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Heavy minerals mine Beenup : environmental review and
management programme

NSW DEPT PRIMARY INDUSTRIES



AA068090

MINERAL DEPOSITS LIMITED
A MEMBER OF



BHP-UTAH
Minerals International

Heavy Minerals Mine **BEENUP**

ENVIRONMENTAL REVIEW and MANAGEMENT PROGRAMME

Prepared by
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BEENUP HEAVY MINERALS MINE ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME

The Environmental Protection Authority (EPA) invites people to make a submission on this proposal.

The Environmental Review and Management Programme (ERMP) for the Beenup proposed Heavy Minerals Mine has been prepared by Lewis Environmental Consultants on behalf of Mineral Deposits Limited in accordance with Western Australian Government procedures. The report will be available for comment for 10 weeks:

- ° beginning Monday 9th April, 1990
- ° finishing Monday 18th June, 1990.

Comments from government agencies and from the public will assist the EPA to prepare an Assessment Report in which it will make recommendations to the Government.

Following receipt of comments from government agencies and the public, the EPA will summarise these comments and forward them to Mineral Deposits Limited, and may ask for further information. The EPA will then prepare an assessment report with recommendations to Government, taking into account issues raised in the public submissions.

WHY WRITE A SUBMISSION?

A submission is a way to provide information, express your opinion and put forward your suggested course of action including any alternative approach. It is useful if you indicate suggestions which could improve the proposal.

All submissions received will be acknowledged.

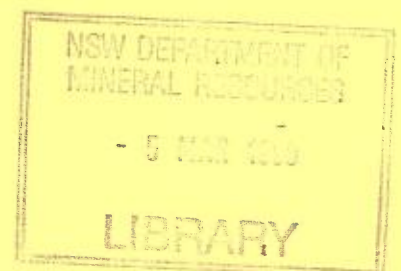
DEVELOPING A SUBMISSION

You may agree or disagree, or comment on, the general issues discussed in the ERMP or with specific proposals. It helps if you give reasons for your conclusions, supported by relevant data.

You may make an important contribution by suggesting ways to make the proposal environmentally more acceptable.

When making comments on specific proposals in the ERMP,

- clearly state your point of view,



- indicate the source of your information or argument if this is applicable, and
- frame your queries in the form of questions,
- suggest recommendations, safeguards or alternatives.

POINTS TO KEEP IN MIND

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

Attempt to list points so that the issues raised are clear. A summary of your submission is helpful. Refer each point to the appropriate section, chapter or recommendation in the ERMP. If you discuss sections of the ERMP, keep them distinct and separate, so that there is no confusion as to which section you are considering.

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

Please indicate whether your submission can be quoted, in part or in full, by the EPA in its Assessment Report.

REMEMBER TO INCLUDE

Your name, address, date.

**THE CLOSING DATE FOR SUBMISSIONS IS: Monday 18th June, 1990
SUBMISSIONS SHOULD BE ADDRESSED TO:**

The Chairman
Environmental Protection Authority
1 Mount Street PERTH WA 6000

Attention: Mr. Warren Tacey.

PREFACE

This Environmental Review and Management Programme (ERMP) contains many studies and evaluations of the environment in which the proposed project is located. The ERMP has been designed to make it easy to read and understand the material in it.

To accomplish this, the ERMP is arranged as follows:

- ° Summary
- ° Table of Contents
- ° Introduction
- ° Description of the existing environment
- ° Description of the proposed project
- ° Analysis and management of potential impacts
- ° Conclusions
- ° Summary of environmental management commitments
- ° Figures
- ° Appendices

There are 14 Appendices containing specialist reports and other material referred to in the ERMP. Appendix XIII gives a list of abbreviations used, and Appendix XIV is a glossary of technical terms used.

Lewis Environmental Consultants, March, 1990

Summary

SUMMARY

INTRODUCTION

The Beenup mineral sands deposit, situated on farmland 17 km north east of Augusta, is one of the world's major ilmenite discoveries. An estimated 500 million tonnes of ore, containing approximately four per cent heavy minerals, will support mining and mineral separation on the site for more than 20 years.

Mineral Deposits Ltd., a wholly owned subsidiary of the Broken Hill Proprietary Company Limited, proposes to mine the deposit for ilmenite, zircon and rutile. An estimated annual production of 500,000 tonnes of heavy minerals will be separated on site and transported by road to the port of Bunbury for export. This Environmental Review and Management Programme (ERMP) has been prepared to review the relevant environmental aspects of the proposal and develop a detailed management programme to maximise the benefits and minimise the potential disadvantages of the project.

KEY ISSUES

- **Transport** - The development of a major new transport route from the Scott River area to Bunbury, bypassing Margaret River, Busselton, Ludlow and Capel.
- **Employment** - The recruitment and accommodation of up to 200 construction workers, up to 135 full time operations employees and a potential transport workforce of 45.
- **Rehabilitation** - The establishment of pasture, natural bushland and tree plantations on the site after mining.
- **Economic aspects** - The direct and flow-on effects of employment, project expenditures, export income and Government revenues.
- **Water Management** - A hydrological management plan to allow for mining without impact on the Scott National Park, the Scott River and the Blackwood River.
- **Flora** - The protection of rare flora species found in the Beenup area.
- **Dust control** - Management plans to prevent the spread of dust in windy conditions typical of the Scott River area.
- **Dieback control** - A research and management plan to prevent the spread of dieback.

- ° **Social issues** - The integration of the project into the Augusta-Margaret River community and the district's tourism/agriculture-based economy.
- ° **Community consultation** - The planning modifications and contributions resulting from an extensive community consultation programme.

The Beenup ERMP has adopted a balanced approach to the environmental impact assessment process by giving equal emphasis to social, economic, biological and physical environmental issues. The attention to social issues was a response to intense local interest in the project, as the first potential mineral sand mining operation in the Augusta-Margaret River Shire. At the same time, many normally sensitive physical environmental issues - such as waste disposal and gaseous emissions - have been ruled out by the proponent's decision not to consider secondary processing.

COMMUNITY CONSULTATION

Local residents have played a significant role in modifying the project proposals to meet some of the community needs. In May, 1989, before the Beenup proposal was confirmed, the proponent held informal talks with the Shire Council to set up a framework for local input to the project planning and review. The resulting community consultation group included representatives from the Shire Council, local landowners, the Leeuwin Conservation Group, the WA Farmers' Federation, the Augusta Ratepayers' Association, the Augusta Businessmen's Association, the WA Fishermen's Association, the South West Development Authority, the Department for Conservation and Land Management and Mineral Deposits Ltd. One of the major roles of the group was the evaluation of options for transporting mineral products. The group also helped to draw up guidelines for the social impact study.

The consultative group made site visits to current heavy mineral operations in New South Wales, where the proponent has existing mining and separation plants. The group's report on the interstate visit identified a generally positive impact of mineral sands production in the Hawks Nest area - a community similar to Augusta in WA. At the same time, the group identified specific issues to be addressed in the ERMP.

The need for a balance between the various aspects of environmental research has been underlined by the priorities identified during community consultation:

- ° Transport of mineral product.
- ° Potential impact on water resources

- ° The socio-economic impact within the Augusta-Margaret River Shire.
- ° The final land use.

Each of these priorities has been given detailed attention in the ERMP.

If the project is approved, the proponent sees a continuing role for community consultation during the construction and operational stages.

THE PROJECT

Mining will be carried out by a bucketwheel dredge floating in a pond having an average depth of 44 m. The water/sand/clay mix will be delivered to a floating concentrator plant. After oversize material and clay slimes are removed, the heavy minerals will be separated from the sand slurry by gravity separation using banks of spirals. The heavy mineral concentrate will be pumped ashore to a stockpile and dewatered by a cyclone. Coarse tailings will be returned behind the dredge pond. Some slimes will be mixed with the tailings and the remainder will be pumped to settling ponds.

The dredge and wet concentrator plant will float on the dredge pond at groundwater level. The method of mining will be designed to accommodate the rise in the pond level during the winter months when the groundwater rises and avoid the need to discharge water from the pond. During summer, if required, makeup water will be supplied to the dredge pond from several deep bores.

The wet concentrate will be transported from the mining operation to a dry mill nearby, where it will be dried in a rotary dryer before being separated into its constituent mineral products ilmenite, rutile and zircon. This separation will be carried out by gravity, electrostatic and electromagnetic techniques.

The surface area affected by pumping each year will be in the order of 30 ha and rehabilitation will be carried out as an integral part of the mining operation. Any vegetation on the mining path will be cleared and the topsoil removed for storage at regular intervals. The topsoil will be replaced as the mined areas are recontoured. Some of the slimes, or clay residues, will be mixed with the soil to improve moisture and nutrient holding capacity. The topsoil on areas of native vegetation will be stripped in two layers: the surface 5-10 cm which contains most of the seeds and other plant propagules, and the remainder, which is expected to be about 15 cm.

A final land use Work Party was set up in May, 1989, with the approval of the Hon. Minister for Mines. The proponent has drawn up the following integrated

rehabilitation plan for the mining area, based on the recommendations of the Work Party and the Beenup Consultative Group:

- ° 72 per cent agriculture, including possible community uses.
- ° 13 per cent rehabilitation of the main remnants of native vegetation.
- ° 11 per cent planting of native vegetation along the major water courses.
- ° 4 per cent planting of a buffer zone of native vegetation along the southern boundary of the Scott National Park.

One of the most significant economic, environmental and social issues to be addressed in the project planning is transport of the mineral product. The proponent considered a range of options based on shipping, rail, road and a combination of road-rail. Preliminary engineering and economic studies showed three viable options:

- ° Road transport via Sues Road to the port of Bunbury.
- ° Shipping from a conveyor and jetty loader in Flinders Bay.
- ° Pumping wet concentrate through a seabed pipeline to a pontoon loader in Flinders Bay.

The final selection was based on more detailed economic studies by the proponent and a social impact assessment by the Beenup Consultative Group. The choice was road transport via Sues Road and a new heavy haulage route bypassing Ludlow and Capel to Bunbury Inner Harbour.

THE EXISTING ENVIRONMENT

The Beenup project area is freehold grazing land adjacent to the Scott National Park and a camping reserve. The area, currently held under exploration licence, is the subject of four mining lease applications. The area has a Mediterranean climate with cool wet winters and warm, dry summers, although some rain is usually received during the summer months. Beenup is part of the Scott River plain, a low-lying swampy region subject to consistent, strong winds year-round.

A comprehensive fauna survey was carried out on the project area and adjoining areas. The only rare fauna species recorded were the Peregrine Falcon and Red-eared Firetail. The Peregrine Falcon is a highly mobile bird with little habitat specificity and is present throughout Australia. The Red-eared Firetail is present throughout the wetter portions of the South West of Western Australia. No rare

mammals, amphibians or reptiles were recorded. It was concluded that none of the fauna species recorded on the area could be considered threatened by the proposed project.

Approximately two thirds of the project area has been cleared for agriculture and cattle have access to the remaining areas of native vegetation. However there is still an extensive range of vegetation communities and floral species with four main groups of vegetation:

- ° Open forests and woodland of Jarrah, Marri, Yarri, *Banksia*, Peppermint and Paperbark.
- ° Low open woodland and forests of *Banksia*, Peppermint, Paperbark and Jarrah.
- ° Open and closed heaths of *Banksia* and mixed Proteaceae-Myrtaceae species.
- ° Sedgeland of *Leptocarpus* species, Cyperaceae-Restionaceae species and *Juncus pallidus*.

A total of 326 species was recorded, representing 55 families and 176 genera. The species list included 31 introduced species. Two species from the Gazetted Rare Flora List were identified, viz. *Darwinia* sp. (G.J. Keighery 3582) and *Lambertia orbifolia*. Ten species from the Reserve Flora Priority List were also recorded. Three Species of Interest were collected on the survey, including a new species of *Boronia*. A new genus which has only recently been described was also collected. The two rare species and nine of the ten species on the Reserve Flora List are outside the proposed mining area.

The presence of the dieback fungus *Phytophthora cinnamomi* was identified in the area proposed for mining. It is planned to carry out a complete survey of dieback on the mining area if approval for the project is granted, to provide the information for a dieback management programme.

No Aboriginal artefacts of Sites of Significance were located on the project area.

A survey of natural surface gamma dose rates showed that the rates on the project area were not significantly different to those in other parts of the district, including Augusta.

A detailed hydrological study was carried out to determine the characteristics of the groundwater resource and to enable a mining plan to be formulated that would not adversely affect the groundwater or surface waters.

A comprehensive socio-economic survey of the Shire was carried out. The major components of the socio-economic study - the economic profile, the demographic profile, housing, land use and development, and social infrastructure - are detailed in the ERMP.

ENVIRONMENTAL IMPACTS AND MANAGEMENT

Economic

Substantial economic benefits are expected to flow from the proposed project:

- Employment. During the construction phase, employment over an 18 month period will peak at 200 persons. Permanent operational employment is expected to be 135 persons. An additional 45 persons will be employed in the road transport of minerals.
- Household income. The generation of household income, including flow-on effects, will total \$17.2M for the construction phase and \$10.7M (\$1989) annually for the operational phase. The increase in year-round economic activity will help to offset the current seasonal fluctuations in income from tourism and agriculture.
- Project expenditures. These will total \$80.6M including flow-on effects for the construction phase and \$92.5M (\$1989) annually for the operational phase.
- Shire income. Apart from paying rates, the proponent will negotiate road maintenance contracts and other financial support arrangements with the Shire Council.
- Government revenues. Both the construction and operational phases will provide revenues for the State and Federal Governments; State Government revenues will be in the order of \$7.0M annually.
- Infrastructure. The value of additions to the State's infrastructure will exceed \$20.0M (\$1989).
- Export income. The project will contribute an average of \$50M (\$1989) annually to the country's export income.

Physical

The nature of the mining method will ensure that there will be minimal drawdown of the water table, even at the end of summer and dams and pastures will not be adversely affected. The regional groundwater resources will not be affected. Measures will be taken to ensure that turbid water is not released to the National Park or the Scott and Blackwood Rivers.

The total length of the transport route will be sealed and where necessary, raised to MRD or Shire standards. Measures will be taken to prevent excessive noise at houses near the road intersection of Scott River Road and Brockman Highway.

The generation of dust from areas that are temporarily disturbed, eg. land cleared of vegetation and soil in advance of mining, topsoil stockpiles, tailings, dried slimes, concentrate heaps and stockpiles, and unsurfaced haul roads within the mining area will be controlled by a combination of vegetative covers, windbreaks, and watering of unsurfaced haul roads.

Biological

A management programme for the the two species on the Gazetted Rare Flora List and nine of the 10 species on the Rare Flora Priority List is being developed in conjunction with CALM.

The possible spread of dieback caused by mining operations and road widening and re-alignment will be controlled by management and hygiene measures.

Rehabilitation will be fully integrated with mining operations and the rehabilitation and land use plan agreed upon will be implemented following mining.

Social

The proposed project will lead, indirectly, to an accelerated population growth in the Shire. Although the proponent is hoping to recruit a majority of its employees from the local area, increased economic activity will lead to an overall employment growth of more than 300. The change is expected to lead to some workforce turnover in the local community. A socio-economic study included in the ERMP has estimated that the Beenup project will account for approximately 42 percent of the population increase between 1989 and 1992.

The enlarged workforce will place a significant demand on housing in the Augusta area, creating the need for advanced planning to ensure adequate housing and units. The proponent will provide on-site and caravan park accommodation for the construction workforce, expected to peak at 200 in the second half of 1991. One of the options being considered by the proponent and the Shire Council is

the development of a permanent caravan park, to be transferred to the Shire once construction is finished.

The proponent is working with the Shire Council and the Beenup Consultative Group to identify all community infrastructure needs likely to be generated by the project. A series of commitments in the ERMP includes an undertaking by the proponent to ensure that the Shire is not financially disadvantaged by the project.

Social adjustment of the workforce into the Shire will be minimised by some general measures, such as the employment of suitable local residents where possible, the timely provision of facilities and services needed by any incoming population, the establishment of a new residents' information kit, concerted efforts by existing clubs to attract new members and special activities to encourage social interactions.

The proponent has considered the potential impact on tourism in the Shire. Evidence from previous mining operations, including Mineral Deposits' Hawks Nest operations, indicates that conflict between the two industries is unlikely. The proponent will investigate the potential for future mine site tours.

ENVIRONMENTAL COMMITMENTS

In the ERMP the proponent has outlined a number of commitments relating to the construction phase, mining operations, rehabilitation, mineral separation, transport, control of dieback and monitoring. These commitments may assist the EPA to formulate conditions should approval be granted for the project to proceed.

