Corvus coronoides* | Australian Raven | | | 3 | |
| | species richness | 18 | 15 | 19 | 5 |
| | relative abundance/transect | 15 | 14 | 19 | 6 |

Key: F- Jarrah-Marri forest; S - Melaleuca woodlands; W - Low open Banksia woodlands; Sdg - Sedge/shrub wetlands.

**TABLE 2: Birds recorded in habitats of the Ewington Coal Project area.**

| | Habitat Code | F | S | W | Sdg |
|---|---|---|---|---|---|
| LEPTODACTYLIDAE | | | | | |
| *Crinia georgiana* | | | | | 4 |
| *Heleioporous psammophilus* | | 3 | | 2 | |
| PYGOPODIDAE | | | | | |
| *Aprasia repens* | Fry's worm lizard | 1 | 2 | | |
| AGAMIDAE | | | | | |
| *Pogona m. minor* | Dwarf Bearded Dragon | | | 1 | |
| SCINCIDAE | | | | | |
| *Ctenotus labillardieri* | | 2 | 1 | 1 | |
| *Egernia napoleonis* | | 4 | 1 | 5 | 3 |
| *Leiolopisma trilineatum* | | 1 | 1 | | |
| *Lerista distinguenda* | | 2 | 2 | 1 | |
| *Morethia obscura* | | 4 | | 8 | 2 |
| *Tiliqua r. rugosa* | Bobtail | 7 | 1 | 1 | 2 |
| VARANIDAE | | | | | |
| *Varanus gouldii* | Gould's Monitor | | | 1 | |
| TYPHLOPIDAE | | | | | |
| *Rhamphotyphlops australis* | | 1 | | 1 | |
| ELAPIDAE | | | | | |
| *Pseudonaja a. affinis* | Dugite | 1 | | | 1 |
| *Rhinoplocephalus gouldii* | Gould's Snake | 1 | | | |
| | species richness | 4 | 7 | 8 | 1 |

**TABLE 3: Herpetofauna recorded in habitats of the Ewington Coal Project area.**

### 4.5 Faunal Habitats

Faunal habitats are closely aligned with landform - vegetation associations. Four major faunal habitats occur within the Ewington Project area, jarrah - marri forests with a variety of understoreys (Plate 1), Banksia woodlands (Plate 7) and Melaleuca woodlands (Plate 2) with varying degree of sedge and shrub understoreys and the sedge and shrub wetlands in drainage lines and swamps (Plate 3). Table 4 details the approximate percent occurrence and detailed site - vegetation types. Full descriptions of the site - vegetation types are contained within Mattiske & Associates (1991).

The jarrah - marri forest habitat produced the richest faunal assemblages with 36 species (7 mammal, 18 bird, 11 reptile/amphibian) while the banksia and melaleuca woodlands exhibiting a similar level of richness with 31 species (3 mammal, 19 bird, 9 reptile/amphibian) . Additionally the

Plate 1: Jarrah - Marri forest on sand, Site 1.

Plate 2: Paperbark *Melaleuca* open forest on sand, Site 2.

Plate 4: Banksia Woodland, Site 7.

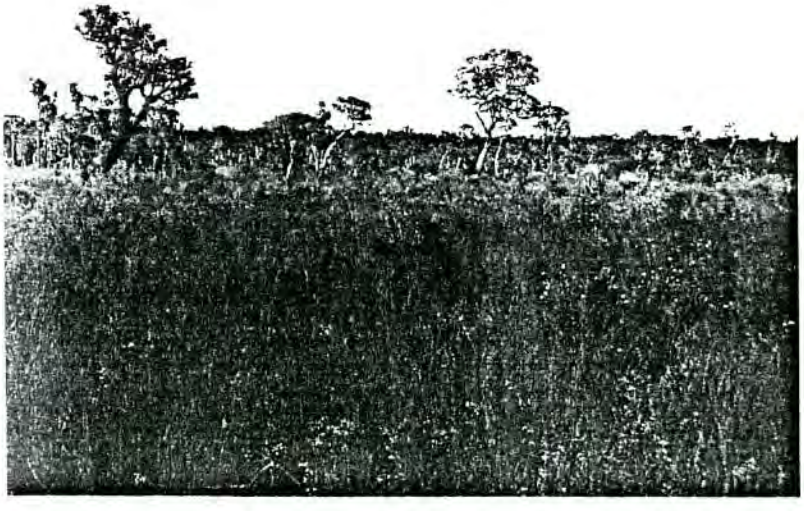


Plate 3: Sedge and shrub wetland community, Site 9.

quantitative bird survey revealed that this habitat was the most heavily utilised with 51% of all individuals recorded (Table 3). Although the poorest with only 14 species recorded, a distinctive faunal assemblage occurs in the sedge and shrub wetland system which provides a dense understorey vegetation and semi-aquatic environment for many species of frog, reptile and small mammals (4 mammal, 5 bird, 5 reptile). The forest and woodland habitats are dominated by a highly mobile avian community and terrestrial lizards.

| Habitat-vegetation unit | Code | Description | Percent |
|---|---|---|---|
| Jarrah - Marri Forrest | F | Open forest over shrubs, $S_1$, $S_2$, $S_3$, P, D | 60 |
| Banksia Woodlands | W | Open woodland over low understorey of sedges and shrubs, J | 15 |
| Melaleuca woodlands | S | Open woodland over sedges and shrubs, $A_1$, $A_2$ | 15 |
| Sedge Shrub Wetlands | Sdg | Low open woodland over dense understorey of sedges and shrubs, C, B | 10 |

Note: Vegetation association codes full description in Mattiske & Associates (1991)

**TABLE 4 : Habitat-vegetation units in Ewington Coal Project Area with approximate percent occurrence.**

## 5. ECOLOGICAL SIGNIFICANCE

The project area encompasses landform and vegetation associations which are widespread throughout the South West Region and the Darling Ranges. Thus the habitats within the project area which support the greatest biodiversity, such as the jarrah - marri forest are of minor ecological significance. The high level of disturbance from dieback, logging and fire (Mattiske & Associates, 1991) has contributed to the reduced conservation value of these areas through the reduction of fauna resources such as hollow logs and deep litter beds. The sedge shrub wetland habitats are in relatively good condition and most closely represent pre-disturbance status, whereas the other habitats have been severely affected by disturbance. The conditions are a reflection of historical forestry practices.

The habitat - vegetation type present within the project area which is least well represented in the Collie Basin is the sedge - shrub wetland units. It is therefore of importance that some such areas are set aside for fauna conservation to preserve the presence of rare species within this habitat.

Fauna of significance which occur within the project area are the Southern Brown Bandicoot and the Tammar Wallaby, the population of which is of uncertain status and may require further investigation. With confirmation of status, these species may require special protection at specific localities within the area.

## 6. ENVIRONMENTAL IMPACT AND MANAGEMENT

The principal impacts from the construction of the proposed development will be the loss of vegetated area, reduction in area of forest and woodland habitat and the impositions on the swamp drainage system. The area loss from the development (800 ha) is insignificant in comparison to the ecological habitat - vegetation units represented within the region. The area is already of a degraded nature due to historical forestry practices.

The impact on the fauna is generally secondary. There will be major local impacts initially with destruction of habitat and loss of sedentary species and relocation of mobile species into adjacent habitats. Impacts may be minimised by staging clearing, limiting clearing to absolute essential minimum, fencing off dangerous areas and limiting road and track development. Increased traffic may cause localised death of larger mobile species, predominately kangaroos, wallabys and monitor lizards.

The perceived factors which may impact the fauna in adjacent areas are dust and increased vehicular traffic. The subsequent localised mortality of adjacent vegetation, hence fauna, through excessive dust may be minimised by dust inhibition methods. No other environmental impacts are perceived to impinge upon the integrity of the surrounding areas.

### 6.1 Pit Area

All vegetation will be cleared from the pit area. Reduction in size of pit to minimum essential will minimise impact to the area. Severe local environmental impacts in the pit area will occur. However the impacts are deemed not significant for these widely distributed vegetation associations. Modification to the sedge - shrub wetlands, while extreme is of significance only at the local level. However the local population of the Southern Brown Bandicoot *Isoodon obesulus,* currently gazetted as "rare and endangered" will be adversely affected by this development. Despite an intensive survey of the project the Tammar Wallaby was not found. Further consultation and or field survey to ascertain the presence of the species may be required.