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REFERENCES

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Introduction

1.0 INTRODUCTION

1.1 BACKGROUND TO THE PROJECT

The Company

The Proponent, Mineral Deposits Ltd. (MDL¹) is a wholly owned subsidiary of the Broken Hill Proprietary Company Limited (BHP) and is a member of BHP-UTAH Minerals International. MDL has mined mineral sands on the east coast of Australia for almost 50 years, and through its predecessors Mineral Deposits Pty. Ltd. and Mineral Deposits Syndicate, is now the oldest operating heavy mineral mining company in the world. The Company currently has three wet plant/dredging operations north of Newcastle, New South Wales with the mineral concentrate being processed at MDL's dry mill at Hawks Nest. MDL is also the world's leading supplier to the mining industry of spiral and cone gravity concentrators and electrostatic separators, and is a major supplier of complete mineral separation plants.

Location of the Project

The Beenup deposit is situated approximately 17 km north-east of Augusta (Figure 1.1). The area falls within the Scott coastal plain, which is essentially low lying with local topographic relief in the order of only a few metres.

Beenup is situated on privately owned land which is used for grazing by cattle and sheep. MDL has purchased approximately 937 ha of this land, which contains the area to be mined. The previous landowners are continuing to occupy the land under a lease-back arrangement with the Company.

Development of the project

BHP commenced exploration in the area in 1986 and identified a potential heavy mineral resource in 1988. Since then they have carried out additional drilling to determine the extent of the deposit. During the early part of 1988 MDL became involved in assisting BHP Exploration to assess the potential of the deposit. There is no previous record of mineral sands exploration being carried out within the

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current project area at Scott River, although there have been investigations of coal and iron ore deposits in the area.

It has now been established that the Beenup deposit contains in excess of 500 million tonnes of ore, with approximately 4% heavy mineral content by weight. At expected production rates the orebody will be sufficient to sustain the mining operation for more than 20 years.

The major mineral contained in the deposit is ilmenite suitable for the production of titanium dioxide pigment using the sulphate process. Secondary minerals in the deposit are zircon and rutile. Monazite, which is the major source of radioactive material in heavy mineral sands, is virtually absent - the percentage of monazite contained within the *concentrated* heavy mineral is less than 0.001%.

The water table at Beenup is close to the surface and at times during the winter months, is at the surface. The orebody is therefore suitable for excavation by dredging. The electrically powered dredge will excavate ore at the rate of 3,000 tonnes per hour to a depth of up to 50 metres below the ground. Because of the considerable depth of the orebody, the surface area of land to be affected by mining each year will be in the order of only 30 ha. The heavy minerals will be extracted by a floating wet plant, utilising MDL's gravity concentration technology. The remaining material, comprising the bulk of the orebody, will be returned to the area immediately behind the dredge pond.

Initially there will be a minor increase in sand volume (5-10%), due to the "bulking" effect of the sand tailings. This will be compensated for in part by the removal of the mineral. Over the ensuing 20 to 30 years the volume will gradually compact back to a level very close to the original surface.

The heavy mineral concentrate will be trucked to the dry mill, where it will be dried and the constituent minerals separated using further gravity, electrostatic and electromagnetic techniques.

Approximately 500,000 tonnes of heavy minerals will be produced annually. Following an assessment of transport options (Section 3.4), the proponent proposes to transport the mineral products to Bunbury by road. Subject to approval, the proponent proposes to commence mine construction work in October, 1990 and to commence mining in March, 1992.

The reconstitution of landforms and rehabilitation of the land will be a continuous process behind the mining operation, as the dredge pond advances along the mining path. The proposed post-mining land use has been agreed upon in conjunction with relevant Government bodies and other interested parties and is discussed more fully in Section 3.1.9.

1.2 OBJECTIVES OF THE PROJECT

The aims and objectives of the Beenup project may be summarised as follows.

- ° Develop the heavy mineral resource at Beenup:
 - To mine the heavy mineral orebody by a dredging operation to produce a heavy mineral concentrate.
 - To produce heavy minerals by drying the heavy mineral concentrate and separating it into the constituent minerals, viz. ilmenite, zircon and rutile.
- ° Transport the heavy minerals to Bunbury for export to world markets.
- ° Implement mining and operational procedures and safeguards to ensure that there is no or minimal adverse environmental impact on the physical, biological and community environments at Beenup, within the Shire of Augusta/Margaret River, on the preferred transport route to Bunbury and at the Bunbury facility.
- ° Conduct a mining operation for a period in excess of 20 years, which will bring economic benefits to the proponent, the residents of the Shire, the State and the Nation.

1.3 IMPLICATIONS OF THE "NO PROJECT" OPTION

If a decision is made that the proposed project not proceed, the following benefits would not eventuate:

- ° Direct construction employment over an 18 month period, peaking at 200, would not eventuate. Direct operational employment of 115, with a flow-on effect of 309, would not eventuate.
- ° Household income generation, including flow-on effects, totalling \$17.21 M for the construction phase and \$10.718 M (\$1989) annually for the operational phase, would not eventuate.
- ° Project expenditures including flow-on effects totalling \$80.63 M for the construction phase and \$92.5 M (\$1989) annually for the operational phase, would not eventuate.
- ° The steady income derived from the project would not help to offset the seasonal variations in the Shire's economy.

- ° Both the construction and operational phases would provide revenues for the State and Federal Governments. State Government revenues in the order of \$7.05 M per year would not eventuate.
- ° Additions to the State's infrastructure, exceeding \$20.0 M (\$1989) in value, would not eventuate.
- ° The project's contribution to the country's export income of an average of \$50 M (\$1989) per annum would not eventuate.
- ° The upgrading and sealing of an all-weather heavy haulage route which bypasses Capel, Busselton and Margaret River would not occur in the foreseeable future.

1.4 THE ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME

In April, 1989 BHP and MDL announced their interest in developing the Beenup deposit and began actively consulting with relevant government departments and community groups, to help identify areas of possible public interest about the development. A Notice of Intent was lodged with the Department of Mines setting out basic information about the proposed Beenup project and advising their intention of applying for mining leases at Beenup. The Company also approached the Environmental Protection Authority to obtain environmental guidelines relevant to the project.

The EPA determined that the environmental aspects of the project should be evaluated at the level of an Environmental Review and Management Programme (ERMP). The EPA prepared guidelines for the preparation of the ERMP (Appendix I). This report is the ERMP prepared in accordance with the EPA guidelines.

Objectives of the ERMP

- ° Describe all relevant aspects of the physical, biological and community environment which may be influenced by the project.
- ° Describe the overall project and the major components in detail.
- ° Evaluate alternatives to the various aspects of the project, viz. mining, mineral processing, project development, transport of product, rehabilitation.
- ° Assess the likely impact on the environment.

- Develop an environmental management programme which will ensure that adverse impacts are avoided or minimised.
- Provide adequate information about the project and the environment in which it will operate to the relevant authorities to enable formal approval to commence operations to be granted.

Outline of the ERMP

The ERMP is set out in a logical sequence as follows:

- Summary
- Introduction
- The existing environment. Only those aspects of the environment which are relevant to the project and may be affected are described in this Section, i.e.
 - The physical environment - land tenures and licences, existing land use, climate, geology, landforms and soils, hydrology, radiation levels, dust and noise.
 - The biological environment - flora and fauna.
 - The community environment - archaeology and ethnography, population, employment, infrastructure levels.
- Description of the project. In this Section all of the processes that are carried out to obtain the ore, process it and ship it to markets are described in an orderly sequence, i.e. mining, mineral processing, infrastructure and services, transport of the product, rehabilitation of land after mining, workforce and decommissioning at the end of the project.
- Analysis and management of the potential impact on the environment. In this Section all of the environmental parameters which may be affected by the project are described and ways of enhancing positive impacts and avoiding or mitigating negative impacts are discussed. Alternatives to proposed actions are presented and reasons given for the preferred course of action in each case.
- Environmental management commitments. The remaining major Section of the ERMP is a summary of the environmental management and monitoring commitments that will be undertaken by the Company.

Legislative framework and approval processes

The EPA has determined that the Beenup project is a major development, and as such requires the preparation of an ERMP. The ERMP is a public document and submissions are invited from interested persons and groups; these assist the EPA in its assessment of the proposal and in the preparation of recommendations to the Minister for the Environment.

The legislation under which the ERMP will be assessed is the *Environmental Protection Act*, 1986. This Act provides the framework for the review process and provides for the enforcement of management commitments made by the proponent. Following the preparation of the ERMP by the proponent and its acceptance by the EPA as a suitable document for review, there is a period of review by members of the public and the government. Following this period of review, submissions are collated by the EPA and passed to the proponent for the preparation of suitable responses. These responses are then reviewed together with the ERMP and all the public comments and the outcome presented by the EPA in a public assessment report. This report includes recommendations to the Minister for the Environment. Following a period of public appeal on the EPA's report, the Minister determines whether the project may proceed and under what conditions.

Other State legislation which is relevant to the project and has been taken into consideration in the ERMP includes:

- Aboriginal Heritage Act*, 1972-1980
- Agriculture and Related Resources Protection Act*, 1976-1983.
- Bushfires Act*, 1954-1981.
- Conservation and Land Management Act*, 1984.
- Country Areas Water Supply Act*, 1947-1979
- Environmental Protection Act*, 1986
- Local Government Act*, 1960
- Mines Regulation Act*, 1946-1974
- Mining Act*, 1978-1987
- Noise Abatement Act*, 1972
- Radiation Safety Act*, 1975
- Rights in Water and Irrigation Act*, 1914-1981
- Road Traffic Act*, 1974-1982
- Soil and Land Conservation Act*, 1945-1982
- State Planning Commission Act*, 1985
- Water Boards Act*, 1984
- Wildlife Conservation Act*, 1950-1980.

1.5 HEAVY MINERAL MINING IN THE LOWER SOUTH WEST

The lower South West comprises the two statistical subdivisions of Vasse and Blackwood (Figure 1.1). Exploration for heavy mineral sands has been carried out in the Leeuwin-Naturaliste Block and in the Scott Coastal Plain. Mineral occurrences which have been identified are described in the McKellar report on the South West mineral sands industry.²

Many deposits of heavy minerals, most of them quite small, have been identified. However it should be realised that the finding of a deposit does not necessarily mean that it is a mineral resource which can be mined. Most deposits are too small to be economically viable.

Mining for heavy minerals is not currently carried out in the lower South West. There are presently two proposals to commence mining operations in this area:

- ° Jangardup, near Nannup. An ERMP for this proposed operation has recently been reviewed and recommended for approval subject to a suitable transport option being defined.
- ° Beenup, near Augusta. This proposed operation is the subject of this ERMP.
- ° In the whole South West region of the State, the Southern Swan Coastal Plain has been subject to the greatest intensity of exploration. A large number of deposits have been proven and some of these have been mined or are being mined. The first mining operation commenced in Koombana Bay in 1956.

These deposits are located in the following areas along old shorelines successively further inland:

- Minninup Shoreline
- Ludlow Shoreline
- Capel Shoreline
- Yoganup Shoreline
- Waroona Shoreline

Although other deposits may be identified in the future, there are no other known proposals being put forward at the present time.

²South West Mineral Sands Industry Report (1990)
South West Development Authority

Existing
Environment

2.0 THE EXISTING ENVIRONMENT

2.1 REGIONAL SETTING

The Beenup project is located in the Scott coastal plain, which is a low lying swampy region up to 15 km wide along the south coast of W.A. (Figure 2.3). This plain was formed when coastal dunes blocked an earlier drainage system. The Scott River plain is a distinctive entity of the Western Australian landscape and differs from other coastal lands in the south-west of the State.

The land is flat and featureless and much of it, particularly the area of the project, has been cleared for pasture. Because of the flat topography, drainage lines are poorly defined and there are extensive areas of seasonal wetlands. On the low sandy ridges there is open woodland with Jarrah (*Eucalyptus marginata*), Marri (*E. calophylla*) and Karri (*E. diversicolor*). Remnants of woodland and swamp vegetation occur on the project site.

2.2 LAND TENURES AND LICENCES

Land tenures on the project site and environs are shown in Figure 2.1. The project site is situated on freehold land wholly owned or controlled by the Company. Part of the project site is bounded on the west and south by the Scott National Park. The Park is accessible principally from the Blackwood River and usage by the public is relatively light. There is no management plan for the Park at present but the Department of Conservation and Land Management proposes to develop one in several years time. A camping reserve abuts part of the southern boundary. The remaining boundaries of the project site abut freehold land owned by the Company and others.

The Beenup area is currently held under exploration licences by BHP Minerals Ltd. However four mining leases have been applied for over the area of the project site. It will be necessary for these mining leases to be granted before the project can commence.

One exploration licence application has been made by BHP Minerals Ltd. to cover the Scott National Park. This has been done solely to protect the area from application by other companies until the government resolves the issue of exploration in National Parks.

2.3 EXISTING LAND USE

The cleared land on the farms in the area is used for grazing of sheep and cattle, and hay production. The soils are sandy and low in fertility in their natural state

and where improved grass/clover pastures have been established, these require regular applications of superphosphate with copper and zinc. The land is generally not suitable for cereal cropping, being sandy and shallow, and waterlogged for part of each year.

There has been no other land use since settlement in the late 1800's, although there has been investigation of the deposits of limonitic iron ore and lignite coal in the area in the past.

2.4 CLIMATE

Records from Cape Leeuwin near Augusta may be taken as indicative of conditions experienced at Beenup (Appendix IV). Mean annual rainfall is about 1,020 mm, with most of the rain being received between April and October each year (Figure 2.2). The rainfall for Beenup is expected to be similar, as indicated by the mean annual rainfall of 1,035 mm received at Alexandra Bridge, 8 km north of Beenup.

The climate is the typical Mediterranean type experienced by the south-west of the State, with warm summers and cool, wet winters. This regime is modified to some extent at Beenup by its geographical position near the ocean. Rainfall is higher than in most other parts of the south-west and also, some rain is usually received in each month during the summer.

Monthly potential evaporation rates (class A pan) for Cape Leeuwin are shown in Figure 2.2. The mean annual evaporation is approximately equal to the mean annual rainfall, but the evaporation is significantly greater than rainfall during the summer months.

Mean monthly minimum temperatures range from 11.0°C in the winter to 17.3°C in the summer, and mean monthly maximum temperatures range from 16.5°C in the winter to 23.5°C in the summer.

Winds are consistent all year round. The percentage occurrences of wind speed versus direction at Augusta are presented in Appendix II for every month of the year, at 9.00 in the morning and at 3.00 in the afternoon. Wind directional roses for the four seasons are also presented. Prevailing winds during the summer are from the east and south-east in the morning, changing to the south-east and south in the afternoon. During the autumn-early winter period the prevailing winds are from the north-east and west in the morning and south-east and south-west in the afternoon. During the winter months the pattern is for winds from the south-west and west throughout the day. These winds are usually associated with rain-bearing depressions.

The occurrence of light winds (up to 10 km/hr) is low in all seasons and from all directions, indicating that there is little calm weather. The highest winds (greater than 30 km) are experienced during the summer from a south-easterly direction.

2.5 GEOLOGY

The Beenup area is located in the southern part of the Perth Basin, a deep fault-bounded trough of predominantly sedimentary rocks extending north-south for some 1000 km in the southwest of Western Australia. It lies in the Vasse Shelf, between the Schroeder and Alexandra Bridge faults which define the structural boundaries with the Leeuwin Block and the Bunbury Trough (Figure 2.3).

The Beenup deposit is situated within the Scott Coastal Plain, a low-lying swampy area separated from the Blackwood Plateau to the north by the Barlee Scarp. The plain is composed of four major dune and shoreline systems referred to as the Donnelly, Warren, Milyeaanup and Quindalup Shorelines. All four contain sporadic heavy mineral deposits, generally in subeconomic amounts.

There is no outcrop within the Beenup tenement. The area is underlain by unconsolidated or poorly consolidated sediments of Mesozoic and Cainozoic ages. Small outcrops of the Cretaceous Bunbury Basalt have been noted in the Scott River a few kilometres to the east.

The heavy minerals occur throughout a thick sequence of grey, complexly interfingering gravel, sand, silt and clay horizons, which reaches a maximum thickness of some 50 metres. This is covered by a wedge of fine, well-sorted buff sands considered part of the Warren dune system. Local ferruginisation of these younger sands forms a fairly extensive, although relatively thin, iron pan best developed over the eastern portion of the deposit.

The mineralised zone unconformably overlies an older beach/dune sequence comprising generally fine grained, well sorted buff to white sands with minor gravels. A relatively large, almost east-west striking palaeodune underlying the Governor Broome Road and the northern boundary of the Scott National Park, delineates the southern portion of the deposit.

The heavy minerals are dominated by ilmenite. Zircon, rutile and leucoxene occur in minor quantities. The original source of most of the heavy minerals is considered to be the high grade metamorphic terrains in the immediately adjacent Leeuwin and Yilgarn Blocks.

2.6 LANDFORMS AND SOILS

The mining lease application area (Figure 1.2) has a subdued relief, with approximately 10 m fall over the project area. There are many swamps, most of which become part of the drainage system during the wet season. There is an iron pan at or near the surface in the eastern part of the area. Drainage is apparently by sheet flow, eventually reaching the drainage lines which take the water west to the Blackwood River and south towards the Scott River. The western parts have a gently undulating sandy landscape which is interrupted by the drainage lines. Soils and native vegetation are closely related to topography.

The project area forms part of the Scott River plain which has been described by Smith (1951) and Tille and Latzke (unpublished) as a low-lying and poorly drained area, sloping very gently to the south where it is bounded by Pleistocene and Holocene coastal dunes. The Plain is covered by unconsolidated detrital material which appears to have originated on the Darling Plateau (Smith 1951).

No detailed survey of the soils of the Beenup area has previously been carried out, but the main soils recognised by the above authors include extensive areas of shallow sands over a massive ironstone pan, deep sandy podsolis on low rises and minor areas of podsolis soils with a grey sandy surface over sandy clay subsoil; both authors also mention the high water table over the area for much of the year.

A soil survey of the Beenup project area was carried out during 1989, and a complete description of the soil study is given in Appendix III. The soils are mapped in Figure 2.4 and their essential characteristics are described below. The soil was surveyed and described by boring holes on a 200 m grid over the area.

The soils fall into six main groups:

- ° Soils with an iron pan within 1 m. These soils vary greatly in depth over short distances, with an iron pan often outcropping at the surface or within 10 cm of the surface. Colours may be grey, yellow-brown or red-brown.
- ° The gently undulating sandy terrain. The soil in this area occurs mainly in the western part of the area, where it forms the interfluvies between the shallow drainage lines. The surface soil is sand to sandy loam and weakly podsolised.
- ° The gravelly yellow earth soils. These are a minor group, but occasionally seen on the banks of the shallow drainage lines.

- ° The dunes and hummocks. These are low mounds of sand, usually linear, occurring sporadically over the area. They have a well developed podsol profile.
- ° Swamps. These are shallow depressions which form part of the drainage system in a very poorly drained landscape. The profile is sandy throughout.
- ° The drainage lines. These are broad and shallow and, though they are mainly swampy, most have a well defined water channel. In many cases the channel has eroded down to the iron pan. The soils are similar to those that occur in the swamps.

These soils were derived from the sands, silts and clays that were deposited to form the Scott Coastal Plain as a result of the deposition of sediments from local rivers and the migration of ancient shorelines.

The top layer of soil has accumulated organic matter, and is referred to as topsoil in the rehabilitation section (3.1.9). In the cleared areas where pasture has been established, the introduction of grasses and clovers and regular fertilising has increased the organic matter and plant nutrient content of the topsoil.

2.7 HYDROLOGY

A complete report on the hydrology is given in Appendix IV.

The hydrology of the area can be subdivided into those environmental processes relating to surface water (surface hydrology) and those relating to groundwater (aquifer hydrology). Both are intimately connected with rainfall infiltration providing seasonal recharge to the aquifers, and groundwater migration slowly toward the rivers where riverbank seepage returns groundwater to the surface water system.

The proposed minesite area is only a small region of the much larger Scott coastal plain - an extensive plain comprising interposed sands, silts and clays deposited as a result of the migration of ancient shorelines and deposition of bedload from local rivers. The north west section of the site lies to the west of the drainage divide between the Blackwood River and the Scott River catchments and drains to the Blackwood River. The south eastern section of the proposed mine area drains to the Scott River.

As mentioned in Section 2.4, during summer months high evaporation rates exceed rainfall by a significant margin. January is most often the driest period with an

average 20 mm being received. Potential evaporation at this time is about 140 mm due to the combined effects of temperature and wind.

Seasonal rainfall (and variability) over much of the south western region is generally widespread and consistent; comparison of monthly records across 5 gauging sites shows a high level of correlation (see Figure IV-3, Appendix IV). Increased rainfalls and low evaporation during winter commonly result in local ponding and inundation of low lying and flat areas. Underlying aquifers are recharged via downward seepage of waters and aquifer water tables are noted to rise rapidly and contribute to runoff during winter. Within the minesite, several drainage lines serve to collect and transport runoff in a west and south westerly direction to the Scott and Blackwood rivers. Low rainfall and high potential evaporation during summer result in minimal infiltration and during this period, water tables are observed to decline steadily. Surface runoff ceases and some areas develop hard pan.

Local aquifers comprise a layered or intercalated sequence of sands, silty sands and clays through which heavy minerals are distributed. Shallow indurated sands are also noted to occur at depths of about 2 to 5 metres over parts of the area.

The prevailing water table has been measured at 45 observation bores. Water table geometry reflects the topography with flows mainly to the west, southwest and south from the drainage divide (Figure 2.5). Perching of water tables may occur in areas of extensive induration. Seasonal fluctuations have been recorded (Appendix IV-4) with up to 1.5 metre variation noted during 1988-1989. Greater movements are expected in drier years.

The overall geology of the aquifer in the mining area is reasonably consistent, however considerable local variations in grain size, mineralogical composition and percentage slimes occur within it. The aquifer contains three distinct permeability zones (Figure 2.8). Mining will take place only in the upper (A1) zone, but the lower two zones have significance from an overall water management point of view.

Zone 1 (A1) consists of grey, complexly interfingering gravel, sand, silt and clay horizons. It represents the ore bearing zone with permeability values ranging between 0.2 and 2.5 m/day.

Zone 2 (A2) is a clear, fine-grained buff to white sand with an estimated permeability of 8.5 m/day.

Zone 3 is a grey feldspathic sandstone. No hydrological holes have intersected this zone but from its geology, it is expected to have lower permeabilities than Zone 2 and probably acts as a hydrological barrier between Zone 2 and the underlying regionally extensive Lesueur Sandstone aquifer.

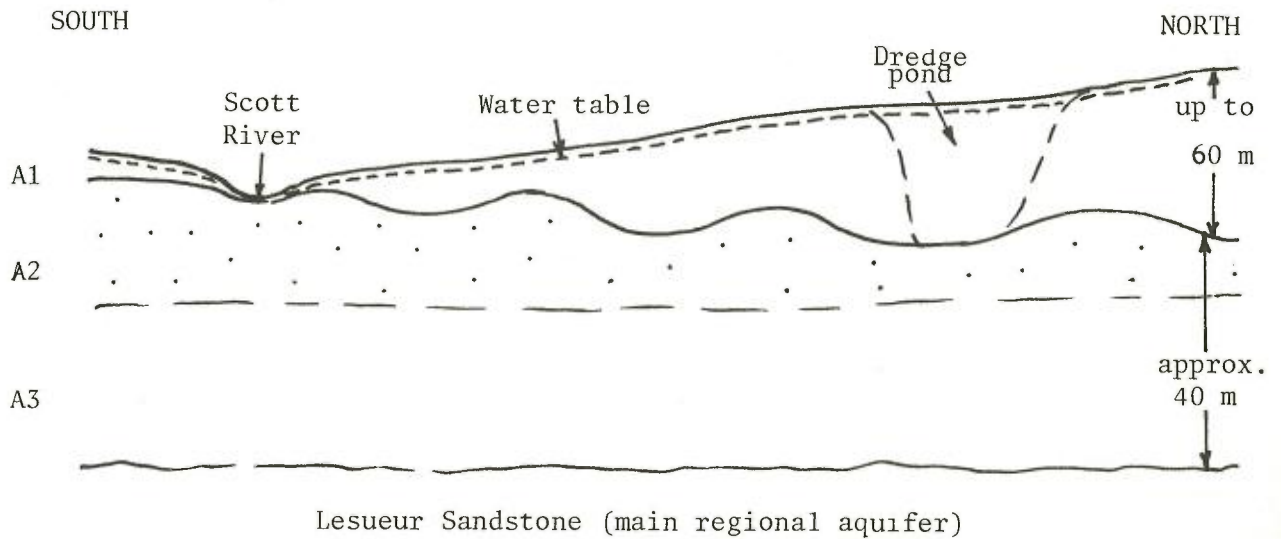


FIGURE 2.8

Diagrammatic cross section of mine site aquifer (not to scale)

The standing water levels observed in bores drilled into Zones 1 and 2 were equivalent, indicating no upward movement of water from the lower (A2) into the upper (A1) zone.

The Lesueur Sandstone aquifer has been intersected in the region in a number of holes drilled by the Geological Survey of W.A. (P. Commander pers comm) and is the major regional aquifer referred to by the Interdepartmental Task Force³ (1989) on transport infrastructure.

Groundwater quality is generally good with characteristics reflecting rainwater recharge. Acidity is mild while sodium chloride and bicarbonate dominate the ionic species. Salinity is low with total dissolved solids counts mostly below 300 mg/l (see Appendix IV - Table IV-5). Occasional layers of silty material may yield up to 600 mg/l but the quality remains generally potable.

Local water usage is restricted to shallow dams.

³ Transport Infrastructure for proposed mineral sands and source developments in the South West of Western Australia. Report by Interdepartmental Task Force, Department of Resources Development, Sept. 1989.

2.8 RADIATION LEVELS

The State Government requires a survey of radiation levels to be carried out over land proposed for mining heavy minerals, as some of these minerals may be slightly radioactive. A survey was carried out by measuring the absorbed dose rate on a grid pattern over the mining area and the dry mill and office site. A full report is given in Appendix V. The results show that the radiation levels are low (0.05-0.14 micrograys per hour) and similar to background radiation levels in the district.

2.9 DUST

Existing dust levels are very low due to the regular rainfall and the pasture and natural vegetation cover on the land. Traffic densities on the roads are very low and generate little dust.

2.10 SOUND LEVELS

The existing background sound levels at residences near the proposed mining area and dry mill were established. Values varied between 22 dB(A) and 40 dB(A), depending on wind conditions and other factors such as barking dogs and aircraft. A full description of this study is given in Appendix VI.

Acceptable outdoor noise levels are given in the Regulations of the *Environmental Protection Act, 1986*⁴, as follows, for a neighbourhood category A-1 which is only or predominantly country, with negligible transportation:

- (a) Monday to Friday, 7am to 7pm: 40 dB(A)
- (b) Monday to Friday 7pm to 10pm,
weekends and public holidays,
7am to 10pm: 35 dB(A)
- (c) Always, 10pm to 7 am: 30 dB(A)

⁴Environmental Protection Act, 1986
Noise Abatement (Neighbourhood Annoyance) Regulations, 1979

2.11 VEGETATION AND FLORA

A complete report is given in Appendix VII. The essential features of that report are presented below.

2.11.1 Scope of study

The primary survey area is shown in Figure 2.6. It includes all of the proposed mining area (which is shown in Figure 3.2) and also areas to the north-east and south-east. The dry mill and office site, the location of which is shown in Figure 3.2, was also surveyed (Figure VII-2). Together these areas comprised the Beenup survey area. Remnants⁵ of native vegetation grow on these areas, however most of the area has been substantially cleared and pastures established. It is estimated that 35% of the mining area comprises remnants of the original native vegetation.

Additional site inspections were carried out in nearby areas (Figure 2.1):

- ° Scott National Park.
- ° State Forest.
- ° Camping Reserve A^{12951/4753}.
- ° Road verges.
- ° Remnants of natural vegetation on private land, particularly within BHP mining lease applications (including Location 4255).
- ° Near the proposed mill and office site (part of Location 4151).

The survey was carried out to:

- ° Define and map the plant communities.
- ° Produce an inventory of flora species.
- ° Assess the local and regional significance of the plant communities.
- ° Assess the conservation significance of the flora on a local and regional basis.

⁵ Remnant: any patch of native vegetation around which most or all of the original vegetation has been removed.

- ° Assess the degree of similarity of the flora and vegetation when compared with nearby areas of State Forests, National Parks, in particular Scott National Park, the Camping Reserve, road verges and remnants on private land.

Locations of particular botanical interest have been identified and methods are suggested for minimising the potential impact of the mining operation.

Field studies were carried out in June, 1989 and during the September to December, 1989 period. The major part of the field work was delayed until the spring-early summer period (September to December), to enable a maximum number of positive identifications to be carried out on flowering plants. Survey methods are described in Appendix VII.

2.11.2 Vegetation

Vegetation describes the native plant communities growing on the area. Vegetation communities are mapped in Figure 2.6.

Nineteen plant communities were defined, which fall into 4 broad groups:

Vegetation Code 1

Open forests and woodlands of Jarrah, Marri, Yarri, *Banksia*, Peppermint and Paperbark.

Vegetation Code 2

Low open woodlands and forests of *Banksia*, Peppermint, Paperbark and Jarrah.

Vegetation Code 3

Open and closed heaths of *Banksia* and mixed Proteaceae-Myrtaceae species.

Vegetation Code 4

Sedgelands of *Leptocarpus* species, Cyperaceae-Restionaceae species and *Juncus pallidus*.

These plant communities are closely related to landforms and soil types.

2.11.2.1 Forest and woodland vegetation - Vegetation Codes 1 and 2

The most extensive areas of these communities occur on the western section of the mining area (Figure 2.6). The dominant trees are Jarrah (*Eucalyptus marginata*), Marri (*E. calophylla*), Yarri (*E. patens*), Peppermint (*Agonis flexuosa*), a range of *Banksia* species and Paperbark (*Melaleuca preissiana*). The overstorey species reflect the range of soil and moisture conditions, with the range from *Banksia* species on the sandier sites, Paperbarks on the wetter sites to Yarri on the alluvial sites. The total area of forests and woodlands has been markedly affected by clearing for agricultural activities. Few areas within these communities in the paddocks have escaped grazing and trampling pressures, with the result that the understorey in many of these remnants has been substantially modified.

The proposed mill and office site on Location 4151 (Figure 2.1) occurs in a disturbed low woodland of *Agonis flexuosa* - *Banksia ilicifolia* - *Eucalyptus marginata* on a small sandy rise (Vegetation Code 2.2 Figure VII-2). The understorey has been affected by cattle grazing and as a result, there is a range of introduced species. No gazetted rare species were recorded in this area.

By contrast, the forest and woodland communities (Vegetation Code 2.1) in Location 4254 and the eastern half of Location 4264 (Figure 2.1) are relatively free of disturbance and introduced species.

The other groups of low woodlands occur on the series of depressions, swamps and drainage lines throughout the survey area (Vegetation Codes 2.3, 2.4 and 2.5). All these areas support *Melaleuca preissiana* in the overstorey, with varying associated species depending on local soil and drainage conditions.

2.11.2.2 Heath communities - Vegetation Code 3

These occur on the sandier and shallower soils. Local distinctive features include the thickets of *Banksia occidentalis* ssp. *occidentalis* (Vegetation Code 3.1), a small area of which occurs on Location 4254, the stands of the gazetted rare species *Lambertia orbifolia* and *Darwinia* sp. (G.J. Keighery 3582) and the high range of species in the heaths. Nine of the ten species from the Reserve Flora Priority List identified in the Beenup survey area and both of the species from the Gazetted Rare Flora List identified in the Beenup survey area occur on the closed heaths on the shallow sands over the iron pan in the eastern half of Location 4264 (Refer Section 4.9.2). This area is outside the proposed mining area.

2.11.2.3 Sedgeland - Vegetation Code 4

These occur on the broad, seasonally moist to wet depressions and drainage lines. The density of plant cover in some areas has been affected by past burning and grazing activities.

2.11.2.4 Remaining areas

These have been mapped as cleared areas, but include the modified communities along the road verges and in the cleared and semi-cleared farmlands. The dominance of introduced species in these areas and the occurrence of grazing animals have left few areas of significant native vegetation. These largely cleared areas occur in approximately 65% of the Beenup survey area.

2.11.3 Flora

Flora refers to the individual plant species that grow on the area. They determine the type of plant community.

A total of 326 species was recorded in the Beenup survey area, representing 55 families and 176 genera. Of the 326 species, 31 were introduced species.

The distinctive flora of the Scott River Plain appears to occur in association with specific soil types in the area. A recent soils study, Tille and Lantzke (in press), has indicated that these soil types are restricted in occurrence to the localised area which encompasses the Beenup survey area. This explains why a range of flora species has been recorded on this survey as being geographically restricted to the area near the proposed Beenup project.