### 6.2 Dust

The duration of potential dust generation from the waste dumps may be minimised under a progressive rehabilitation strategy whereby top soil, is spread over the terraces and revegetated progressively as the waste dumps are raised. Additionally dust inhibition measures would minimise dust production on site to ensure no impact to adjacent vegetation occurs.

### 6.3 Noise

The only fauna which will respond to noise are large mobile species of macropods and birds where it may act as a deterrent on a local scale adjacent to the development. The result of localised noise would be the avoidance of the noise origin area. This behaviour would be beneficial to the fauna by avoiding potentially hazardous areas. Monitoring fauna response to noise is confounded by other factors such as habitat disturbance, mining activities and continual human presence. It is considered that no significant impact will occur to the biota through noise.

### 6.4 Feral Animal Eradication

The eradication of feral predators, foxes and cats, from the project area will significantly enhance the survival of remaining bandicoot populations in the area (Endersby, 1989). An eradication program can be devised in consultation with CALM and the Agriculture Protection Board (APB) and target species may be poisoned with 1080 (Sodium monofluoroacetate) in accordance with APB guidelines.

## 7. RECOMMENDATIONS

In order to reduce impact to the fauna of the project area, it is recommended that The Griffin Coal Mining Company Pty. Limited;

- Minimise clearing of land to essential minimum consistent with safe and efficient operations.

- Minimise impact and encroachment to sedge - shrub wetland system and thus the local Southern Brown Bandicoot population.

- Install silt traps to collect run-off and prevent sediment from entering the drainage systems

- Cap all boreholes and pipes.

- Control dust in the project area.

- Establish feral animal eradication programme.

- Prohibit domestic pets in the project area.

- Prohibit off road driving and shooting in the project area.

- Maintain strict fire control procedures.

- Set up an educational programme for employees which enhances awareness of the conservation value of the surrounding area.

- Ensure that employees and sub contractors are made aware of any environmental restrictions placed on the project by the EPA.

In order to adequately assess environmental impact arising from the project and to develop appropriate techniques which will ensure successful rehabilitation and minimal impact, it is additionally recommended that The Griffin Coal Mining Company Pty. Limited;

- Establish fauna monitoring programme developed in consultation with CALM.

- Keep abreast of developments in rehabilitation, monitoring techniques and environmental management procedures.

Upon decommissioning The Griffin Coal Mining Company Pty. Limited should remove all structures and equipment and rehabilitate all disturbed areas.

## CONTRIBUTORS TO PREPARATION OF REPORT

The Ewington Open-cut Coal Mine Project flora and fauna survey described in this document was planned, coordinated and executed by;

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In addition;

1. Dr A.A. Burbidge, Head of Research, CALM Research Woodvale, kindly offered information on CALM policy for the Southern Brown Bandicoot and the translocation of rare and endangered fauna.

2. Mr L.A. Smith, Western Australian Museum Perth, supplied reptile and amphibian collection records from the Museum's collection databases

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# APPENDIX A

Collie Basin Fauna
Species List

**APPENDIX A :** MAMMALS OF THE COLLIE BASIN

| | |
|---|---|
| **MONOTREMATA** | |
| TACHYGLOSSIDAE | |
| *Tachyglossus aculeatus* | Echidna |
| **MARSUPIALIA** | |
| DASYURIDAE | |
| *Antechinus flavipes* | Mardo |
| *Dasyurus geoffroii* | Western Native Cat |
| *Phascogale calura* | Red-tailed Wambenger |
| *Phascogale tapoatafa* | Brush-tailed Wambenger |
| *Sminthopsis murina* | Common Dunnart |
| *Sminthopsis griseoventer* | Grey Bellied Dunnart |
| BURRAMYIDAE | |
| *Cercartetus concinnus* | South-western Pygmy Possum |
| PETAURIDAE | |
| *Pseudocheirus peregrinus* | Common Ringtail |
| PHALANGERIDAE | |
| *Trichosurus vulpecula* | Brush-tailed Possum |
| TARSIPEDIDAE | |
| *Tarsipes rostratus* | Honey Possum |
| PERAMELIDAE | |
| *Isoodon obesulus* | Southern Brown Bandicoot |
| MYRMECOBIIDAE | |
| *Myrmecobius fasciatus* | Numbat |
| MACROPODIDAE | |
| *Bettongia penicillata* | Woylie |
| *Macropus eugenii* | Tammar |
| *Macropus fuliginosus* | Western Grey Kangaroo |
| *Macropus irma* | Brush Wallaby |
| *Setonix brachyurus* | Quokka |
| **CHIROPTERA** | |
| MOLOSSIDAE | |
| *Mormopterus planiceps* | Little Mastif Bat |
| *Tadarida australis* | White-striped Mastiff Bat |
| *Tadarida planiceps* | Little Flat Bat |
| VERSPERTILIONIDAE | |
| *Chalinolobus gouldii* | Gould Wattled Bat |
| *Chalinolobus morio* | Chocolate Bat |
| *Eptesicus regulis* | Little Bat |
| *Nyctophilus geoffroyi* | Lesser Long-eared Bat |
| *Nyctophilus timoriensis* | Greater Long-eared Bat |
| *Nyctophilus major* | |
| *Pipistrellus tasmaniensis* | Tasmanian Pipistrelle |
| **RODENTIA** | |
| MURIDAE | |
| *Hydromys chrysogaster* | Water Rat |
| *Rattus fuscipes* | Bush Rat |

**INTRODUCED MAMMALS**

| | |
|---|---|
| *Mus musculus* | House Mouse |
| *Rattus rattus* | Black Rat |
| *Bos taurus* | Cow |
| *Ovis aries* | Sheep |
| *Equs caballus* | Horse |
| *Oryctolagus cuniculus* | Rabbit |
| *Vulpes vulpes* | Fox |
| *Sus scrofa* | Pig |
| *Cervus elephas* | Red Deer |
| *Felis cattus* | Cat |

**APPENDIX A:** BIRDS OF THE COLLIE BASIN

| | |
|---|---|
| CASUARIDAE | |
| *Dromaius novaehollandiae* | Emu |
| PODICIPEDIDAE | |
| *Podiceps novaehollandiae* | Little Grebe |
| *Podiceps poliocephalus* | Hoary-headed Grebe |
| PHALACROCORACIDAE | |
| *Phalacrocorax melanoleucos* | Little pied Cormorant |
| AREIDAE | |
| *Ardae novaehollandiae* | White-faced Heron |
| *Ardae pacifica* | White-necked Heron |
| ANATIDAE | |
| *Anas gibberifrons* | Grey Teal |
| *Anas superciliosus* | Black Duck |
| *Bizira lobata* | Musk Duck |
| *Chenonetta jubata* | Wood Duck |
| *Cygnus atratus* | Black Swan |
| *Tadorna tadornoides* | Mountain Duck |
| ACCIPITRIDAE | |
| *Accipter cirrhocephalus* | Collared Sparrowhawk |
| *Accipter fasciatus* | Brown Goshawk |
| *Aquila audax* | Wedge-tailed Eagle |
| *Circus approximans* | Swamp Harrier |
| *Elanus notatus* | Black-shouldered Kite |
| *Haliastur sphenurus* | Whilstling Kite |
| *Hamirostra melanosternon* | Black-breasted Buzzard |
| *Heraaetus morphnoides* | Little Eagle |
| *Lophoictinia isura* | Square-tailed Kite |
| *Milvus migrans* | Fork-tailed Kite |
| FALCONIDAE | |
| *Falco berigora* | Brown Falcon |
| *Falco cenchroides* | Nankeen Kestrel |
| *Falco longipennis* | Little Falcon |
| *Falco peregrinus* | Peregrine Falcon |
| TURNICIDAE | |
| *Turnix varia* | Painted Button-quail |
| RALLIDAE | |
| *Porphryio porphryio* | Swamphen |
| CHARADRIIDAE | |
| *Charadrius melanops* | Black-fronted Plover |
| *Vanellus tricolor* | Banded Plover |
| COLUMBIDAE | |
| *Phas chalcoptera* | Common Bronzewing |
| PSITTACIDAE | |
| *Barnardius zonarius* | Port Lincoln Parrot |
| *Calyptorhynchus baudini* | White-tailed Black Cockatoo |
| *Calyptorhynchus latirostris* | Carnaby's Cockatoo |
| *Calyptorhynchus magnificus* | Red-tailed Black Cockatoo |
| *Glossopsitta prophyrocephala* | Purple-crowned Lorikeet |
| *Neophema elegans* | Elegant Parrot |
| *Platycercus spurius* | Red-capped Parrot |
| *Platycercus icterotis* | Western Rosella |
| CUCULIDAE | |
| *Chrysococcyx basalis* | Horsefield's Bronze Cuckoo |
| *Chrysococcyx lucidus* | Shining Bronze Cuckoo |
| *Cuculus pallidus* | Pallid Cuckoo |
| *Cacomantis pyrrhophanus* | Fan-tailed Cuckoo |