° Species from the Gazetted Rare Flora List

Two Gazetted Rare Species were recorded in the Beenup survey area, viz. *Darwinia* sp. (G.J. Keighery 3582) and *Lambertia orbifolia*. These two species were recorded in the eastern half of Location 4264, which is not on the proposed mining area and along Governor Broome Road. Reconnaissance for both of these species was carried out in nearby areas of State Forest, Camping Reserve no. 12951, Scott National Park, adjacent private property within the BHP mining lease applications and the road verges. No additional locations of these species were recorded outside the Beenup survey area, besides those already known by the Officers of the Department of Conservation and Land Management.

° Species from the Reserve Flora Priority List

Ten species from the Reserve Flora Priority List were recorded in the Beenup survey area (Appendix VII). All of these species for varying reasons are potentially

rare, depending on their future management and monitoring. In some cases the lack of information and data have resulted in their inclusion on this list. Nevertheless the conservation status of all these species is under consideration and is being monitored by CALM. Nine of these ten species occur in the eastern half of Location 4264, which is not on the proposed mining area.

° Species of interest

Three of the species and a new genus which were collected, were of particular interest. A new species of *Boronia* was collected for the first time on this survey; *Hovea stricta* is geographically restricted and has been poorly collected in the past; *Verticordia lehmannii* is geographically restricted and has been collected from only a few locations; the new genus has been only recently described and not yet published, therefore identification of the specimen collected during the survey cannot be fully named. It is referred to as Genus nov. (aff. *Loxocarya* sp.).

° Summary of occurrences of restricted species

The botanical study has revealed that a majority of these species occur in the eastern half of Location 4264, as follows:

- The two Gazetted Rare Species.
- Nine of the ten species on the Reserve Flora Priority List. The tenth species *Hypocalymma* aff. *cordifolium*, is also known from Scott River and Northcliffe areas.
- The new *Boronia* species. Of the two remaining species, *Hovea stricta* has been recorded on the northern sandplains and from the Busselton/Cape Naturaliste area; *Verticordia lehmannii* is confined to the Busselton/Scott River area. Information on the distribution of the new genus must await more extensive botanical surveys throughout the region in the future.

The eastern half of Location 4264, has been excluded from all mining proposals.

2.11.4 Presence of dieback due to *Phytophthora cinnamomi*

During the intensive survey a series of recent deaths was noted for Blackboys (*Xanthorrhoea preissii*), Jarrah (*Eucalyptus marginata*) and *Lambertia orbifolia* (one of the gazetted rare flora species). Three samples of root and bark material were collected by Officers of CALM from recently dead *Lambertia* and three samples of root and bark material were collected from dying or dead Blackboys and Jarrah. The dieback fungus *Phytophthora cinnamomi* was isolated from all three *Lambertia orbifolia* collections made in the eastern half of Location 4264

and from the recently dead *Xanthorrhoea preissii* on the lower moist slopes in the south-west corner of the Beenup survey area. It was not positively identified in the Jarrah collection.

A comprehensive dieback survey was not carried out on the Beenup survey area; however these results confirm the presence of this fungal disease in the area. A survey of dieback over the mining area and dry mill and office site is planned after approval for the project to proceed is granted and a dieback management programme will be prepared (Section 4.9.3). The pattern of infection in the south-west corner appears to be similar to the frontal pattern seen in other Jarrah forest communities to the north and east of the survey area. In contrast, the pattern on the seasonally wet shallow soils which support the rare *Lambertia orbifolia* in the eastern half of Location 4264 appears to be spot infections. The implications for management are discussed in Section 4.9.3.

2.12 TERRESTRIAL VERTEBRATE FAUNA

A complete report is given in Appendix VIII. The essential features of that report are presented below.

2.12.1 Scope of study

The primary survey area was the Beenup survey area as defined in Section 2.11.1. In addition faunal assessments were carried out on the following areas adjacent to the Beenup survey area (Figure 2.1):

- Scott National Park.
- Camping Reserve A^{12951/4753}.
- Locations 4152, 4253, 4255, 4256 and 4258, to the north, south and west of the Beenup survey area.

The primary objectives of the terrestrial vertebrate fauna survey of the Beenup survey area were to:

- Produce an inventory of the vertebrate fauna of the area and, based on the habitats present, a provisional list of unrecorded species.
- Assess the conservation significance of the fauna on a regional and local basis.

- ° Give particular attention to species declared rare under Schedules 1 and 2 of the *Wildlife Conservation Act*, 1950-1980.
- ° Relate the fauna recorded to the major vegetation types of the area.
- ° Where possible, carry out systematic data collection from representative sites to allow for valid statistical comparisons between the various habitats.
- ° Compare faunal habitats i.e. vegetation and soil types, in terms of their fauna species richness and abundance.
- ° By means of site inspections, assess the similarity and conservation status of fauna habitats in nearby areas.
- ° Assess the potential impact of mining activity on the fauna of the area and define locations of particular concern.
- ° Review methods whereby the impact of mining activity can be minimised.

Methods used to collect field survey data are described in detail in Appendix VIII. The field survey data were collected at three periods during 1989:

- ° A brief winter reconnaissance survey in June, 1989.
- ° An intensive, integrated flora, vegetation and vertebrate fauna survey in late September-October, 1989.
- ° An opportunistic summer assessment in mid-December, 1989.

2.12.2 Survey results

Six broad habitat categories representing the major vegetation communities and their variants have been defined to facilitate extrapolation of results to structurally similar habitats outside the Beenup survey area. While these adjacent areas may differ in their floristic composition, they remain essentially similar in terms of their fauna.

- ° Tall Eucalypt forests - Vegetation Code (1).
- ° Low woodlands dominated by *Banksia* species and/or *Agonis flexuosa* - Vegetation Code (2).
- ° Heathlands - Vegetation Code (3).

- Wetlands, viz. swamps, creeks, temporary pools - Vegetation Code (4).
- Road verge (undifferentiated habitats).
- Farmland.

A total of 76 species of birds was recorded in the Beenup survey area. Two of these bird species are gazetted "rare, or otherwise in need of special protection". These were the Peregrine falcon *Falco peregrinus* and Red-eared Firetail *Emblema oculata*. Both were recorded in the heathlands habitat. None of the remaining bird species recorded on the Beenup survey area, or expected to occur there, is rare or restricted.

Comparative data are given on the species richness and abundance of bird species in the various vegetation communities (Appendix VIII).

Eleven native and seven introduced species of mammal were recorded in the Beenup survey area during the field surveys. None of the mammals recorded was unexpected or unusual for the area. Results indicate that *Eucalyptus* spp. open forest and the open heath/scrub are the richest in native mammals. The grey kangaroo (*Macropus fuliginosus*) was the most frequently recorded native mammal in the Beenup survey area. This animal has the ability to range over the whole area, both native vegetation remnants and pasture land. The bush rat (*Rattus fuscipes*) was the most commonly captured small native mammal. Rabbits were extremely common along vegetated road verges but there were few signs of their presence in the larger remnants of native vegetation within and beyond the Beenup survey area. Other introduced mammals which were recorded were the house mouse, the black rat and foxes.

Eight amphibian and 15 reptile species were recorded during the field surveys. These species have all been previously recorded in the general area, although several represent minor range extensions.

Poor sampling conditions (due to heavy rain and waterlogging) during the main survey period, preclude any definitive statement on the comparative reptile assemblages of the various vegetation communities. The forested sites are most likely to be richer, because of their greater diversity of micro-habitat such as fallen logs, standing dead trees and deeper, friable soils suitable for burrowing.

2.12.3 Assessment of adjacent areas

The proposed mining area cannot be viewed in isolation, as it is intimately connected with two areas of reserved land and adjoining farmland which has been cleared to a greater or lesser degree. Time was therefore allocated during

all surveys to assess this relationship. The main objective of these inspections was to assess how each location (Figure 2.1) related to the proposed minesite in terms of habitat representation, conservation of species potentially affected by mining and possible impact of the project.

2.12.3.1 Scott National Park

The park is a large area of relatively undisturbed habitat which has the capacity to support healthy populations of all the vertebrates recorded or expected to occur in the proposed mining area, plus several other species adapted to specific habitats not represented at Beenup.

2.12.3.2 Camping Reserve A^{12951/4753}

Although small, the Camping Reserve supports a range of habitats, all of which are in better condition than the bulk of the Beenup survey area. The camping area is unlikely to support any species not recorded on the Beenup survey area, as the habitats are similar to those on the survey area. Populations may be higher however, because of the lack of recent stock grazing.

2.12.3.3 Location 4255 - north-west of the mining area

This block is contiguous with the north-western section of the mining area and is basically an extension of that area. For the most part, this private land supports large areas of habitat similar to the Beenup survey area and in particular the Jarrah/Marri forest. The low heath/sedgeland of the mining area is also well represented, particularly in the southern, central portions. Both of these habitats are likely to support a similar range of vertebrates as was recorded on the Beenup survey area.

2.12.3.4 Location 4256 - west of the mining area

This block is between the mining area and Scott National Park. It is mainly cleared with remnant degraded vegetation along creek lines and around swampy country. For the most part its fauna is liable to be depauperate and equivalent to the fauna of the farmland.

2.12.3.5 Location 4258 - west of the mining area

This block between the mining area and Scott National Park. It is mainly cleared land with some remnant vegetation along creek lines and near the park boundary. The fauna is expected to be fairly depauperate except close to the park boundary.

2.12.3.6 Location 4253 - north of the mining area

This block is almost entirely cleared and the species present, with few exceptions, are likely to be those listed for farmland.

2.12.3.7 Location 4152 - north of the mining area

This block is mainly cleared and the remaining vegetation has been grazed by stock, some areas more than others. Elements of swamp country, low heath and low *Banksia*/Peppermint woodlands are present and are likely to support all the species listed for these habitats (Appendix VIII).

Two locations of some significance to fauna were on this block: an open water swamp surrounded by a paperbark forest on the southern boundary; and a long sandy ridge supporting a low, mixed woodland of *Banksia*/Peppermint.

The open swamp still contained a large amount of water during the summer survey and evidently plays a role as a drought refuge in dryer months of the year. It is possible that it also acts as a feeding and breeding area for water birds. The sandy ridge area supporting low, mixed woodland may be expected to support all the species listed for similar sites on the Beenup survey area; however its significance to fauna is that it is the largest remnant of this particular type of low woodland in the vicinity of the proposed mining area.

2.12.4 Conclusions

The only rare faunal species recorded on the Beenup survey area were the two birds Peregrine falcon and Red-eared Firetail. The Peregrine falcon is a highly mobile bird with little habitat specificity. It is present throughout Australia and while nowhere common, is a species with a cosmopolitan distribution. The Red-eared Firetail is distributed throughout the wetter portions of the south-west of Western Australia, in dense vegetation along streams. No rare mammals, amphibians or reptiles were recorded.

With regard to significant species, no vertebrate, including those gazetted as rare, or otherwise in need of special protection, can be considered as being threatened.

Approximately 65% of the Beenup survey area is pasture or grazed native vegetation with very little understorey and therefore represents severely degraded faunal habitat. The remaining patches of uncleared land, although accessible to grazing stock still have a moderately high fauna conservation value, judging by the results of this survey. While these remnants do not have the significance of large, cohesive units such as the adjacent National Park, they do fulfil a prominent role in maintaining populations of the vertebrate species recorded or expected to occur in the Beenup survey area.

2.13 ARCHAEOLOGY AND ETHNOGRAPHY

An archaeological and ethnographic survey of the project area was carried out in May, 1989 by Peter Veth of the University of Western Australia and Philip Moore of Curtin University, under the direction of the Centre for Prehistory, The University of Western Australia. A full report is given in Appendix IX and the essential features are presented below.

2.13.1 Ethnohistorical background

The region east and south of the Blackwood River, including the area of the Scott River, comprises one of the ethnographically least known regions of the south-west of Western Australia. Difficulties of access and clearing, for either agricultural or pastoral purposes, resulted in a late penetration of the region by European settlers.

Although only about 12 km from Augusta, the Scott River area was rarely visited by Europeans for a variety of reasons. The European settlement established at Augusta in 1830 was small, with never more than 80 inhabitants closely clustered about the mouth of the Blackwood River. The town and the majority of land grants were located on and about the western shores. Large areas on the east side, including the Scott River and the project site, were granted to George Leake and Thomas Turner but were almost certainly never used and probably rarely visited.

The European settlers at Augusta did not take the same interest in Aboriginal lifestyles that was shown in the larger colonies. Although interaction with the Aboriginal population was virtually continuous and at least some people were able to speak Nyungar and were obviously well regarded by the Aboriginal inhabitants, there does not appear to have been any deliberate attempt to record any information about them.

Another limiting factor to ethnographic observation in the region was that in 1834 approval was finally given for most of the land grants to be transferred from Augusta to the more easily cleared country about the Vasse. There was a rapid exodus to the north, although many people moved between their holdings at both settlements for the next few years. By 1840 Augusta was virtually abandoned.

Commencing in the 1850's a number of pastoralists began to spread southward from the Vasse, concentrating on coastal areas and the grassed plains along the river valleys. It is difficult to assess when they might have penetrated to the east bank of the Blackwood, although it was probably not until the late 1860's or 1870's and then not in any great numbers.

Consequently, by the time permanent European homesteads were established in the late 1800's, most Aboriginal people had probably gravitated towards the towns or other settlements, leaving little or no opportunity for the observation or recording of traditional culture or economy.

2.13.2 Archaeological survey

Archival research has yielded little material relevant to the survey area. The general Aboriginal occupation pattern for the Scott River area east of the Blackwood was probably not intensive and generally limited to the summer months. The winter was a period of dispersal into the forest for hunting larger game. The main concentrations of economic life about the lower Blackwood and Scott River districts were probably the river systems, swamps and wetlands.

Seven archaeological sites have been previously recorded within a 10 km radius of the project site (Figure 2.7). These comprise five reworked surface scatters, one surface artefact scatter and one engraving on flat limestone outcrops. All are recent and represent ephemeral occupation.

All cleared parts of the project site were surveyed along traverses at 200 m intervals. Soil exposures were studied in detail. The woodland remnants were surveyed along traverses at 50 m intervals.

No cultural material was located, which was a surprising result. This may be due to the disturbance that has taken place over most of the survey area in the past, due to clearing and pastoral activities.

2.13.3 Ethnographic survey

The purpose of this survey was to locate any sites within the project site which may have significance for living Aboriginal people and to make an assessment of any such sites in terms of Western Australia's *Aboriginal Heritage Act, 1972-1980*. The survey involved examining site documentation for the area and previous historical and ethnographic accounts of the region, as well as visiting the project site in the company of Aboriginal spokesmen for the area.

A review of the site files of the Department of Aboriginal Sites, Western Australian Museum (carried out by the Centre for Prehistory, The University of Western Australia), indicated that no sites of significance to Aboriginal people have been registered in the vicinity of the survey area. The ethnohistorical review of the region indicated no known sites of significance to Aboriginal people in the area.

The most knowledgeable Aboriginal people with respect to the area were contacted with the assistance of the Bunbury Aboriginal Progress Association and the

Southern Aboriginal Corporation, located in Bunbury. These Aboriginal people located no sites of significance within the boundaries of the project site.

2.14 THE SOCIO-ECONOMIC ENVIRONMENT

The principal components of the existing community environment which are likely to be affected by the proposed project are discussed below. For the most part this discussion is confined to the Augusta-Margaret River Shire area, and the two main settlements of Margaret River and Augusta. A complete report is given in Appendix X. The regions and Shires discussed in this section are shown in Figure 1.1.

2.14.1 Community Consultation Programme

The proponent has set up a community consultation programme to involve the district's residents in the planning of its Beenup mineral sands venture. The nature of the project - and the characteristics of the Augusta-Margaret River Shire communities - have made effective consultation an important step in planning the Beenup development. Many local residents are interested in environmental and lifestyle issues.

The proponent has taken the view that the technically uncomplicated Beenup venture - mining and mineral separation - allows for planning modification to meet local community priorities. As a result, the community has been asked to take a constructive role in the project planning.

The proponent's programme has incorporated the following key elements:

- ° The formation of a locally based community consultation group.
- ° Direct mail advice to all of the Shire residents.
- ° Regular media release and advertising information, directed to local newspapers, rather than regional or State media.
- ° Shopping centre displays.
- ° On site information days.
- ° Guest speaking engagements to local community groups.
- ° A survey of community issues.

This programme was a Company initiative which later attracted the interest of the State Government's Social Impact Unit. Full details of the Community Consultation Programme are given in Appendix XII.

2.14.2 Economic profile

The historical base for economic activity in the Leeuwin-Naturaliste region has been various forms of primary production, namely agriculture, timber production and, to a lesser extent, fishing. Today, the economy is more diverse with a major dependence on agriculture and tourism, and with significant contributions from the mining and service industry sectors. The timber and fishing industries remain important but now play a lesser role in the economy of this area.