| | |
|---|---|
| STRIGIDAE | |
| *Ninox novaeseelandiae* | Boobook Owl |
| *Tyto Alba* | Barn Owl |
| PODARGIDAE | |
| *Podargus strigoides* | Tawny Frogmouth |
| AEGOTHELIDAE | |
| *Aegotheles cristatus* | Australian Owlet-nightjar |
| ALCEDINIDAE | |
| Dacelo gigas | Laughing Kookaburra |
| *Halcyon sancta* | Sacred Kingfisher |
| MEROPIDAE | |
| *Merops ornatus* | Rainbow Bee-eater |
| HIRUNDINIDAE | |
| *Hirundo neoxena* | Welcome Swallow |
| *Hirundo nigricans* | Tree Martin |
| MOTACILLIDAE | |
| *Anthus novaeseelandiae* | Richard's Pipit |
| CAMPEPHAGIDAE | |
| *Coracina novaehollandiae* | Black-faced Cuckoo-shrike |
| *Lalage sueurii* | White Winged Triller |
| PACHYCEPHALIDAE | |
| *Colluricincla harmonica* | Grey Shrike-thrush |
| *Colluricincla rufiventris* | Western Shrike-thrush |
| *Eopsaltria australis* | Yellow Robin |
| *Eopsaltria georgiana* | White-breasted Robin |
| *Pachycephalus pectoralis* | Golden Whistler |
| *Pachycephalus rufiventris* | Rufous Whistler |
| *Petroica goodenovii* | Red-capped Robin |
| *Petroica multicolor* | Scarlet Robin |
| *Petroica cucullata* | Hooded Robin |
| MONARCHIDAE | |
| *Myiagra inquieta* | Restless Flycatcher |
| *Rhipidura fuliginosa* | Grey Fantail |
| *Rhipidura leucophrys* | Willie Wagtail |
| ACANTHIZIDAE | |
| *Acanthiza apicalis* | Broad-tailed Thornbill |
| *Acanthiza chrysorrhoa* | Yellow-rumped Thornbill |
| *Acanthiza inorta* | Western Thornbill |
| *Gerygone fusca* | Western Flyeater |
| *Sericornis frontalis* | White-browed Scrub-wren |
| *Smicrornis brevirostris* | Weebill |
| MALURIDAE | |
| *Malurus elegans* | Red-winged Fairy Wren |
| *Malurus splendens* | Splendid Fairy-wren |
| DAPHOENOSITTIDAE | |
| *Daphoenositta chrysoptera* | Australian Sittella |
| CLIMACTERIDAE | |
| *Climacteris rufa* | Rufous Tree Creeper |
| DICAEIDAE | |
| *Dicaeum hirundinaceum* | Mistletoe Bird |
| PARDALOTIDAE | |
| *Pardalotus punctatus* | Spotted Pardalote |
| *Pardalotus striatus* | Striated Pardalote |
| ZOSTEROPIDAE | |
| *Zosterops gouldi* | Silvereye |
| *Zosterops lateralis* | Grey-brested White-eye |

| | |
|---|---|
| MELIPHAGIDAE | |
| *Acanthorhynchus superciliosus* | Western Spinebill |
| *Anthochaera carunculata* | Red Wattle Bird |
| *Anthochaera chrysoptera* | Little Wattle bird |
| *Ephithianura alibifrons* | White-fronted Chat |
| *Lichmera indistincta* | Brown Honeyeater |
| *Manorina flavigula* | Yellow-throated Miner |
| *Meliphaga virescens* | Singing Honeyeater |
| *Melithreptus lunatus* | White-naped Honeyeater |
| *Phylidonyris novaehollandiae* | New Holland Honeyeater |
| *Phylidonyris nigra* | White-cheeked Honeyeater |
| *Phylidonyris melanops* | Tawny-crowned Honeyeater |
| PLOCEIDAE | |
| *Emblema oculatum* | Red-eared Firetail |
| GRALLINIDAE | |
| *Grallina cycanoleuca* | Magpie-lark |
| ARTAMIDAE | |
| *Artamus cyanopterus* | Dusky Woodswallow |
| CRACTICIDAE | |
| *Cracticus torquatus* | Grey Butcherbird |
| *Gymnorhina tibicen* | Black-backed Magpie |
| *Strepera versicolor* | Grey Currawong |
| PARADISAEIDAE | |
| *Ptilonorhynchus maculatus* | Spotted Bowerbird |
| CORVIDAE | |
| *Corvus coronoides* | Australian Raven |
| *Corvus bennetti* | Little Crow |

**APPENDIX A:** REPTILES AND AMPHIBIANS OF THE COLLIE BASIN

| | |
|---|---|
| HYLIDAE | |
| *Litoria adelaidensis* | |
| *Litoria moorei* | |
| LEPTODACTYLIDAE | |
| *Cirnia georgiana* | |
| *Geocrinia leai* | |
| *Heleioporous barycragus* | |
| *Heleioporous eyrei* | |
| *Heleioporous inornatus* | |
| *Heleioporous psammophilus* | |
| *Limnodynastes dorsalis* | |
| *Neobatrachus pelobatoides* | |
| *Ranidella glauerti* | |
| *Ranidella pseudinsignifera* | |
| CHELIDAE | |
| *Chelodina oblonga* | Western Long-necked Tortoise |
| GEKKONIDAE | |
| *Crenadactylus o. ocellatus* | Clawless Gecko |
| *Diplodactylus granariensis* | |
| *Diplodactylus polyopthalmus* | |
| *Gehyra variegata* | Tree Dtella |
| *Phyllodactyllus marmoratus* | Marbled Gecko |
| *Phyllurus milii* | Thick-tailed Gecko |
| PYGOPODIDAE | |
| Aprasia pulchella | Pretty Worm Lizard |
| Aprasia repens | Fry's worm lizard |
| *Delma fraseri* | |
| *Lialis burtonis* | Burtons Snake Lizard |
| *Pygopus lepidopodus* | |
| AGAMIDAE | |
| *Ctenophorus adelaidensis* | Sandhill Dragon |
| *Pogona m. minor* | Dwarf Bearded Dragon |
| SCINCIDAE | |
| *Ctenotus fallens* | |
| *Ctenotus labillardieri* | |
| *Ctenotus lesueurii* | |
| *Hemiergis i. initialis* | |
| *Hemiergis p. peronii* | |
| *Egernia kingii* | |
| *Egernia napoleonis* | |
| *Egernia p. pulchra* | |
| *Leiolopisma trilineatum* | |
| *Lerista distinguenda* | |
| *Lerista m. microtis* | |
| *Menetia greyii* | |
| *Morethia obscura* | |
| *Morethia lineo-ocellata* | |
| *Omolepida branchialis* | |
| *Sphenomorphus australis* | |
| *Tiliqua r. rugosa* | Bobtail |

VARANIDAE

| | |
|---|---|
| *Varanus gouldii* | Gould's Monitor |
| *Varanus rosenbergi* | Rosenberg's Monitor |

TYPHLOPIDAE

| | |
|---|---|
| *Rhamphotyphlops australis* | |
| *Rhamphotyphlops bituberculata* | |
| *Rhamphotyphlops pinguis* | |

BOIDAE

| | |
|---|---|
| *Python spilotus imbricatus* | Carpet Python |

ELAPIDAE

| | |
|---|---|
| *Densionia gouldii* | Little Whip Snake |
| *Drysdalia coronata* | Crowned Snake |
| *Notechis curtus* | Bardick |
| *Notechis scutatus occidentalis* | Tiger Snake |
| *Pseudonaja a. affinis* | Dugite |
| *Rhinoplocephalus nigriceps* | Black-headed Snake |
| *Vermicella bertholdi* | Jan's Banded Snake |
| *Vermicella fasciolata* | |
| *Vermicella semifasciata* | Southern Shovel-nosed Snake |

**SOURCES**

**1** Worsley Alumina Pty Ltd (1985). "Worsley Alumina Project. Flora and Fauna Studies, Phase Two. pp.348. Worsley Alumina Pty Ltd, Perth.

**2** Dames and Moore (1985)

**3** Nichols,O.G. and Nichols, F.M. (1984) The Reptilian, avian and mammalian fauna of the Mount Saddleback State Forest, Western Australia. W.A. Nats. 15: 179-189.