The Shire's workforce at the time of the 1986 Census comprised 2324 persons of whom 292 were unemployed. It is estimated that the workforce currently numbers some 2600 persons of whom approximately 200 are unemployed. Skills distribution of the existing Shire workforce, and details of labour force status and industry employment are presented in Appendix X.

The South West Region of Western Australia (Figure 1.1) is a major producer of mineral sands, with the rich deposits in the vicinity of Capel forming the basis of the industry. The region produces in excess of 14% of the world's ilmenite. The value of mineral sands production for the South West region totalled \$75.78M in 1986-87, and the industry employed in excess of 350 persons. Western Australia is now the leading producer in the international mineral sands industry. The State supplies 43% of the world's ilmenite, 21% of the rutile, 40% of the zircon and 54% of the monazite. Mineral sands production for the entire State in 1987-88 totalled 1.61 million tonnes valued at \$293M.

The Shire covers an area of 2370 square km with approximately one third of this area being held in freehold title. Total Shire revenue for the 1987-88 financial year amounted to \$3.283M of which rates revenue accounted for 26.6%, and government grants 28.1%. Total outgoings amounted to \$3.175M and comprised recurrent payments (49.5%), capital payments (44.4%) and debt servicing (6.1%). It is Council's current policy to raise a minimum of 50% of its revenue needs from local activities, and to keep rate increases in line with the Consumer Price Index.

Council is currently concerned that the increasing demand on its resources for tourist related facilities may reduce the availability of funds for meeting the needs of the permanent population. Council's aim is to ensure that no undue impact is placed on the resident community as a result of this growth.

2.14.3 Demographic profile

The South West Region of Western Australia is the most densely populated, rural region of the State. In June, 1987 the estimated resident population was 121,763 persons representing 8% of the State's population and 29% of the population living outside the Perth Metropolitan Area. The Shire of Augusta-Margaret River (Figure 1.1) with a resident population of 4,825 persons in 1986, contained 4.06% of the region's population. This compares with 3.61% in 1981, and 3.5% in 1976. Over the 10 year period 1976-1986, the South West Region's population grew at an annual average rate of 3.27%, whereas the population of the Augusta-Margaret River Shire grew at a rate of 4.83%.

The past decade has seen a substantial change in the Shire's population characteristics. Rapid growth in visitor and resident numbers has taken place, with the resident population increasing 31% between 1981 and 1986. The latest ABS population estimate for the Shire is 5,505 persons (June, 1988). Shire population growth projections, prepared by the Department of Planning and Urban Development, indicate that the Shire can expect a resident population of between 8,700 and 10,600 by the year 2001. Figure 2.9 illustrates these projections.

In addition to the Shire's permanent population, the Shire has a floating tourist population. The Department of Planning and Urban Development estimates that peak tourist numbers during the summer season reach some 12,400 persons, with the average throughout the summer being approximately 6,000 persons. These persons are overnight or longer term tourists. If one includes an estimated 3,000 (peak) daytrippers, the population of the Shire can exceed 20,000 persons on occasions such as the Leeuwin concert and the Margaret River surf classic. This tourist influx places a severe strain on the Shire's facilities and financial resources.

2.14.4 Housing

The Shire's housing market is currently very tight with supply and demand very closely balanced. Over the past few years demand for housing has outstripped supply generating a consequential rise in housing and property prices. In Augusta, there is a land and housing shortage whereas in Margaret River there is surplus land for home building available.

Current residential prices in Augusta vary between \$37,000-\$80,000 for a standard residential allotment, and between \$80,000 and \$350,000 for an established home. Homes with views across the Blackwood River and Flinders Bay command the highest prices. Property prices in East Augusta for a standard residential allotment without town services range between \$37,000 and \$52,000 depending on proximity to the river.

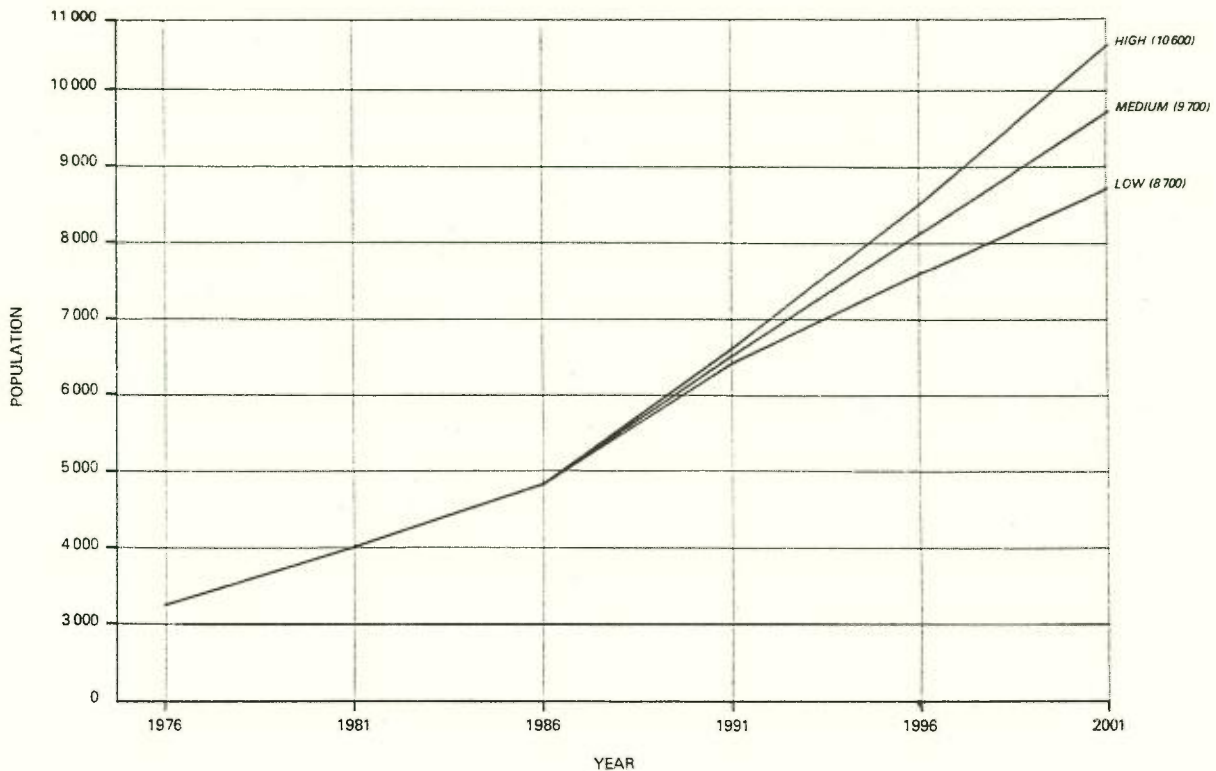


FIGURE 2.9

Shire of Augusta-Margaret River
Population growth pattern to the year 2001

Residential land prices in Margaret River generally vary between \$35,000 and \$50,000 for a standard serviced allotment, and between \$50,000 and \$75,000 for a small acreage block. Established house prices vary between \$85,000-\$150,000 (standard allotment) whereas prices for homes on small acreage properties vary between \$120,000 and \$315,000. Residential land at Prevelly Park ranges between \$50,000 and \$86,000 with the average established home selling in the \$120,000-\$140,000 range.

The two smaller settlements of Karridale and Witchcliffe have little or no capacity to provide additional allotments for residential purposes. Karridale has no vacant residential lots whereas Witchcliffe has approximately 20. These blocks are not

serviced by reticulated water or sewerage systems although they have access to power and telephone.

The existing housing stock consists primarily of single detached dwellings with a limited number of other housing types. A significant feature of this housing is that approximately 13% of private homes are unoccupied for a major part of the year as they are used for holiday purposes only, and approximately 12% are available for private rental. Further details are provided in Section 3.3.3, Appendix X.

The Shire, being a tourist destination, has a substantial range of temporary accommodation facilities ranging from serviced hotel/motel accommodation to camping/caravan sites. Details are provided in Appendix X.

2.14.5 Land use and development

Land tenures in the vicinity of the Beenup project are shown in Figure 2.1. Lands comprising the proposed mining area are currently used for agricultural purposes, viz. grazing of cattle and sheep on improved pastures. Lands adjoining the proposed mining area are used for similar purposes, with the exception of lands to the west and south which comprise parts of Scott National Park and lands to the south which comprise Camping Reserve 12951. The Scott National Park protects about 3300 ha of open jarrah and marri woodland, swamps and riverine vegetation. It features pristine bushland, and provides habitats for many different animals and birds common to the South West. Only one area in the park is used for recreational pursuits. Twinems Bend, accessible by boat only, is a water ski area.

The proposed mine site is zoned "Rural" under the Augusta-Margaret River Shire town planning scheme. Under the Leeuwin-Naturaliste Region Plan (Stage Two) the area forms part of the South Coast Planning Area (Area No. 7). This regional plan recognises the value of these grazing lands (which have a higher rainfall and longer growing season than other sectors of the region), and is committed to ensure the continued use of agricultural land for extensive grazing purposes. The Plan also recognises the value of the fragile coastal dunes and wetlands between the Scott River and Flinders Bay, immediately to the south of the proposed mine site. In this regard, it announces an intention to declare the coastal dune systems and environs a "Soil Conservation District" and the foreshore area a "Soil Conservation Reserve" pursuant to the provisions of the Soil and Land Conservation Act. The occurrence and potential for the development of heavy mineral sands mining in the area is noted in the Plan. It stipulates that any proposals to mine should have due regard to the water quality of the Scott River and the management of coastal wetlands and dunes.

With respect to the establishment and/or expansion of settlements within the Shire, it is the planning intention to centre all new development in or adjacent to existing urban centres. It is intended that the further expansion of East Augusta be restricted to holiday-retreat type uses, and that Augusta may be promoted as the major tourist and retirement destination.

The proposed mine site is readily accessible by means of the existing Shire road system. The site, located on Scott River Road, has access to Augusta via Payne and Courtney Roads, and the Brockman and Bussell Highways; and to Margaret River via the same road system or an alternative route using Warner Glen Road.

The town of Augusta has a town water reticulation system which is based on a spring located near Cape Leeuwin. It currently provides water to 600 premises, but during the summer tourist season the system is reaching the point where it is overloaded. The supply volume from the spring has been dropping over recent years and now the system can supply only approximately 2000m³ of water per day. The Water Authority is currently investigating a new water source in the Fisher Road locality.

The township is not seweraged at present. It is planned to commence construction of a limited deep sewerage system in 1990 to service the commercial area and a new subdivision being constructed by the Shire Council.

Margaret River's water supply is considered to be marginal both in terms of quantity and quality. At present, 750 services are provided with the system's storage capacity only sufficient to handle a 1 in 50 year drought. To overcome the situation a new dam is proposed to be constructed on 10 Mile Brook and be operational in the summer of 1992/93. The town is currently partly seweraged, and a programme is currently being undertaken to catch up the backlog of existing properties.

The Shire is well served by telephone and electricity supply with most residents having access to such services if they desire to do so. Problems are, however, experienced with the quality of the electricity supply as voltage drop is common, especially in Augusta. This causes problems with sensitive electronic devices such as business computers and the like. A 64 KVA transmission line brings power from the State grid to a substation at Margaret River from whence it is distributed around the Shire.

The Shire is not serviced by a regular air service, although airstrips exist at both Augusta and Margaret River. The Augusta strip is capable of handling small commuter aircraft and can operate both day and night. It is regularly used by small planes and emergency services aircraft.

2.14.6 Social infrastructure

The Augusta-Margaret River Shire contains 4 primary, 1 secondary and 1 non-government school. In addition to these facilities, the South West College of Technical and Further Education is located in Bunbury and this facility provides both in-house and external teaching facilities. The Bunbury Institute of Advanced Education provides tertiary courses in business, nursing, education, computers, arts and fine arts.

The Shire contains two hospitals, one situated in Margaret River and one in Augusta. They, in conjunction with regular visits from specialists, the more extensive medical facilities of Busselton and Bunbury, and local doctors, provide for the populations health care.

The range of community facilities provided in the Shire is quite substantial given the relatively small population base and the need to spread resources to provide similar facilities in both Augusta and Margaret River. Margaret River, as it has the larger population and is the Shire's administrative and commercial centre, has a greater range of facilities, although given the travel time involved in moving between the two communities, most facilities are within easy reach of the vast majority of the Shire population. Details of sporting and civic facilities, and the various clubs and organisations in the Shire are presented in Appendix X.

The retail, commercial offices and service and light industrial facilities operating in the Shire are reasonably comprehensive, given the size and nature of the local community. The influence of the area's tourist industry and the demands of the in-migrating population are largely responsible for this. The range of facilities is sufficient to cater for all day-to-day convenience needs and basic comparison shopping. The range and number of tourist shopping outlets and restaurants provide a level of service which would not normally be supported given the local population base. The centres of Busselton and Bunbury provide for virtually all other needs.

The Augusta-Margaret River community consists of a number of subgroups - the farming/fishing community, the business community, the retirement population and those who pursue their own alternative lifestyles. These groups, whilst they may be categorised in the above manner, interact closely in their day-to-day business, social, sporting, and civic administration activities. The community is considered to be better for this interaction, and for the more interesting and varied community life such interaction generates. This does not mean that particular issues do not generate different views or the polarisation of views within the community.

Description of the Project

3.0 DESCRIPTION OF THE PROJECT

3.1 MINING

3.1.1 Development and Construction

Based on the time taken for the recent Cable Sands-Jangardup ERMP review and assessment, the Beenup ERMP document being submitted to the EPA in March 1990, and the document being released for public review in late March, 1990, the proponent anticipates that a decision on the project will be obtained by early to mid September, 1990.

On this basis, if approval for the project is granted, construction will commence in October 1990, with the major emphasis being civil works, to take advantage of the "dry season". Initial activities will be:

- ° Upgrading of roads from site to Vasse Highway via Sues Road.
- ° Construction of site access and preparation/erection of construction areas.

In early 1991 work will commence on site services and facilities including:

- ° Construction workforce accommodation.
- ° Administration, workshop and stores buildings.

At the same time, fabrication of plant and manufacture of equipment will commence. On-site erection of the dredge, wet plant and dry mill is scheduled to commence in August 1991. An alternative access road to replace Scott River Road access to Brennan Bridge and East Augusta will be constructed. Upgrading of the proposed transport route will be concluded. Construction will be complete and commissioning will take place in March 1992, and mining and processing operations will commence.

The dredge and wet plant will be erected on the proposed site for commencement of operations (Figure 3.2). During the peak construction period, temporary single persons quarters, recreational facilities and messing facilities will be provided adjacent to the dry mill site. Accommodation for married personnel will be provided via existing commercial caravan parks, and a caravan park at Alexandra Bridge (Section 3.5.1).

3.1.2 Description of mining operations

The proposed dredge operations involve the construction of a bucket wheel dredge which will float in a pond averaging 44 metres in depth. The position of the dredge will be controlled by spuds, movable anchors and winches (Figure 3.1). The presence of the water table close to the surface, combined with the depth of mineralisation, precludes a "dry mining" method using conventional earthmoving equipment.

The positive cutting action of the bucketwheel will maximise the lump size of discrete clay bands and minimise dispersion of the clay. The design of the wheel and buckets will direct ore into the dredge pump suction at the bottom of the dredge ladder. The pump will deliver the water/sand/clay mixture through a floating delivery line to a floating concentrator (Figure 3.1).

The concentrator will be manoeuvred by the use of winches which will be attached by steel ropes to movable anchors located on the bank.

On board the concentrator, the slurry will be screened through a trommel to remove oversize material which will be returned to the dredge pond. Clay slimes will be removed via planned overflows from the primary feed bin, and pumped to the shore where it will be remixed with coarser tailings. Excess slimes will be pumped to settling ponds. The heavy mineral concentrates will be separated from the sand slurry by gravity separation using banks of spirals. The concentrate will then be pumped ashore to a centrally located stockpile and dewatered by a cyclone. Cyclone overflows will be returned to the dredge pond.

An area of 10 ha will be used for the construction of the dredge and concentrator (Figure 3.2). The concentrator will be constructed as a floating unit requiring an area of 2.5 ha to be excavated to a depth of 3 m below ground level. The dredge will be constructed on a 2 ha area of dry ground situated beside the concentrator site. Following construction both areas will be flooded to a level which will enable the concentrator to float above the dredge construction pad.

Material excavated will be used to build levee walls around the excavated areas to enable the water level to be increased following construction.

The water supply bores will be constructed adjacent to the mine path and their output, together with the surface water from the 1991 rains, will be used to fill an initial water supply dam. The dam will be formed by constructing a levee wall across a drainage area lying to the south of the dredge start point (Figure 3.2).

At the commencement of operations, the dredge and concentrator will be floating above the construction pad. As the dredge pond is excavated to full size, tailings

from the operation will be pumped to the water storage dam. Water will be pumped from the dam to the dredge pond to maintain the pond water level.