**4** Butler (Fuel and Power Commission of WA, 1974)

# APPENDIX G
# ABORIGINAL SITES REPORT

# A REPORT OF

# A SURVEY FOR ABORIGINAL SITES

# EWINGTON COAL LEASE

# COLLIE

PREPARED FOR

HALPERN GLICK MAUNSELL

BY

**R. LOCKE (PhD) and A. M. MURPHY (BSc Hons)**

McDONALD, HALES AND ASSOCIATES

5 ELLEN STREET

FREMANTLE

JANUARY 1991

CONTENTS

# 1. INTRODUCTION

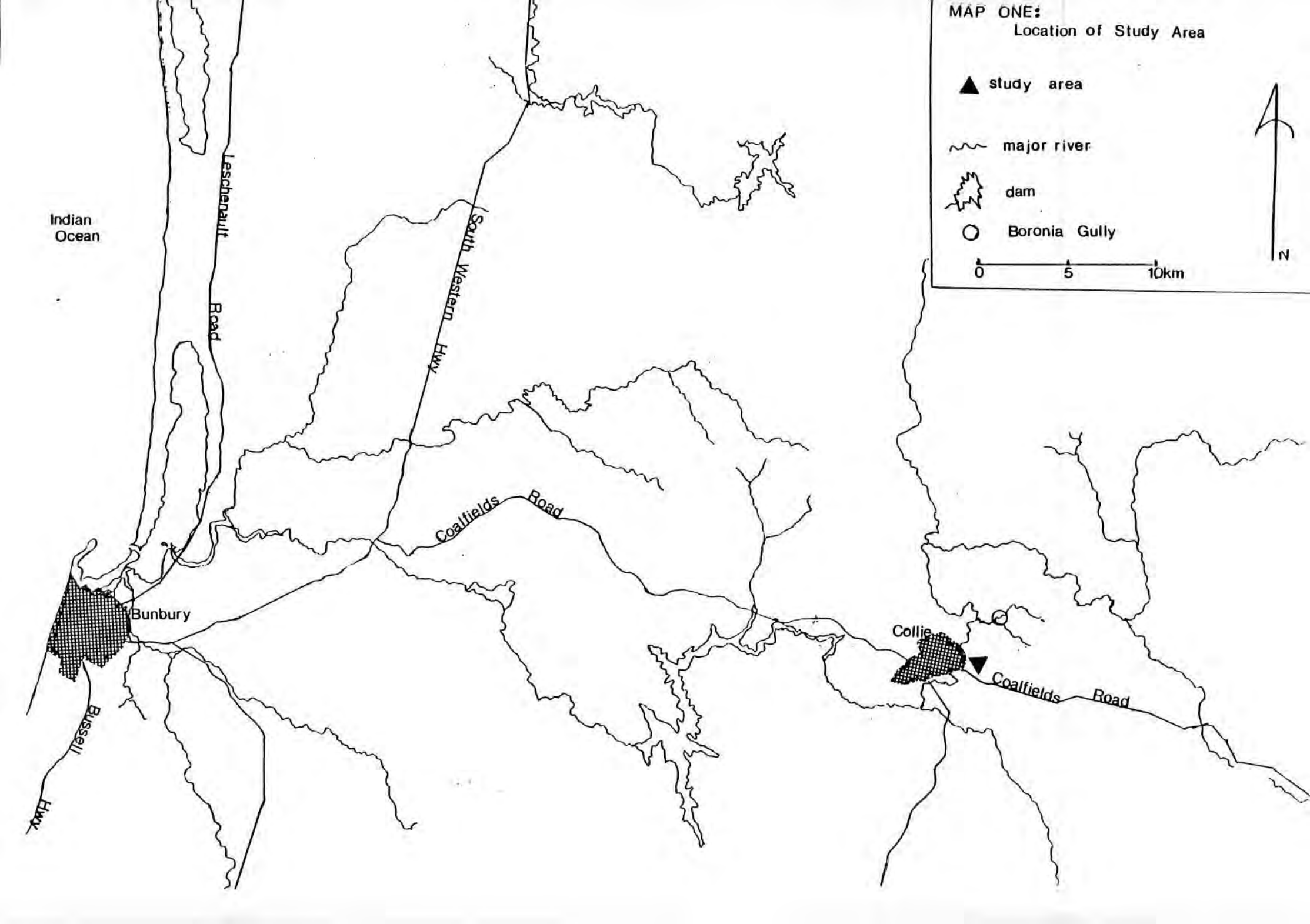
## 1.1 Consultancy Brief

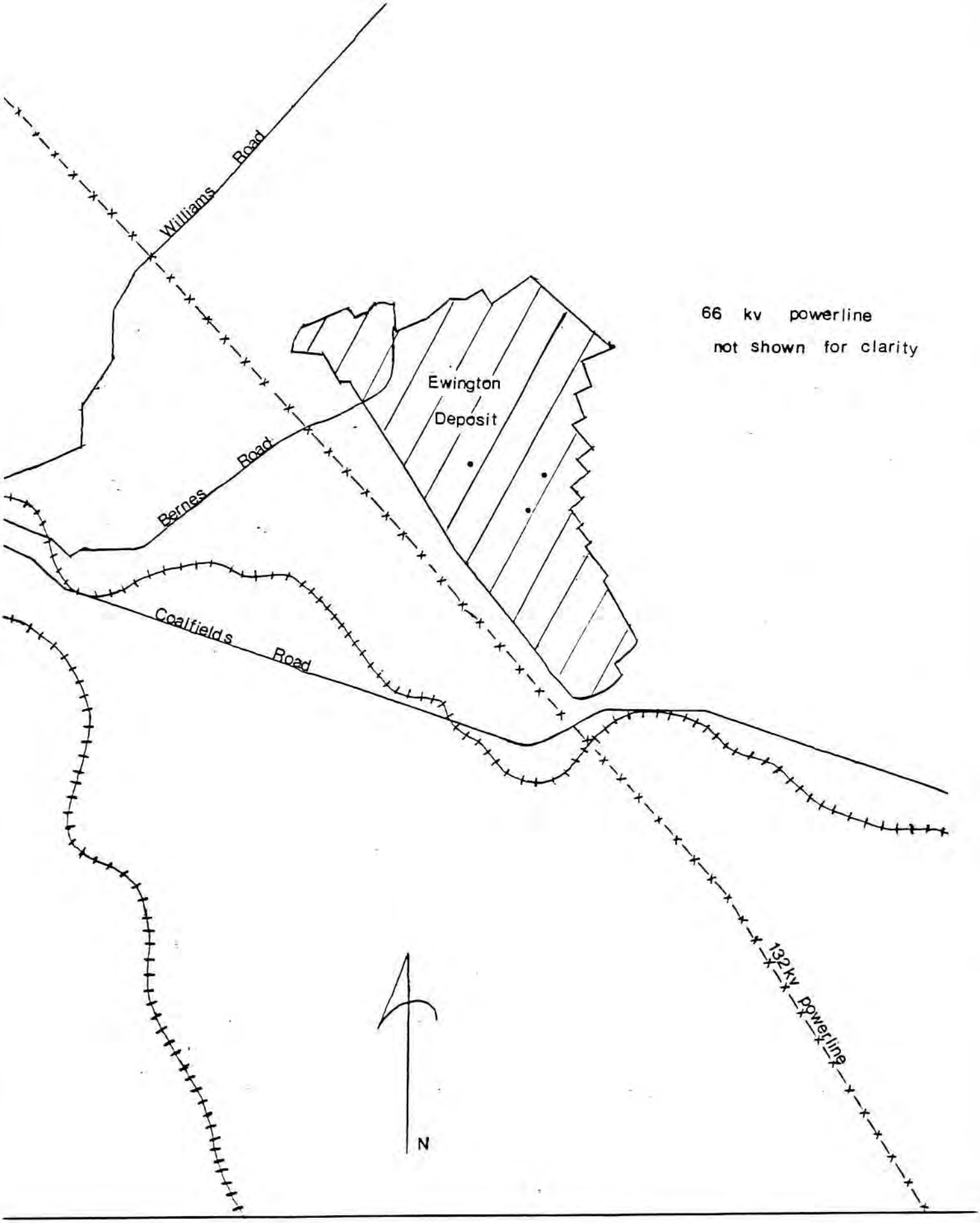
With the proposed commissioning of a new base load, coal fired power station in the Collie area (SECWA, 1990) and one of the Western Australian Government's stated policy options being to develop export markets for WA's coal (WA Government, 1989) it is now advantageous for new deposits to be cleared for coal production. It is within this general framework that the development of the Ewington Coal lease is occurring.