The water dam will be filled with tailings during the first four months of mining. Beyond that time the dredge pond will have sufficient volume to allow the normal continuous operation of placing tailings in the dredge pond to the rear of the concentrator.

In those parts of the mining area where iron pan occurs at or near the surface, it will be ripped by bulldozers in advance of the mining operation. Some of this material may be used as road base construction material during the construction phase; later during the operation it will be returned to the dredge pond via the tailings.

3.1.3 Dredge path and rate of mining

The mining path is shown in Figure 3.2. Mining will commence at the southern end of the mining area and finish at the northern end. The width of the mining path will be 250 m and the dimensions of the dredge pond at ground level will be in the order of 390 m wide by 1,000 m long. The pond bottom will be up to 50 m below ground level.

The dredge will be able to reach the bottom of the dredge pond without need to lower the water table by pumping water out. The dredge and concentrator plant will float at natural groundwater surface.

Mining will proceed at the rate of up to 3,000 tonnes per hour, equivalent to 69,000 tonnes per day based on a 23 hour day. The rate of advance of the operation will be 3.5 m per day.

3.1.4 Handling of slimes

The slimes will be separated from the slurry where it enters the floating concentrator plant and before the heavy minerals are separated, a portion of the slimes will be remixed with the coarse tailings and a portion pumped to a separate dam for settling. Thickeners will be used if necessary, to hasten the settling of slimes. The supernatant liquid will be pumped off periodically. After each settling dam has dried, portion of the slimes will be incorporated into the topsoil to be used in pasture areas. The remainder will be incorporated into the tailings using farm machinery or a grader.

3.1.5 Operations in advance of mining

The land in front of the advancing mining operation will require preparation before the mining operation reaches it. These steps are described as follows.

3.1.5.1 Clearing of vegetation

Before clearing operations are carried out, any millable timber will be logged and removed from the site by arrangement with local contractors. Large vegetation remaining on the mining path will be cleared by bulldozer and burnt. Other vegetation will be removed with the topsoil.

3.1.5.2 Removal and storage of topsoil

The soil from pasture rehabilitation areas and from native vegetation rehabilitation areas will be treated separately.

The topsoil will be stripped in advance of the mining operation and stockpiled for use in rehabilitation after mining. The depth of topsoil to be removed will be determined by the soil type through which the operation is proceeding, but this depth will generally be in the order of 20 cm.

In areas where native vegetation is to be re-established, the soil will be stripped in two passes : the top 0-10 cm, which contains the seeds and other plant propagules and the remainder -about 15 cm, but the exact depth will depend on the soil type.

The topsoil will be stripped from the area and stored in temporary stockpiles beside the mining path (Figure 3.1). The topsoil stockpiles will be constructed in such a way as to minimise any adverse effects which the storage may have on the soil. Soil will be stored in low stockpiles to keep heat build-up to a minimum thereby keeping oxidation of organic matter and any adverse effects on soil micro-organisms and seeds to a minimum.

3.1.6 Wet concentration of ore

The floating concentrator plant will be designed to receive the flow of slurry from the dredge and, after removing the slimes, separate the heavy minerals from the silica sand by gravity separation techniques. This is accomplished by pumping the slurry to the tops of banks of spirals. As the slurry flows to the bottom under the force of gravity, the lighter silica sand is separated from the heavier minerals. No chemicals are used in the process.

The plant will be connected to shore by a floating pontoon system, which will provide access and also carry flexible concentrate, water and tailings lines and a power cable.

3.1.7 Tailings placement and recontouring

The tailings bin at the rear of the wet concentrator plant will be fitted with pump circuits capable of pumping tailings to the tailings boom stacker or to cyclone stackers onshore. The tailings boom stacker at the rear of the plant will be manoeuvred to hydraulically control the positioning of the tailings. The final shaping of the tailings will be carried out by bulldozer.

Drainage lines will be re-established and the land will be recontoured in a form similar to the pre-mining topography. Rehabilitation procedures are described in Section 3.1.10

3.1.8 Ore concentrate stockpiling and haulage to the dry mill

The wet ore concentrate from the floating concentrator plant will be pumped ashore to temporary stockpiles situated adjacent to the dredge pond. The concentrate will be dewatered using hydrocyclones on a skid mounted stacker, and excess water will be returned to the dredge pond. The stacker will be moved from time to time as the mining plant advances.

The concentrate will be transported north to the dry mill by truck, using Scott River Road as the transport route (Figure 1.2). Refer Section 3.2.1 for a discussion of dry mill selection criteria. Scott River Road from the northern boundary of the mining area to the dry mill will be sealed. Road access within the mining area will be unsealed.

3.1.9 Rehabilitation of land after mining

Rehabilitation operations are regarded as an integral part of the mining operation and as equally important as mining. Rehabilitation work will be carried out on a day to day basis as the mining operation proceeds.

3.1.9.1 Final land use

In May, 1989 the Beenup final land use Work Party was set up with the approval of the Hon Minister for Mines. A full report of the Work Party's activities and recommendations is given in Appendix XI.

Based on the recommendations of the Work Party and Consultative Group, the proponent has drawn up the following integrated rehabilitation plan for the mining area:

- (a) 72% agriculture, including possible community purposes, eg. a commercial tree crop.

- (b) 13% rehabilitation of the main remnants of native vegetation back to native vegetation.
- (c) 11% planting of native plants along major water courses, to assist in stabilising the soil and absorbing fertiliser nutrients leached from farming activities.
- (d) 4% planting of a buffer zone of native tree and understorey species along the southern boundary, adjacent to the Scott National Park.

The proponent's proposed implementation is illustrated in Figure 3.3, and a comparison with the existing land use can be drawn from Figure 1.2. There is some difference between the Work Party's breakdown of final land use and the above plan. This is due to the proponent wanting to return as much of the remnant native vegetation to its original land use as possible. The proponent also wishes to establish the best types of trees to grow as a commercial crop as well as complete experimental work as to the most suitable area to plant these trees before committing a specific area to this final land use.

3.1.9.2 Rehabilitation operations

A rehabilitation plan will be drawn up to the satisfaction of the EPA should approval for the project to proceed be granted, and before the proposed operation commences. This rehabilitation plan will form part of an overall mine management plan. There will be an on-going programme of evaluating proven rehabilitation techniques to test their suitability in the Beenup environment.

(a) Pasture areas

Before the topsoil is returned to the mined land, dried slimes will be incorporated into the topsoil in a proportion deemed appropriate by the Department of Agriculture. This incorporation of the fine material will enhance the moisture retention and nutrient retention characteristics of the soil. The leaching of phosphorus, for example, will be retarded.

Care will be taken to make sure that no unmixed slimes or subsoil are returned to the surface. The tailings surface would have been previously prepared by contouring and reforming drainage lines. The surface drainage pattern will be maintained during topsoiling operations.

When the topsoil is spread, a grass/clover seeding mixture will be planted, together with fertiliser at the appropriate rate. The final selection of pasture species and fertiliser type and rate will be undertaken in consultation with the Department of Agriculture.

(b) Areas of native vegetation

Dieback has been identified on one part of the mining area (the south west corner, refer Section 2.11.4). The proponent will carry out a dieback survey over the whole mining area and dry mill and office site should approval be granted for the proposed project to proceed, and before operations commence. This survey will enable a dieback management plan (Section 4.9.3) to be prepared, which will form part of an overall mine management plan.

(i) Along drainage lines. The major drainage channels will be reconstituted after mining and a belt of native vegetation will be established along these channels. Species of the Sedgelands and Low Open Woodlands of Paperbarks (eg. Vegetation Codes 2.3, 2.4, 2.5, 3.1 and 4.2; Figure 2.6) will be established by:

- ° Returning topsoil which was stripped from such areas in advance of mining.
- ° Raising seedlings of the major tree and shrub species and planting these out during the cooler, wetter months of the year.
- ° Collecting seeds of a wide range of understorey species and sowing them prior to the winter months.

The dominant tree species will include *Melaleuca preissiana* and *Agonis juniperina*. Rehabilitation species will be drawn from members of the *Myrtaceae*, *Cyperaceae* and *Restionaceae* families that grow in these communities.

(ii) In two blocks on the western side of the mining area. These areas support the largest remnants of native vegetation presently growing on the mining area (Figure 2.6). Native vegetation will be re-established in these areas. Techniques referred to in 3.1.9.2 (b) (i) above, will be used to accomplish the establishment of native vegetation.

A forest of Jarrah and Marri (with occasional Yarri and *Banksia*) is common in these blocks, where these trees grow on the sandier soils (eg. Vegetation Codes 1.1, 1.2, 1.3, 1.4, 1.5 and 1.6). Species from which seed will be collected for nursery production and direct planting will include the dominant tree species *Eucalyptus marginata*, *E. calophylla*, *E. patens* and *Agonis flexuosa*. Understorey species include members of the *Papilionaceae* and *Mimosaceae* families.

Topsoil will be removed from areas of native vegetation in two layers : 0-10 cm and the remainder, the depth to be determined by the soil type. This technique will ensure that seeds in the surface layer are not diluted throughout the whole depth of topsoil.

The topsoil removed from areas of native vegetation will be segregated from other topsoil and returned to areas that carried native vegetation as soon as practicable. Trials will be carried out to determine whether the incorporation of slimes into soils for native vegetation areas will have a beneficial effect on the rehabilitation.

The final planning of topsoil movements will be carried out after a dieback survey over the whole area is carried out (Section 4.9.3.2).

(c) Buffer of native tree species along the southern boundary of the mining area and the Scott National Park. Most of the native vegetation has been cleared in this area and pasture established. The topsoil is not likely, therefore, to have a store of native plant seeds. It is proposed to raise seedlings of the major forest/woodland species and plant them in this zone to provide a buffer between the Park and agricultural lands. The area will be fenced from grazing stock and colonisation by many of the plant species growing in the Park is likely to occur over a period of time. Weed control will be carried out on a spot basis as required. This area will also be used as an alternative temporary access to Brennan Bridge.

(d) Commercial tree plantation. It is proposed to plant a 5 ha trial plot on the mining site to evaluate several species of trees for growing in a plantation. The trial will be evaluated over the ensuing years, to determine the viability of a larger plantation.

(e) Final pit. When mining operations are concluded the dredge pond will be converted into a wetland area or open water recreation area. This final land use decision will be made at that time after community consultation.

3.1.10 **Consideration of alternatives**

During the development of the final land use proposal a variety of alternatives were considered. These alternatives are detailed below.

3.1.10.1 Dairy pasture

The potential for improving the pasture of the rehabilitated land to provide pasture suitable for dairy production has been identified. Further studies will be undertaken in conjunction with the Department of Agriculture. Any decision regarding the potential for dairy production will not effect the proposed composition of rehabilitation. Improved road access for milk tankers via the proposed haulage route of mineral to Bunbury, will assist the viability of any such proposal.

3.1.10.2 Cork production

Preliminary investigations were conducted into establishing a commercial cork plantation on the mined area. Although the climate was considered suitable, and the product could be readily marketed to the local wine and craft industries, the tree would not produce any cork for 25 to 30 years. On this basis no further investigations were conducted.

3.1.10.3 Rehabilitation to native species

The potential to rehabilitate the total mined area to native species was not considered appropriate for the following reasons:-

- (a) The areas of cleared pasture are devoid of native species seed stock and therefore deemed unlikely to be successfully rehabilitated to native vegetation.
- (b) Within the Shire, 42,072 ha of a total 237,000 ha is used for pastoral production. The rehabilitation of the land to native species would result in a 2% loss of the Shires' pastoral land and a corresponding decrease in income.
- (c) Any decrease in the Shires' productive agricultural land, will place pressure on other areas of uncleared freehold land to be developed for pasture.

3.2 PROCESSING OF MINERALS

3.2.1 Dry mill

The wet concentrate will be transported by truck from the temporary stockpile adjacent to the dredge pond to the dry mill (Figure 3.2). The wet heavy mineral concentrate will be upgraded using additional gravity techniques and then dried in a rotary dryer before being separated into its constituent mineral products ilmenite, rutile and zircon by electromagnetic and electrostatic techniques. Sand and other waste products which are removed in the process will be returned to the minesite for disposal.

The dry mill is located approximately 2 km north of the proposed mining area on freehold land adjacent to Scott River Road. The site is slightly elevated, providing protection from flooding during winter (Refer Figure 3.4).

The principal criteria for the selection of the dry mill and office site were:

- ° Near Scott River Road.

- ° On one of the low sand ridges.
- ° Not on land to be mined.
- ° Within the proponent's mining lease applications.

A number of locations were examined but the site selected on Location 4151 is the only one that meets all the above criteria. It also has the desirable features of good drainage, topographic and vegetative protection from winds and isolation from residences. It is also directly accessible to trucks heading north with the final product.

The site supports a low woodland of Peppermint, *Banksia* and Jarrah. The area is grazed by cattle and the native understorey has been replaced largely by introduced species. No gazetted rare species were recorded on the site.

The administration office, workshop, laboratory, store and nursery will also be located at the dry mill site. These facilities will be positioned adjacent to the remnant low woodland, which will provide visual screening and afford some protection from prevailing southerly winds. Additional vegetation will be planted prior to construction to provide further visual screening. Approximately 1 ha of remnant woodland will be cleared during construction. The additional 8-10 ha required for the site will be on land that has previously been cleared and had pasture established.

Transport of the product mineral and vehicle access, will be north along Scott River Road to the Brockman Highway intersection (Refer Section 3.4). The mill area will be encircled by a one-way ring road to provide unimpeded movement of vehicles. The ring road and minor access roads within the site area will be sealed.

3.2.2 Atmospheric emissions and liquid effluent

The only atmospheric emissions from the dry mill will be exhaust gases from the coal, oil or LPG generated dryer. Water vapour will be driven off during the drying process. Dust will be collected to prevent its discharge to the atmosphere; vented air will meet EPA emission standards.

The results of laboratory test work to date indicate that no chemical reagents will be used in the dry mill. If the approval for the project is obtained further test work will be conducted to verify current results. The additional test work will examine the need to remove organic coatings from the surface of the individual grains, and the separation of pyrite from the heavy minerals.

If present, organic coatings are removed by scrubbing the mineral in an alkaline solution of caustic soda, the majority of the solution is recirculated in a closed circuit. Quantities of consumed solution are diluted with water and pumped to the tailings pond where it becomes neutralised. Given the slightly acidic nature of water in the area (pH 5.0 to 6.6), in the event of the mineral requiring scrubbing, neutralisation of the solution will occur very rapidly. It is anticipated that scrubbing of the mineral will not be required.

To separate grains of pyrite from the other heavy minerals, flotation of the pyrite is required. Within the composition of heavy minerals pyrite occurs in very minor quantities (less than 1%). The need for flotation of the pyrite is not anticipated, but will be investigated further. If it is found necessary to remove pyrite, it will be returned to the dredge pond.

3.3 INFRASTRUCTURE AND SERVICES

3.3.1 Water supply

Water will be provided to the dry mill and office from a nearby borefield. The borefield will be equipped with two bores, each capable of producing 400 m³/hour. The process water pond (1 ha x 2 m deep) will have a nominal capacity of 20,000 m³ (equivalent to mill usage for one day). The reclaim pond is to be 1 ha x 2 m deep, with a capacity of 20,000 m³, equivalent to one day's reclaim requirement (Figure 3.4).

The plant water requirement for the dry mill will be 900 m³/hour and it is estimated that this will be made up of 75% reclaimed water and 25% bore water, to limit slimes build-up.

The bore water will be treated in a package water treatment plant to provide potable water to the dry mill, office, wet plant and dredge.

3.3.2 Electricity

An electric power supply to the operation will be provided from the State electrical grid by SECWA. This supply will be broken down to 22kV in an electric sub-station at the dry mill.

SECWA have indicated that either an extension of the 132kV line east of the project site or upgrading of the 66kV power line to Margaret River, and extension of the line to the project site may be viable alternatives.

A study by SECWA of both options will be conducted to determine the preferred alternative. The Shire Council has indicated that they would like to relocate the sub-station at Margaret River away from adjacent residential development. The viability of relocating the sub-station will be included in the SECWA study. All capital costs associated with provision of power to the project site will be met by the proponent.

3.3.3 **Communications**

Telecommunication facilities at the dry mill/office area and at the mine site will be provided by Telecom Australia. The use of micro-wave link or line service will depend on Telecom advice.

3.3.4 **Waste disposal**

3.3.4.1 **Dry mill**

Slimes from the dry mill will be disposed of in a slimes dam 5 ha x 2 m deep, (Figure 3.4) giving a capacity of 100,000 m³. Dry waste (sand etc.) will be transported back to the mine site and incorporated in the tailings.