McDonald, Hales and Associates was commissioned to undertake a survey for Aboriginal sites by Halpern Glick Maunsell throughout the above mentioned lease, which covers some 25 square kilometres of land immediately to the east of the Collie town site. The area is roughly bounded in the north by farmland still under production (some portions of which have previously been subjected to underground mining) to the east and west by high tension powerlines and the south by Coalfields Road. The archaeological survey was undertaken by A Murphy assisted by L Collard and the ethnographic research by Dr R Locke.

## 1.2 Summary and Recommendations

No sites of either ethnographic or archaeological significance were located as a result of the survey work. There are, therefore, no impediments to the proposed developments occurring.


MAP ONE:
Location of Study Area
study area
major river
dam
Boronia Gully
0
5
10km
N
Indian Ocean
Leschenault Road
South Western Hwy
Coalfields Road
Bunbury
Collie
Coalfields Road
Bussell Hwy




MAP TWO:

Ewington Deposit Study Area – Detail

// study area

• artefact

0 1 2km

# 2. ENVIRONMENT

## 2.1 Geology

The study area is located entirely within the Collie Coal Basin, a geologic feature which is approximately 26 km long and 13 km wide. The Basin is composed of 3 sub-basins each consisting of several hundred metres of coal seams, shales and sandstones which are capped by laterised sands and tertiary clays of the Nakina Formation. This Formation may be as much as 20 metres deep overlying coal seams which are often thin, steeply dipping and highly faulted (SECWA, 1990).

The Collie Basin itself lies within the even larger physiographic unit of the Darling Plateau consisting of extensive dissected uplands. Geologically the Darling Plateau is composed mainly of Archaean granites which have invaded extensive belts of metamorphic rock (Biggs and Wild, 1980). Within the plateau there are 3 types of surface soil:

i Lateritic soils

- ferruginous/bauxitic caprock on the ridges
- gravelly colluvial soils on the slopes

ii Grey alluvial sands overlying clays along drainage lines

iii Deep sands (Nakina Formation) (Biggs and Wild, 1980)

Of these only the first are present in the study area.

## 2.2 Vegetation

The Darling Plateau is vegetated by the Northern Jarrah Forest consisting of an array of vegetation sub-complexes of which Jarrah (Eucalyptus marginata) is the dominant species, covering some 10,000 ha. This complex extends virtually unbroken between Mundaring and the Collie area, constrained by the Coastal Plain and Wheatbelt to the west and east respectively. Whilst it is largely uncleared by virtue of its status as State Forest and generally poor soil fertility, the Jarrah forest does support a number of land uses including agriculture and mining (bauxite and coal) both of which are in evidence in the study area.

The vegetation sub-complexes characteristic of the study area are on upland. Jarrah-Marri (E calophylla), open forest and wetland types (Heddle et al 1980). The open forest covers the greater portion of the lease and, as mentioned, Jarrah and Marri are dominant. The open canopy permits the development of a lower canopy and dense understorey vegetation strata. Lower canopy species, which grow between 3 and 6 metres high, include species of Banksia, Hakea, Persoonia and Dryandra. The understorey may be further divided into shrub and ground layers, the former consisting of Macrozamia riedlei (Zamia palms), Xanthorrhoea preissii (blackboy) and Acacia sp. A ground layer may develop where there are breaks in the preceding layers, which permits light to reach the forest floor and it is characterised by prostrate shrubs, grasses, ferns and mosses of varying species (Heddle et al 1980; SECWA, 1990).

In only one portion of the lease is the wetland vegetation type well represented, around an ephemeral swamp at its southern edge. Whilst there was open water visible at the time of survey it is likely that during the height of summer this dries up. Surrounding the open water are generally dense swards of sedges and/or rushes such as Baumea sp and Tyhpa sp.

Further from the central portions of the wetland low Melaleuca (Titree and Paperbark) heathlands may occur intermixed with taller shrublands dominated by Hakea prostrata, Hakea varia and Melaleuca sp and interspersed with the Jarrah-Marri overstorey. (Heddle et al, 1980, SECWA, 1990).

## 2.3 Climate

Other general environmental parameters characteristic of the area may be obtained from climatic data derived from Collie Post Office records (since 1899), Worsley Refinery (since 1980) and SECWA's meteorological stations (since 1983). This data shows that the Collie area experiences a typical cool Mediterranean climate characterised by warm, dry summers and cool, wet winters.

The mean summer maximum temperature (February) is 31½ C and the winter mean maximum (July) is 16.5½ C. Collie has an average annual rainfall of around 988 mm the greater proportion of which (more than 80%) falls during winter (May to October). Summer droughts are not so severe as for areas further east and west since lower temperatures reduce losses through evaporation, although it is not uncommon for the upper courses of the region's rivers to be reduced to chains of pools during this season (SECWA, 1990)

## 3. ARCHAEOLOGICAL BACKGROUND

Prior to field investigation records held by the Department of Aboriginal Sites were examined in order to determine the location and nature of any archaeological material already known for the study area. As a result some 33 sites were found to be known within a 25 km radius of the lease, of these 7 are located within its boundaries (Novak, 1980).

The site types identified as being in the Collie region, through this process, include small stone artefact scatters (the vast majority) stratified archaeological deposits, quarries, stone arrangements and one scarred tree. The stratified sites have provided the first firm evidence for intensive use of the Jarrah Forest (Pearce 1981a, Veth, 1989).

In general site distribution in the Collie area mirrors that of much of the southwest, including the coastal plain and metropolitan area (Murphy 1989, Veth 1989), with most sites being located in close proximity to water sources. Large sites particularly, appear to be found most commonly in association with swamps and permanent pools in the rivers (Pearce 1981b).

All the sites located within the lease fall into the first category mentioned; small stone artefact scatters. Of these all but one (SO961) have less than 5 artefacts, most being isolated finds (SO959, SO960, SO962, SO963, SO964, SO965) (Novak, 1980).

At present only three dated assemblages are available for the Jarrah forest zone; Collie (5810 + 330 BP), Boddington (3230 + 70 BP) and North Dandalup (21280 + 80 BP). Whilst these sites indicate that at least some portions of the uplands were intensively occupied from at least the mid-Holocene, no indication of a basal date for forest usage has yet been obtained. This is due mainly to two factors, the poor archaeological visibility characteristic of the heavily vegetated uplands and lack of sites in this zone which are suitable for excavation. As already stated the majority of sites so far discovered in the Jarrah forest are small artefact scatters which, according to Anderson (1984) may represent short term stops taken by Aboriginal groups moving between the seasonally resource rich environments of the Coastal Plain and less heavily vegetated eastern edge of the Darling Plateau. The small sites in the dense forest reflect not only this east-west movement but also the nature of the groups undertaking its exploitation. It is thought that this involved small, family based groups, who could maintain a high level of mobility which would have been necessary to procure the scarce forest resources most efficiently. Additionally, small mobile groups would have placed less pressure on the environment, than a comparable number of people forming large congregations such as those seen, at contact, on the Coastal Plain (Anderson, 1984).

The three dated sites do indicate, however, that there were exceptions to the general pattern. Unfortunately there is little information upon which to base speculation as to why these congregations occurred. Since much of Aboriginal life, and therefore habitation pattern, was driven by resource procurement it is possible that these locations were somehow linked to more favourable microenvironments. Ritual, also, was a determinant of site location (eg Bowdler, 1981) and the possibility of male usage of the Jarrah Forest for ceremonial purposes cannot be ignored, especially as the lack of grinding material may be consistent with men's activities mainly occurring in this zone (Anderson, 1984).

When viewed in this context and considering the information already available for the Ewington Coal lease, it is unlikely that a great deal of additional archaeological material would be uncovered by further surveys. If material were to be discovered it could be expected to consist of isolated artefacts or small scatters (less than 10 pieces) which would more likely be located in close proximity to swamps or drainage features.

## 4. ETHNOHISTORICAL BACKGROUND

In attempting to reconstruct past Aboriginal land use strategies, the writings of the early colonists form an invaluable resource as their eye witness accounts can illuminate aspects of Aboriginal life not preserved by the archaeological record. Collie, however, is located well away from the foci of European settlement in the forest belt which was not looked upon as suitable for inhabitation. As a result few colonial records are available for the area.