3.3.4.2 **Sewage**

A package sewage treatment plant will be installed at the dry mill and office area. As the soils in the area are water-logged during the winter, the Shire pump-out service will be used if necessary.

3.3.4.3 **Garbage**

Garbage and other rubbish will be disposed of regularly in an approved Shire disposal site.

3.3.4.4 **Other waste material**

All waste steel, timber etc. will be disposed of at an approved Shire disposal site. Workshop wastes such as oil and grease will also be disposed of in an approved manner.

3.3.5 **Fire prevention measures**

Suitable fire-fighting equipment approved by the W.A. Fire Brigade Board will be maintained on site.

3.3.6 On-site facilities

The structure and facilities to be constructed at the dry mill and office area are shown in Figure 3.4. Buildings will be erected at the mine site to provide accommodation for site office, store, workshop and laboratory.

3.3.7 Local road systems

At present access to East Augusta is via Brockman Highway, Courtney road, Payne road and finally Scott River road. Since it is proposed to mine part of Scott River road in the first eight years, an alternative access will be provided to East Augusta. This will involve consultation with the Shire but it is anticipated that the route will use existing surveyed roads which run down the eastern side of the Scott National Park surrounding the Blackwood River and then turn east along Strucels road. The proponent will make land available to enable connection to Strucels road and Brennans Bridge without any encroachment into the Park or the mining operation. The anticipated route is Courtney road, Payne road, Scott road, Strucels road, through Location 4259, then Scott River road (Figure 2.1).

3.4 TRANSPORTATION OF PRODUCT

Very early in the development phase, the proponent realised that approval of the project would depend on the identification of a viable option for transportation of the mineral product that was sensitive to potential environmental impacts. The matter was also referred to the Community Consultative Group and a range of options was considered.

In January 1989, the proponent engaged BHP Engineering to undertake a feasibility study to identify alternative methods of transporting product from the Beenup Project near Augusta direct to overseas markets, or to a dry separation plant at Kwinana or Bunbury prior to export. This study assessed shipping, barging, rail and road transport options to prepare order of magnitude estimates for capital and operating costs. The work was essentially a desk study with enquiries being made to relevant State Government, Local Government, Regional groups and commercial operators.

3.4.1 Options considered

Transport options considered were sea, rail, rail/road and road (Figures 3.7 and 3.8).

3.4.1.1 Sea options

The sea options considered were:

- ° Direct export shipping of the mineral product by 25,000 tonne vessels from Flinders Bay, south of the deposit.
- ° Shipping of wet concentrate via 8-10,000 tonne vessels from Flinders Bay to a dry mill at Kwinana for final upgrading.
- ° Barging of wet concentrate on 2,000 tonne vessels to a dry mill at Bunbury.
- ° Transportation of the wet concentrate to Kwinana by pumping the slurry offshore and loading onto 10,000 tonne vessels was also examined.

Initially, the transportation of the wet concentrate from the mine site to the port loading facilities in Flinders Bay was proposed to be by pipeline. However, further investigations highlighted the risk of spillage in the National Park and later studies assumed all four options would use road transport to Flinders Bay loading facilities.

3.4.1.2 Rail option

The rail option considered, proposed a direct rail link from the Beenup project to a storage facility at the inner harbour, Bunbury. One train comprising a locomotive and 11 x 52.5 tonne bottom dump wagons would operate continuously. The existing rail easement from Busselton via Margaret River and Karridale was considered unsuitable by Westrail. The proposal therefore involved a totally new alignment for this rail option.

3.4.1.3 Rail/Road options

In addition to the direct rail link, a series of rail/road combinations was also considered. These options included:

- ° Trucking from the project to a rail head at Nannup and then cartage of the material by rail to Bunbury.
- ° Extending the existing Nannup to Bunbury rail line parallel to the Brockman Highway to Stewart Road with truck cartage from the Beenup project to the Brockman Highway/Stewart Road junction.
- ° Haulage along Sues Road/Sabina Road to Wonnerup siding where the mineral would be loaded onto rail transportation to Bunbury.

3.4.1.4 Road options

Two road options were considered:

- ° Haulage of final product via truck from the Beenup project to the Brockman Highway, from the Brockman Highway west to the Bussell Highway, and north along the Bussell Highway via Margaret River and Busselton to Bunbury.
- ° Haulage of the product from the Beenup project east along the Brockman Highway to Sues Road, then north from Sues Road to intersect Sabina Road and east to the Vasse Highway. Access from the Vasse Highway to the Bussell Highway would then be the subject of an independent study by MRD, taking into account the requirements of other major users within the region.

3.4.2 Detailed assessment in consultation

From the preliminary studies undertaken, the proponent outlined to the Beenup Consultative Group three transport options which appeared to have similar cost factors (a combination of capital and operating costs) worth further consideration. The options provided to the Consultative Group for comment were:

3.4.2.1 Option 1

The transportation of the dry product from a separation plant at Beenup by road to a temporary undercover storage area behind the foredunes in the vicinity of Johnston Road. This product would then be loaded into a 25,000 tonne ship using a conveyor belt along a 1.65 km jetty in Flinders Bay. Approximately 20 ships per year would be needed to ship the product direct to world markets.

3.4.2.2 Option 2

The wet concentrate would be transported by road transport or pipeline from the Beenup project to a ponding facility near the foreshore in the vicinity of Johnston Road. The wet concentrate would then be pumped in a sea-floor pipeline from the holding ponds to an offshore ship loading buoy. A specially designed dedicated ship in the order of 10,000 tonnes would then be used to transport the concentrate to Kwinana. Approximately 80 visits per year would be necessary to transport the concentrate.

3.4.2.3 Option 3

Road transport from the Beenup project to Bunbury via Sues Road, using a fleet of approximately 14 trucks operating 24 hours per day, 5 days per week.

3.4.3 Preferred option (Figure 3.6)

After due consideration of:

- ° The Consultative Group's comments.
- ° Public opinion expressed to Company representatives and in the local media.
- ° A more detailed economic assessment undertaken by BHP Engineering and other engineering consultants.
- ° Reference to the DRD Transport Task Force Study.
- ° Assessment of the Task Force Advisory Committee from the Shires of Augusta, Margaret River, Capel, Busselton and Nannup.

The proponent decided to opt for road transport via Sues Road and Sabina Road to Bunbury as its preferred option. The main considerations in selecting this road option were environmental and economic:

- ° The risk of damaging the sensitive coastal environment by installing storage and access facilities for either of the sea options.
- ° Local opposition to either sea option on environmental grounds.
- ° The ability to develop a heavy haulage road route that for the majority of its length would not go near major population centres or tourist destinations.
- ° The increased capital and operating costs required by the two tugs needed for the jetty option.
- ° The risks to the proponent if the dedicated ship required for the pipeline option were to be damaged and become inoperable. Concentrate could not be transported and the mine would have to shut down.

The finalisation of this route will be in consultation with the Main Roads Department, especially in the section between Vasse Highway and Capel. Indications from MRD are that this section of road would be constructed by them and the section from the mine site to Vasse Highway would be constructed by MDL and other heavy haulage transport users.

3.4.3.1 Detail of the preferred route

The preferred route is as follows:-

- ° From the dry mill north along Scott River Road approximately 5 km to the Brockman Highway intersection.
- ° East along the Brockman Highway for 12 km to Sues Road junction.
- ° North along Sues Road for a distance of 42 km to Sabina Road.
- ° North-east along Sabina Road to the Vasse Highway.
- ° The route between Sabina Road and the Capel to Bunbury Highway will be the subject of a separate study by MRD. The proponent has expressed the opinion that a preferred route will be needed to by-pass the townships of Busselton, Capel and Ludlow.
- ° Existing highways and roads will be used between Capel and the Inner Harbour at Bunbury.

Loaded trucks to Bunbury and empty trucks returning will use the same route. The total length of the preferred route will be sealed. Maintenance facilities may be at the site or in Bunbury, as deemed appropriate by the haulage contractor.

3.4.3.2 Interaction with other road users

The preferred option avoids major tourist routes and farming areas. The current condition of the existing roads discourages road users.

Use of Scott River Road north of the dry mill site is limited mainly to landowners along that section of the road. The majority of landowners in the area, and East Augusta residents use Courtney and Payne Roads to the east of Scott River Road as their preferred access. The proponent will maintain access to their properties for local landowners.

The intersection of Scott River Road and Brockman Highway is currently inadequate as visibility is poor and there are three houses within 250 m of the intersection. This intersection will be modified in consultation with the Shire and the landowners most affected.

Brockman Highway from the Scott River Road turnoff to Sues Road has 4 houses within 100 metres of the road. All driveways are clearly visible to passing drivers. The houses are at the western end of the highway, on the edge of a farming district. Most of the route is through State Forest to Sues Road. There

are no school buses operating on this part of the highway. Average daily traffic counts are estimated to be 200.

Sues Road to Sabina Road runs through State Forest only. There are no houses and no school buses use this road. The daily traffic count is estimated to be 20. There is some public use of this road to gain access to Sues Bridge camping area on the Blackwood River.

Sabina Road to the Vasse Highway is currently a well-formed road as far as Kemp Road and then diminishes to a bush track once it crosses Sabina River. The road is entirely through State Forest and is used mostly by CALM and WA Water Authority personnel.

The proponent has initiated a study into the likely changes that the preferred route will have on existing traffic patterns. The results of this study will not be available until later this year.

3.4.4 Bunbury port facilities

Consultation has commenced with the Bunbury Port Authority regarding facilities for the storage and ship loading of the product from the Inner Harbour. Undercover, warehouse type storage for 150,000 tonnes of product will be required. It is proposed that this will be at the proposed mineral sands loading berth (Berth C) in the inner harbour. Since the dredging of this berth is unlikely to be completed before the shipping commences, it is proposed that the product be trucked from the Berth C storage area to either Berth 2 at the inner harbour, or to the outer harbour during the interim. Discussions are currently underway with the Bunbury Port Authority and various trucking companies to determine the most desirable short and long term solutions to the Company's needs.

It is proposed that the storage and loading facilities be provided by the trucking company. Several undertakings will be required by the proponent.

- (1) All storage is undercover in warehouse type construction.
- (2) All ship loading facilities are covered to prevent dust and noise nuisance.
- (3) Port loading facilities with a loading capacity of 1,500 tonnes per hour to enable rapid turnaround of ships.

3.5 WORKFORCE

The project consists of two phases - a construction phase and an operational phase. The characteristics of each are outlined below.

3.5.1 Construction phase

The construction phase of the project is expected to take approximately 18 months and will involve a peak construction workforce of some 200 persons. Construction is planned to commence in October 1990, and be completed by March 1992. The expected buildup on a bi-monthly basis is shown in Table 3.1:

TABLE 3.1

Bi-monthly Period	Workforce
1	5
2	25
3	60
4	120
5	180
6	200
7	200
8	150
9	50

The skill distribution of this workforce, which will be made up of approximately 5% company personnel and 95% contractors and their staff, is given in Table 3.2

TABLE 3.2

Construction Workforce Skill Profile - Beenup Project

Skill Group	%
Staff	11
Mechanical Trades	33
Electrical Trades	10
Materials Handling	12
Painters	4
Labourers	18
Administrative/Clerical	12

Construction firms will be encouraged by the proponent to employ locally where possible.

Construction work will be carried out only during daylight hours.

It is proposed to house all the single construction workforce at the project site in a construction camp complex. This temporary camp, with single quarters, messing and recreational facilities, will be located at the dry mill and office site, on the area that will later be the parking area. Native trees and shrubs indigenous to the area will be planted during 1990, to screen the camp from the road, once approval for the project to proceed is granted.

Married construction personnel accommodation will be provided via existing commercial caravan parks and, subject to agreement with the Shire Council, construction of a Company caravan park approximately 8 km north-west of the project site at Alexandra Bridge. The site was identified by the Shire as having potential to operate as a commercial venture, providing additional tourist accommodation after completion of construction. The site has power and telephone connected and the W.A. Water Authority will be consulted before installing a bore to supply water. Management of the facility would then become the responsibility of the Shire after the completion of the construction phase.

3.5.2 Operational phase

3.5.2.1 Mine and plant

The operational phase of the project is scheduled to commence early in 1992 following plant commissioning. The operational workforce is expected to number 115 persons of whom 96% will be company employees and 4% contract personnel. This workforce will be utilised on a 3 x 8 hr shifts per day basis, seven days a week. Table 3.3 gives the expected skills profile of the permanent workforce.

It is expected that all workers will be employed under the appropriate industrial Award.

It is understood that the WA Mines Department Acts and Regulations will apply to the site, and that the occupational health and safety measures adopted under the ambit of this legislation will be employed. The mine will employ an occupational health and safety coordinator, and accredited first aid workers will be present on all shifts. A fire tender will be available on site. An environmental officer will be a member of the professional staff.

The proponent's recruitment programme and training policy will be to recruit and train workers locally where possible. If appropriate local persons are not

forthcoming at the time of recruitment, workforce personnel may need to be recruited externally. This latter state of affairs, however, is most unlikely given the Company recruitment experience in other rural areas containing good farming skills. The Company is an equal opportunity employer.

TABLE 3.3
Operational Workforce Skill Profile -
Beenup Project

Skill Group	%
Management	12
Technical	7
Administration	8
Mechanical Trades	4
Electrical Trades	3
Plant Operators	39
Trades Assistants	4
Apprentices	2
Labourers/General Hands & Drivers	21

As the proposed mine is not located in a remote isolated area, and as a large measure of local recruitment is expected, it is the Company's intention to not provide housing for its employees.

Given the broad geographical base from which the Company anticipates employees will be drawn, it is intended that employees be responsible for their transport to and from work using whatever means they choose. It is envisaged that most work trips will be made by private car, and that a degree of car pooling will take place.

3.6 PROJECT REVENUES AND EXPENDITURES

Project construction is expected to involve expenditure in excess of \$100 million over an 18 month period, commencing in October 1990. Operating costs are expected to involve the expenditure of \$20 million annually. During both project phases the following distributions of expenditure is anticipated.

TABLE 3.4

Expenditure Distribution
Beenup Project
%

Location	Construction Phase	Operational Phase
Overseas	9	Nil
Australia	91	100
Western Australia	48	80
South West Region	38	73
AMR Shire	26	36

The project's production will be exported overseas in its entirety. Revenues are anticipated to average \$50 million per annum based on current prices and exchange rates.

3.7 DECOMMISSIONING

When the mining and milling operations are completed, all structures will be dismantled and removed and the sites revegetated. Improvements such as bores and fences will remain in place.

Rehabilitation operations will be completed and managed to the stage where each area and land use will be self-sufficient. Areas of native vegetation rehabilitation will be self-sustaining and pasture areas will be productive provided the usual pasture management methods such as regular fertilising and grazing controls are practiced.

Analysis and
Management of the
Potential Impacts
of the Environment

4.0 ANALYSIS AND MANAGEMENT OF THE POTENTIAL IMPACTS ON THE ENVIRONMENT

4.1 HYDROLOGY

4.1.1 Mining

4.1.1.1 Groundwater

(a) Impact assessment

The dredge and wet plant will float on the dredge pond at groundwater level. During the early years the behaviour of the aquifer will be compared with computer model predictions. The model of the aquifer indicates that seasonal variations of the pond level will occur, with a net increase in the pond level of 0.52 m in winter and a net decline during summer of 1.32 m.

During the period May to August sufficient rains will be received to maintain pond water levels at a zero impact level. From September onward, the deficit in the water balance will induce a small steady decline in the water table level, creating an impact of just less than 0.3 m per month at the pond perimeter. The worst case would be at the end of summer, when the water table drawdown would be at its maximum. Figure IV-13 in Appendix IV shows the position of the 0.1 m drawdown contour, with no makeup water pumped into the pond, at the end of summer.

(b) Management measures

The method of mining will be designed to accommodate the rise in the pond level during the winter months and avoid the need to discharge water from the pond. During summer, if required, makeup water will be supplied to the dredge pond from several bores in the Lesueur Formation at a depth of 150 to 200 m to ensure that there will be no drawdown of the regional water table.

Pumping the makeup water from the deep Lesueur Formation will ensure that no drawdown occurs to the regional water table upon which pastures and farm dams depend. There will be no impact on the water levels in the shallow aquifer, as intercalated clays and silts located above the pumping zone in the Lesueur Formation will effectively confine depressurisation to these lower horizons.

4.1.1.2 Surface water

(a) Impact assessment

The mining area is dissected by three shallow drainages which rise in the north-east and discharge to the south and south-west into the Scott and Blackwood Rivers. As the water table rises during the winter, runoff is generally initiated.

Dredging operations will move across the various drainages in the normal course of operations.