The most extensive survey of the Collie region was undertaken by John Septinus Roe, during 1830, in his capacity as the then Surveyor General. His travels did not extend far inland and he met no Aborigines during the expedition, noting that there was evidence for their presence consisting of "old habitations... of boughs and grass" (Roe, 1839). Other expeditions (eg Stirling 1837) also passed relatively close to the Collie region but did not venture sufficiently far inland so as to pass through it. Stirling (1837) also did not report any contact with Aboriginal people.

If the land use model suggested by Anderson (1984) is correct then it offers a plausible explanation for the failure of survey parties to meet Aboriginal groups. Most journeys were undertaken during the summer months when winter travels would have been necessary to observe Aboriginal usage of the uplands. In contrast to the paucity of reports from the inland, settlers who observed Aboriginal life during summer on the coastal plain (eg Bunbury, 1930) noted large numbers of people and a great breadth of their usual activities.

Although evidence of Aboriginal people remaining on the coast during winter does exist (eg Baudin, 1800 - 1803) their numbers appear to be much reduced from those noted, though somewhat later, by Bunbury (1930). This, it would appear, coincided with traditional movement into the upland forest.

Unfortunately, by the time Collie and its surrounds were settled the Aboriginal population of the south west had been decimated by introduced diseases, deprivation of access to resources and conflict so there was little opportunity for traditional practices to be observed.

## 5. ARCHAEOLOGICAL SURVEY

The survey was accomplished by observing the ground for artefactual material during traverses made both by slow moving four wheel drive vehicle and on foot. The four wheel drive was employed on the many tracks which criss-cross the lease as a result of geological survey and ore grade testing activities. Less accessible areas, and those thought likely to contain archaeological material were examined on foot. Additionally, the supposed locations of the previously recorded sites were revisited to determine their current status. Systematic traverses (on foot) were made across one section of pasture (which comprises less than 10% of the total area). However, the thick growth of fodder plants rendered this method unsatisfactory. In these areas therefore, greatest attention was paid to firebreaks along fence margins and overgrazed patches which occurred throughout. No artefactual material was located within the farmed areas. The three isolated finds were located in the forested remainder of the lease.

As a result of the survey three isolated artefacts were located.

| | | |
|---|---|---|
| 1. | CHIP | 0.7 cm x 0.8 cm x 0.3 cm |
| 2. | FLAKE | 1.5 cm x 2.4 cm x 0.8 cm |
| 3. | FLAKED PIECE | 3.6 cm x 2.1 cm x 1.05 cm |

Pieces one and two were discovered in the area surrounding a seasonal swamp (described in the preceding discussion of the local environment). This area had been identified for close examination from aerial photographs of the lease, as most likely to contain artefacts given the Pearce (1981b) data. Piece three was on a sandy track some distance from the swamp.

Inspection of the probable locations of the previously recorded material failed to locate any trace of them. Despite the uncertainty engendered by the less than pinpoint accuracy of even six figure grid references (Murdoch University, 1990) it is believed that, had any trace of these sites remained, the survey would have relocated them as at these locations exhaustive searches were made. Thus it can be confirmed that collections made (Novak, 1980) were indeed complete and the status of these finds is as previously reported, that is, they were either small scatters or isolated finds and not the surface expression of some larger stratified deposits.

It is estimated that approximately 40% of the Ewington lease was actually examined by this survey. The most limiting factor to a more complete study was ground visibility, which was generally extremely low due to the dense understorey vegetation characteristic of the open Jarrah Forest. This situation was exacerbated by human disturbance factors. Geological and core sampling surveys had removed, in some areas, many of the upper canopy trees, providing light stimulation to the plants beneath. As a result of this there were areas of secondary regrowth more dense than normal, and virtually impenetrable.

## 6. DISCUSSION

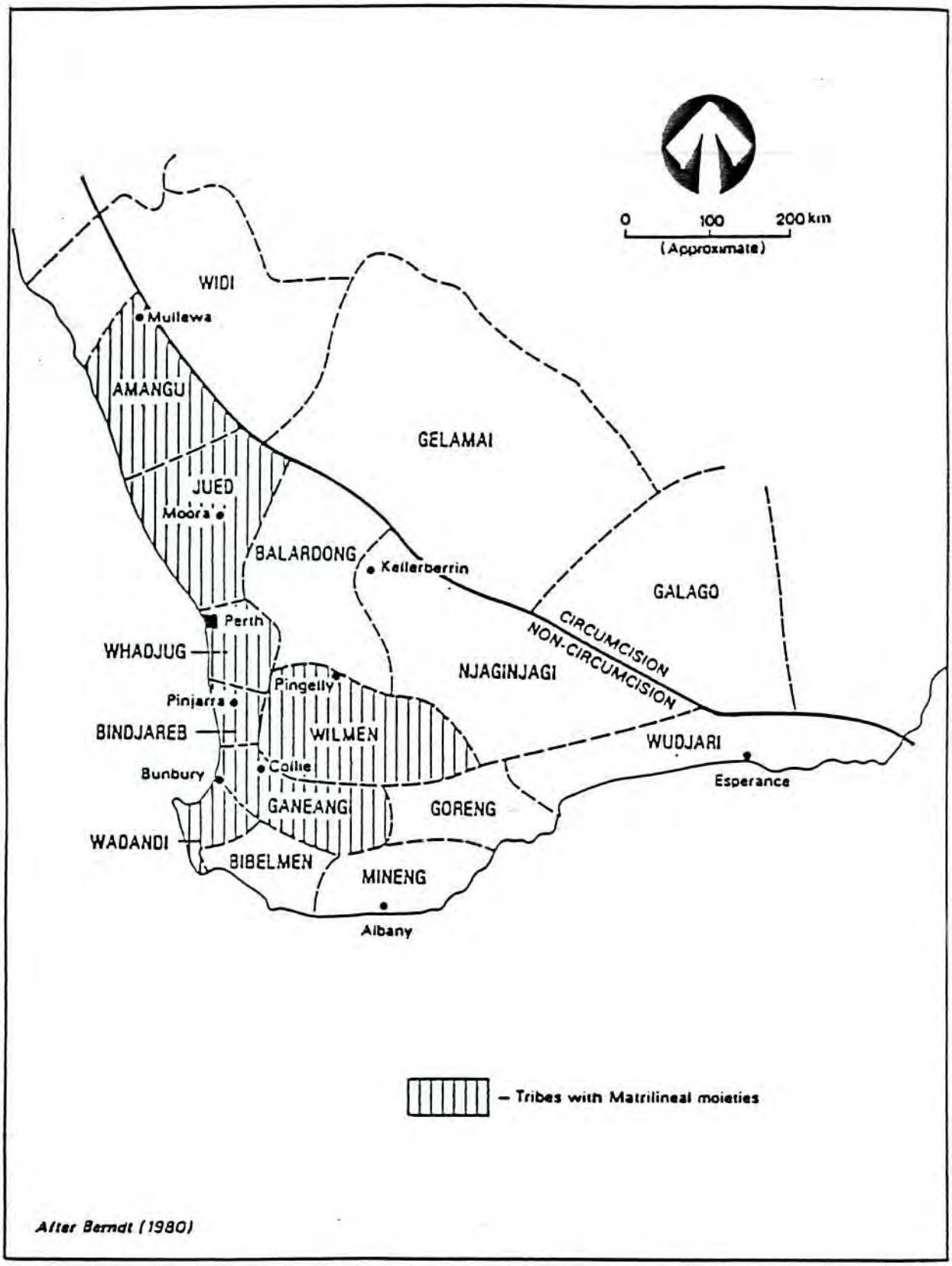
The failure of this survey to locate any significant archaeological material is consistent with previous work undertaken within the lease (Novak, 1980) and surrounding areas. As pointed out in the foregoing sections isolated finds and small artefact scatters are by far the most numerous expressions of Aboriginal occupation to be found in the Jarrah Forest. Whether this patterning represents seasonal usage which is resource or ritual driven (Anderson, 1984) is as yet unclear. With no detailed ethnographic information and a paucity of stratified sites there is no indication as to which of these factors was most influential in past Aboriginal society. The discovery and excavation of a new stratified deposit within the uplands would go some way toward answering this and the question of time depth for forest occupancy. Unfortunately the generally poor visibility occasioned by the heavy vegetation of the Darling Plateau makes discovery of such sites extremely difficult. For that reason any evidence of sub-surface material uncovered by development works should be examined by an archaeologist to determine its potential for excavation.

The study area has little potential to yield stratified sites as it would have provided little incentive in the past for concentrated Aboriginal occupancy. As Pearce (1981b) suggested it is the presence of permanent water and the accompanying resource abundance which allows the congregation of people, hence the development of excavatable archaeological deposits. Whilst there is a freshwater source within the Ewington lease it is most unlikely that it ever held sufficient water to permit intensive usage of the surrounding area. Indeed, it is unlikely that further archaeological material of any significance will be discovered within the lease. On two separate occasions it has been systematically surveyed revealing no material which has the potential to answer substantive research questions.

## 7. CONCLUSIONS AND RECOMMENDATIONS

It is concluded that the artefactual material discovered in the Ewington lease has little potential to expand knowledge of the Aboriginal occupancy of the area. Further, there is little likelihood that such archaeological sites will be discovered within its boundaries, the area having now been surveyed on two occasions. The Ewington lease has, therefore, been subject to sufficient investigation prior to development works commencing.

It is recommended that the proposed development be permitted to proceed as no archaeological impediment has been identified within the lease area.




**Tribal Boundaries of the South West**

MAP 3:

## 8. ETHNOGRAPHIC RESEARCH

### 8.1 Ethnographic Background

It is generally thought amongst anthropologists, that the southwest of Western Australia was occupied by 13 socio-dialectical groups or 'tribes'. These groups formed a distinctive socio-cultural bloc and formed part of the 'Old Australian Tradition'. They were distinguished from their neighbours to the north and east in that they did not practice circumcision or subincision. Although there may have been a collective identity before and for a time after colonisation, it is difficult to establish this. The more important consideration now is that, in the face of cultural destruction, southwest Aboriginal people have forged a strong collective identity as Nyungars.

The survey area falls within a region which was the territory of the Ganeang (Tindale 1974), although it is likely that several groups moved through the area, including the Wilmen, the Pinjarup (or Bindjareb, according the Berndt (1979)) and the Wardani (see Map 3). Tindale (ibid) also suggests that the Ganeang may have moved to Bunbury and the surrounding area only after colonisation. Overall, it is very difficult to establish clear cut boundaries at any time after contact with Europeans. Destruction of Aboriginal culture after that time blurred boundaries and attenuated connections with traditional lands. Also, as noted below, the knowledge of traditional associations with the land (mythological, ceremonial, spritual) was seriously eroded.

The social organization of these groups seems to have included matrilineal moieties ... manitjmat (white cockatoo) and wardangmat (crow). Each moiety was divided into 4 exogamous clans. The names of the clans had totemic associations which placed Aboriginals into a special spiritual relationship with the flora, fauna and landforms. However, Berndt (1979) points out that individuals still had ritual affiliation to sites and hence the ability to define stretches of country through their fathers. Thus, their social organization involved overlapping sets of ritual and land rights based on the dual membership of matrilineal and patrilineal groups.

A basic unit of these groups was a band or horde which characteristically numbered up to 40 persons and was comprised of a number of families which were the fundamental social unit. Ethnohistorical data suggests that there was a great deal of movement in these groups. Individuals, families and bands moved between areas generating a fluid local population size and composition and suggesting that boundaries between them were very permeable.

The destruction of Aboriginal social organization was heralded by European colonization, beginning in the Perth area and extending into the southwest. During this process, the Nyungar population was decimated. Epidemics, shootings by Europeans and draconian policies introduced by the colonial administration, including enforced exclusion of Nyungars from certain areas (eg urban areas), their concentration in settlements (eg Carrolup, Moore River), and restrictions on movement and labour resulted in the attenuation of traditional ties with the land and with sites (Berndt, 1979; Hammond, 1933). As a result, there has been a loss of traditional mythological and ritual associations with the land along with the knowledge which underpins these connections. However, there is still a substantial degree of knowledge available in Nyungar society concerning traditional mythological and ceremonial sites.

This knowledge is characteristically carried and transmitted within family networks (Baines, 1984). These networks have dynamic properties, changing boundaries to included and exclude parties, and revolving about movement along runs which may have a very long history. Myths and stories are deposited within these networks so that family networks associated with the same stretch of country may have equally well-developed, but quite different stories about the country.

With the attrition of knowledge, in some instances the sites are known but the mythology is lost; in other cases, the mythology is remembered but the site location has been forgotten.

In summary, there are two principal kinds of connections between individuals and families and the land and sites in Aboriginal society. They are:

1. Spiritual, mythological or religious. In the southwest, the major axis of myth is the Waugal and its influence on freshwater resources (O'Connor, Quartermaine and Bodney, 1989).

2. Historical/social associations

And it must be added here that, realistically, there is now a political/religious association in force. It has its roots in the land rights movement and in responses to the Aboriginal Heritage Act (1972-1980) which have served to politicize Aboriginal culture, in general, and Aboriginal spirituality, in particular.

The first two associations are not merely a matter of sentiment. Aboriginal connections with the land and specific sites are spiritual. This means that Aboriginal people perceive links which involve the total life-cycle (birth, death, transitions of status/initiations) which infuse sites with dense and culturally palpable meaning. This may extend to beliefs that the trees, earth and other natural features are the domain of spirits of the deceased. This locates Aboriginal attachments to the land and sites in a spiritual history, grounding their present actions, and which provide a framework for a meaningful and culturally continuous future.

There is no doubt that the strength of attachments varies between individuals and families according to their life experiences, values and a range of other factors. However, there is, overall, a recognition that these associations are crucial elements of Nyungar society.

## 9. ETHNOGRAPHIC SURVEY

The ethnographic survey took two forms. Firstly an archival search of the materials held at the Department of Aboriginal Sites. This included perusal of previous research reports and re-examination of research undertaken by McDonald, Hales and Associates consultants in the Collie area. Secondly, an ethnographic field survey which involved accompanying Aboriginal informants to the survey area and circumnavigating and traversing it in order to determine whether there are any sites of significance within it.

### 9.1 Archival Research

A search of the Department of Aboriginal Sites files and reports revealed that the Collie area is rich in ethnographic significance. There is a number of sites in and around the township itself and most of these are associated with the Collie River and the influence of the mythological being, the Waugal. Also, the Collie site complex includes a series of camp sites which have both traditional and historical significance. To the south and east, there are sites of mythological significance. However, the closest site of significance to the survey area is Boronia Gully, a camp site which has traditional associations. It is also the location of burials and has strong local sentiments attached to it. Boronia Gully is well outside the survey area and poses no impediment to development. However, any mining which involves tunneling under or near the site would require consultation with local Aboriginal people.

## 9.2 Ethnographic Field Survey

The field survey took place on the 8th and 16th of January, 1991 and it was undertaken by Dr Ralph Locke. Extensive recourse was made to local Aboriginal informants concerning the survey area through interviews and telephone conversations. Field visits to the survey site were arranged with two knowledgeable informants (A and B) from Collie. However, one of them (A) suffered a heart attack and was transported to Perth for hospitalisation. He is still not available. However, previous research with this individual and his family yielded a detailed picture of the ethnographic heritage in the Collie region, including the survey area.

Both principal informants are elderly men who have considerable status in the local Aboriginal communities by virtue of their social status as 'elders' and their extensive knowledge of Aboriginal cultural matters. Both were born in the area and their families moved through runs (patterns of movement and identification with localities which were often seasonal) which extend from south of Bunbury, inland encompassing Collie and north beyond Perth.

Informant B was accompanied to the survey area which was traversed and circumnavigated. No ethnographic sites were located.

In most of the southwest, the pattern of site distribution, and the identification of site clusters, clearly shows some immportant correlations. Aboriginal movement and camping in the region is connected with waterways, lakes and swamps where groups of people, seasonally, could be accomodated by local food resources. Sometimes these gatherings were quite large and afforded Aboriginal people with the opportunity to consolidate the ceremonial/spritual life which, in turn, deepened the bonds with such localities. Significance attached to such sites is therefore pragmatic, there is an abundance of life-sustaining resources and spiritual locations where large numbers of births, deaths and ceremonial events occurred.

Areas around the Collie waterways which were used a campsites were points on the Aboriginal 'pads' ... routes along which Aboriginal people moved in the course of seasonal movement and in daily hunting and gathering activites. Pads extend from the Collie area, along the rivers and move south, north and west to the coast. It is interesting to note that European settlement patterns followed Aboriginal land occupancy patterns, resulting in direct competition for land and its resources. A struggle which was lost by the Aboriginal people.

One other point of significance in the area is the fact that many of the fresh water resources are not only associated with the mythological being, the Waugal, and therefore avoidance rules, but they are also associated with ethnomedicine. Specifically, they are sites where individuals were brought for healing through the positive action of the Waugal and where herbal and other substances were gathered, prepared and used for healing purposes

## 10. CONCLUSIONS AND RECOMMENDATIONS

No ethnographic sites of significance were found within the survey area, nor are there any sites close enough to impede development.

It is therefore recommended that development be allowed to proceed.

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## APPENDIX 1

### Obligations Relating to Sites Under the Aboriginal Heritage Act 1972 - 1980

Report of Findings

15. Any person who has knowledge of the existence of anything in the nature of Aboriginal burial grounds, symbols or objects of sacred, ritual or ceremonial significance, cave or rock paintings or engravings, stone structures or arranged stones, carved trees, or of any place or thing to do which this Act applies or to which this Act might reasonably be suspected to apply shall report its existence to the Trustees, or to a police officer, unless he has reasonable cause to believe the existence of the thing or place in question to be already known to the Trustees.

Excavation of Aboriginal Sites

16. (1) Subject to Section 18, the right to excavate or to remove any thing from an Aboriginal site is reserved to the Trustees.

(2) The Trustees may authorise the entry upon and excavation of an Aboriginal site and the examination or removal of any thing on or under the site in such a manner and subject to such conditions as they may direct.

Offences Relating to Aboriginal Sites

17. A person who -

(a) excavates, destroys, damages, conceals or in any way alters any Aboriginal site; or

(b) in any way alters, damages, removes, destroys, conceals, or who deals with in a manner not sanctioned by relevant custom, or assumes the possession, custody or control of, any object on or under an Aboriginal site, commits an offence unless he is acting with the authorisation of the Trustees under Section 16 or the consent of the Minister under Section 18.

Consent to Certain Uses

18. (1) For the purposes of this Section, the expression "the owner of any land" includes a lessee from the Crown, and the holder of any mining tenement or mining privilege, or of any right or privilege under the Petroleum Act 1967, in relation to land.

(2) Where the owner of any land gives to the Trustees notice in writing that he requires to use the land for a purpose which, unless the Minister gives his consent under this Section, would be likely to result in a breach of Section 17 in respect of any Aboriginal site that might be on the land, the Trustees shall, as soon as they are reasonably able, form an opinion as to whether there is any Aboriginal site on the land, evaluate the importance and significance of any such site, and submit the notice to the Minister together with their recommendation in writing as to whether or not the Minister should consent to the use of the land for that purpose, and where applicable, the extent to which and the conditions upon which his consent should be given.

(3) Where the Trustees submit a notice to the Minister under Subsection (2) of this Section he shall consider their recommendation and having regard to the general interest of the community shall either -

(a) Consent to the use of the land the subject of the notice, or a specified part of the land, for the purpose required, subject to such conditions, if any, as he may specify; or

(b) wholly decline to consent to the use of the land the subject of the notice for the purpose required,

and shall forthwith inform the owner in writing of his decision.

(4) Where the owner of any land has given to the Trustees notice pursuant to Subsection (2) of this section and the Trustees have not submitted it with their recommendation to the Minister in accordance with that Subsection the Minister may require the Trustees to do so within a specified time, or may require the Trustees to take such other action as the Minister considers necessary in order to expedite the matter, and the Trustees shall comply with any such requirement.

(5) Where the owner of any land is aggrieved by a decision of the Minister made under Subsection (3) of this Section and he may, within the time and in the manner prescribed by rules of court, appeal the decision of the Minister to the Supreme Court which may hear and determine the appeal.

(6) In determining an appeal under Subsection (5) of this section the Judge hearing the appeal may confirm or vary the decision of the Minister against which the appeal is made or quash the decision and substitute his own decision which shall have effect as if it were the decision of the Minister, and may make such an order as to the costs of the appeal as he sees fit.

(7) Where the owner of the land gives notice to the Trustees under Subsection (2) of this Section, the Trustees may, if they are satisfied that it is practicable to do so, direct the removal of any object to which this Act applies from the land to a place of safe custody.

(8) Where consent has been given under this Section to a person to use any land for a particular purpose nothing done by on behalf of that person pursuant to, and in accordance with any conditions attached to, the consent constitutes an offence against this Act."

## APPENDIX 2

## NOTES ON THE RECOGNITION OF ABORIGINAL SITES

There are various types of Aboriginal sites, and these notes have been prepared as a guide to the recognition of those types likely to be located in the survey area.

An Aboriginal site is defined in the Aboriginal Heritage Act, 1972-1980, in section 5 as:

"(a) any place of importance and significance where persons of Aboriginal descent have, or appear to have, left any object, natural or artificial, used for, or made or adapted for use for, any purpose connected with the Aboriginal people, past or present;

(b) any sacred, ritual or ceremonial site, which is of importance and special significance to persons of Aboriginal descent;

(c) any place which, in the opinion of the Trustees, is or was associated with the Aboriginal people and which is of historical, anthropological, archaeological or ethnographical interest and should be preserved because of its importance and significance to the cultural heritage or the State;

(d) any place where objects to which this Act applies are traditionally stored, or to which, under the provisions of this Act, such objects have been taken or removed."

### Habitation Sites

These are commonly found throughout Western Australia and usually contain evidence of tool-making, seed grinding and other food processing, cooking, painting, engraving or numerous other activities. The archaeological evidence for some of these activities is discussed in detail under the appropriate heading below.

Habitation sites are usually found near an existing or former water sources such as a gnamma hole, rock pool, spring or soak. They are generally in the open, but they sometimes occur in shallow rock shelters or caves. It is particularly important that none of these sites be disturbed as the stratified deposits which may be found at such sites can yield valuable information about the inhabitants when excavated by archaeologists.

Seed Grinding

Polished or smoothed areas are sometimes noticed on/near horizontal rock surfaces. The smooth areas are usually 25 cm wide and 40 or 50 cm long. They are the result of seed grinding by the Aboriginal women and indicate aspects of the past economy.

Habitation Structures

Aboriginal people sheltered in simple ephemeral structures, generally made of branches and sometimes tussocks of grass. These sites are rarely preserved for more than one occupation period. Occasionally rocks were pushed aside or used to stabilise other building materials. When these rock patterns are located they provide evidence for former habitation sites.

Middens

When a localised source of shellfish and other foods has been exploited from a favoured camping place, the accumulated ashes, hearth stones, bones and other refuse can form mounds at times several metres high and many metres in diameter. Occasionally these refuse mounds or middens contain stone, shell or bone tools. These are most common near the coast but examples on inland lake and river banks are not unknown.

Stone Artefacts Factory Sites

Pieces of rock from which artefacts could be made were often carried to camp sites or other places for final production. Such sites usually easily recognisable because the manufacturing process produces quantities of flakes and waste material which are clearly out of context when compared with the surrounding rocks. All rocks found on the sandy coastal plain for example, must have been transported by human agencies. These sites are widely distributed throughout the state.

Quarries

When outcrops of rock suitable for the manufacture of stone tools were quarried by Aborigines, evidence of the flaking and chipping of the source material can usually be seen *in situ* and nearby. Ochre and other mineral pigments used in painting rock surfaces, artefacts and in body decoration are mined from naturally occurring seams, bands and other deposits. This activity can sometimes be recognised by the presence of wooden digging sticks or the marks made by these implements.

Marked Trees

Occasionally trees are located that have designs in the bark which have been incised by Aborigines. Toeholds, to assist the climber, were sometimes cut into the bark and sapwood of trees in the hollow limbs of which possums and other arboreal animals sheltered. Some tree trunks bear scars where sections of bark or wood have been removed and which would have been used to make dishes, shields, spearthrowers and other wooden artefacts. In some parts of the State platforms were built in trees to accomodate a corpse during complex rituals following death.

It was the custom to hide ceremonial objects in niches and other secluded places. The removal of objects from these places, or photography of the places or the objects or any other interference with these places is not permitted.

Ceremonial Grounds

At some sites the ground has been modified in some way by the removal of surface pebbles, or the modelling of the soil, or the digging of pits and trenches. In other places there is not noticeable alteration of the ground surface and Aborigines familiar with the site must be consulted concerning its location.

Mythological Sites

Most sites already described have a place in Aboriginal mythology. In addition there are many Aboriginal sites with no man-made features which enable them to be recognised. They are often natural features in the landscape linked to the Aboriginal account of the formation of the world during the creative "Dreaming" period in the past. Many such sites are located at focal points in the creative journeys of mythical spirit beings of the Dreaming. Such sites can only be identified by the Aboriginal people who are familiar with the associated traditions.