(b) Management measures

Existing surface drainage channels will be diverted around the dredge pond. These channels will be established at least 12 months prior to requirement, to enable vegetation to regenerate and stabilise. Silt traps will be constructed on major drainage channels, downstream of the mining operations.

Where practical, water from the slimes dam will be decanted and returned to the dredge pond. Providing turbidity is acceptable, excess decant water from the slimes dam will be discharged into existing drainage channels. Turbid water will not be allowed to enter the Park.

Monitoring the water quality of the Blackwood and Scott Rivers will continue on a regular basis. In addition major drainage channels will be monitored to ensure that turbid water is not discharged to the Scott or Blackwood Rivers.

4.1.2 Mineral separation

4.1.2.1 Impact assessment

The dry mill site will obtain its water supply from two (2) bores in the Lesueur Formation at a depth of 150 to 200 m and there will be no impact on the regional water table. Water from the bores will be held in a process water dam.

Process water from the dry mill will be pumped to an adjacent settling dam. Decant water from this dam will be transferred to a reclaim water dam for reuse in the dry mill.

4.1.2.2 Management measures

A balanced use of water will be maintained by the operation of the water bores, and unless unforeseen circumstances occur, there will be no need to discharge excess water. This is because much of the process water will be re-cycled in the plant. As a precaution a silt trap will be constructed downstream of the dams.

4.2 REHABILITATION

4.2.1 Impact assessment

The proposed mining operations will have a temporary, but major, disrupting effect on the pasture lands and remnants of native vegetation of the Beenup project area. This initial impact will be modified once the rehabilitation programme commences and the post-mining land use plan is implemented (Section 3.1.9). The incorporation of some of the slimes into the topsoil on pasture areas will result in improved pasture growth by imparting a higher water holding capacity and a higher nutrient retention capacity to the soil.

Many of the techniques involved in growing native vegetation communities, pastures and native trees have been developed by the proponent during many years of experience of mining and rehabilitation in coastal areas. The careful implementation of these techniques at Beenup, assisted by the results of research into the particular requirements at Beenup, will ensure that, as each section of land is mined and rehabilitated, a useful natural resource will be left.

4.2.2 Management measures

Rehabilitation is regarded as an integral part of the mining operation and rehabilitation procedures will be fully integrated with mine production procedures. The following commitments are made by the proponent:

- 1) The final land use programme outlined in Section 3.1.9.1 will be implemented.
- 2) The landforms on mined areas will be compatible with surrounding lands.
- 3) The drainage system on mined areas will be integrated with regional drainage.
- 4) All topsoil will be removed before mining, conserved during mining and returned to mined areas after mining.
- 5) Productive pastures will be established on mined areas in the proportions indicated (Figure 3.3).
- 6) Native vegetation will be established on mined areas in the proportions indicated (Figure 3.3).
- 7) The requirements for raising native plant at Beenup will be investigated.
- 8) All rehabilitation areas will be monitored regularly to assess progress and additional plantings will be carried out as required.

4.3 TRANSPORTATION OF MINERAL PRODUCT

4.3.1 Impact assessment

The preferred product transport method is by road to Bunbury for shipment overseas. The proposed transport route from the project area is to use Scott River Road, the Brockman Highway, Sues Road and Sabina Road to its intersection with the Vasse Highway (Figure 3.6).

The section of the proposed haulage route between the mine area and the end of Sabina Road generally passes through sparsely inhabited rural lands and State Forest and involves minimal impacts. Between Sabina Road and the Bussell Highway/Capel is a more closely-settled dairy farming area. A detailed examination of the social impacts associated with the route is presented in Appendix X (Section 5.4).

Between Capel and Bunbury Inner Harbour the existing highway and roads will be used. The transport of minerals from Beenup will add a minor component to traffic volumes on this section.

4.3.1.1 Social impact

The major potential social impacts that have been identified are the possible disturbance by day-to-day residential, farming and business activities; an increase in traffic encountered by other road users; and the effects of dust, noise and vibration generated by passing heavy haulage vehicles.

The social impact along Sues and Sabina Roads is considered minor given the low traffic counts and lack of residences. The picnic and camping area at Sues Bridge is the only tourist attraction on this section. On Scott River Road the main impact will be on employees coming to and from work, and visitors to the minesite. However this road will be widened, sealed and sign-posted.

The preferred route between the Vasse Highway and Capel will be the subject of a separate study by the MRD. The proponent has expressed the opinion that a preferred route will need to bypass Busselton, Ludlow and Capel.

4.3.1.2 Economic impact

The use of road transport will provide additional employment opportunities for the region. Approximately 40 direct employees will be required to administer, operate and maintain the truck fleet. The local economy will also benefit during the construction phase.

4.3.1.3 Land use impact

The upgrading of the roads will have an impact on current land use. Sues and Sabina Roads are forestry roads controlled by CALM. A gazetted road easement will have to be established for these roads and some clearing of timber will be required. The most appropriate alignment will be determined in conjunction with CALM,MRD and EPA.

During construction of the road suitable gravel supplies will be required. Discussions with the relevant authorities will be undertaken to determine the most appropriate source. If necessary mining leases will be applied for and a Notice of Intent prepared.

4.3.1.4 Noise impact

Two houses between Beenup and Sues Road may receive noise levels above acceptable levels as a result of the road transport. These houses are near the intersection of Scott River Road and Brockman Highway (refer to Section 4.8 for details).

4.3.2 Management measures

4.3.2.1 Upgrading of roads

The total length of the preferred route will be sealed. All roads will be constructed to MRD or Shire standards as appropriate.

At the intersections where Scott River Road and Sues Road meet the Brockman Highway, the highway will be widened to incorporate a deceleration lane. The intersection of Sabina Road with the Vasse Highway will include an acceleration lane. All intersections will be positioned to provide clear visibility for a distance of 400 m in both directions.

"Stop" signs will be installed at the three intersections. Signs will be placed along the route to indicate the presence of heavy haulage vehicles. Speed restriction will be imposed in populated areas.

Sound levels at the two houses near the intersection of Scott River Road and Brockman Highway will be recorded under actual operating conditions and appropriate measures will be taken if necessary to reduce the sound levels to acceptable levels.

The provision of a sealed all weather road, suitable for heavy haulage, between Capel and the project site, will alter existing traffic patterns. It is anticipated that heavy haulage traffic along the Bussell Highway between Capel and Margaret

River will be reduced. To quantify these changes, the proponent is currently undertaking a traffic study. The study should be completed by April, 1990.

4.3.2.2 Operation of trucks

The proposed hours of operation are 24 hours per day in three shifts, five days per week. No haulage of mineral product is proposed during Saturday and Sunday. As a condition of the haulage contract, the contractor will be required to maintain the vehicles in a safe operating condition. The mineral will be securely covered by a tarpaulin to prevent spillage en-route.

4.3.2.3 Management of dieback

The widening and re-alignment of some sections of the transport route, and the extraction of gravel for road construction, have the potential to spread dieback. A dieback management programme for these operations will be developed by the proponent to the satisfaction of CALM and EPA.

The proponent will carry out the following studies.

- (a) Description and appraisal of the vegetation and flora along the entire Sues Road-Sabina Road route. The condition of the vegetation will be assessed, with particular emphasis on the occurrence of dieback. A more detailed study will be carried out in the proposed Whicher Reserve section, where a number of possible route alternatives (Figure 4.3) will be studied to ensure minimum impact, both with respect to dieback control and flora.
- (b) Description of the terrain, drainage and soils with particular emphasis on regional drainage and how the proposed upgrading may affect this drainage.
- (c) Description of the fauna and faunal habitats of areas that would be disturbed by the proposed upgrading.
- (d) Survey the areas that would be disturbed by the proposed upgrading for cultural and archaeological sites.

The proponent will endeavour to obtain gravel from private sources, including an investigation of the iron pan contained within the proposed mining area. If there is any shortfall in requirements, the proponent will make a formal approach to CALM for its requirements. The spread of dieback will be prevented by using only uninfected sources of gravel in areas currently free of dieback.

4.4 LANDFORMS AND VISUAL AMENITY

4.4.1 **Impact assessment**

After mining, a generally subdued topography similar to pre-mining will be returned, as the small volume of the heavy minerals removed will be imperceptible. The dry mill and office will be visible to people using Scott River Road to reach East Augusta. The mining operation will also be visible to these people, especially when it is near a road.

The Beenup project area is not visible from Augusta or from any main road. Any adverse effect on the visual amenity is judged to be very low.

4.4.2 **Management measures**

The dry mill and office will be screened from the road by plantings of native trees and shrubs indigenous to the area.

Previous experience indicates that the mining and milling operations will be of interest to many visitors to the area and the proponent plans to conduct tours of the operations to satisfy that demand.

4.5 AUDIT OF GREENHOUSE GASES GENERATED BY THE PROJECT

4.5.1 **Electrical power consumption**

The anticipated electrical power requirement for the project is 8.9 Megawatts (MW). This represents 0.3% of the power generated by the State Government. The major area of consumption will be the mining plant, anticipated to be 6.7MW.

Power will be provided via SECWA who utilise coal to generate electrical energy. The quantity of coal required to generate the project's power requirements is 40,000 tonnes per annum.

The size of the Beenup project enables efficiencies of scale to be achieved. Refer Figure 4.4.

4.5.2 **Pumping**

The single major area of consumption of electrical power is pumping. Pumping can be divided into two sections, transportation of ore slurries around the wet plant and control of the water table for the dredging operation.

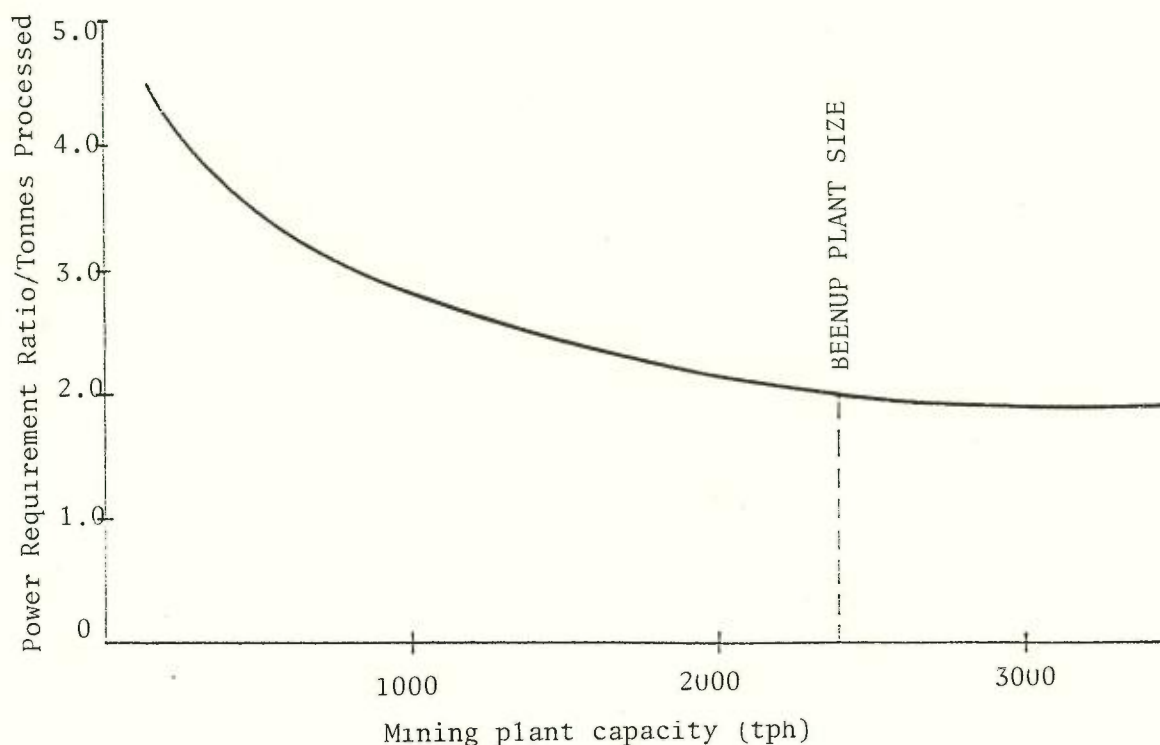


FIGURE 4.4

Energy efficiency relative to size of plant

The wet plant will be constructed to minimise the cost (and hence power requirements) of pumping ore slurries.

The dredge for the Beenup project will have deep digging capabilities to enable operations to take place with minimal need to pump down the existing water table.

4.5.3 Fuel consumption

The major consumption of fuel will be the diesel powered trucks that transport the mineral product to Bunbury. Initial discussion with potential haulage contractors has indicated that on-board computers are available to monitor truck performance. This will enable the fuel efficiency of the truck fleet to be maximised, and emission of greenhouse gases to be minimised.

4.5.4 Chlorofluorohydrocarbons (CFC's)

CFC emissions are responsible for 15% of the warming potential attributable to gaseous emissions in Western Australia. As part of company purchasing policy, only pressure packs not containing CFC's will be purchased. The company will investigate the availability of halon free fire extinguishers, and where practical, utilise suitable alternatives. Gases extracted from air conditioning units during maintenance or repair, will be recovered in suitable receptacles for recycling.

4.5.5 Land clearing and rehabilitation

Areas will be rehabilitated progressively after mining. Clearing of land in advance of mining will be minimised.

Millable timber will be logged and removed from the site by arrangement with local contractors. Shrubs and grasses will be removed with the topsoil.

It is currently planned to burn timber not suitable for milling, however alternative uses will be investigated.

4.5.6 Mill dryers

The minerals must be dried for final processing and shipping. The tonnage to be dried will be held to the minimum necessary and only water will be driven off during the drying process; dust will be collected before discharge to the atmosphere. Coal or oil will be used for this purpose, as electrical heating is grossly inefficient.

4.5.7 Administration office and facilities

The walls and roof of the office, laboratory and amenities block will be thermally insulated to minimise heating and cooling requirements. Windows will be double glazed for thermal insulation. These measures combined with the temperate climate should result in minimal energy requirements.

4.6 RADIATION LEVELS

4.6.1 Impact assessment

Radiation levels on the mining area, the dry mill and office site and other areas in the district were measured by recording the absorbed dose rate 1 m above the ground (Section 2.8). The survey revealed that radiation levels are low on the mining area and dry mill and office site and similar to background levels in other parts of the district. Radiation does not therefore present a hazard at Beenup.

4.6.2 **Management measures**

None required.

4.7 **AIR QUALITY**

4.7.1 **Impact assessment**

The main potential atmospheric pollutant at the mine and dry mill will be dust. The various potential generators of dust and environmental management measures which will be implemented are discussed below.

The project site experiences high wind conditions at times (Refer Section 2.4 and Appendix II). The potential therefore exists for dust to be generated at certain times from the following areas during the course of the mining operation:

- ° Land cleared of vegetation in advance of mining.
- ° Land stripped of topsoil in advance of mining.
- ° Topsoil stockpiles.
- ° Tailings - after shaping.
- ° Dried slimes.
- ° Topsoil - after spreading on tailings.
- ° Concentrate heaps at the minesite.
- ° Concentrate stockpiles at the dry mill.
- ° Unsurfaced haul roads.

4.7.2 **Management measures**

4.7.2.1 **Land cleared of vegetation in advance of mining**

Only the remnants of native vegetation will be cleared in advance of mining, and in those remnants, only the larger plants (trees and large shrubs) will be pushed by bulldozer and burnt. All smaller vegetation will be stripped with the topsoil. This practice will ensure that a maximum number of plant propagules (roots, seeds, etc.) are incorporated into the topsoil.

Pasture areas will not be stripped of their vegetation before mining. The pasture will be stripped with the topsoil.

These practices will help to keep the generation of dust from these areas to a minimum. However if a dust problem occurs due to very windy conditions, these areas will be protected with temporary mesh fences.

4.7.2.2 Land stripped of topsoil in advance of mining

This operation will be carried out at regular intervals as the operation proceeds and the area of land left bare in preparation for mining will be kept to a minimum in keeping with good mining practice. If a dust problem occurs, control measures described in Section 4.7.2.1 will be implemented.

4.7.2.3 Topsoil stockpiles

Topsoil will be stored for a minimum period of time before returning it to mined and shaped tailings. The transport of the topsoil, spreading on the shaped tailings and planting operations will be carried out each year during the period most suitable for planting pasture species and cover crops, which is usually autumn and early winter (Section 3.1.9). A temporary vegetative cover will be planted on the longer-term stockpiles.

4.7.2.4 Tailings

Tailings will be shaped by bulldozer and spread with topsoil during the period of the year most suitable for planting pastures and cover crops. During other times of the year the shaped tailings will be protected from winds if necessary by temporary mesh fences.

4.7.2.5 Dried slimes

Slimes will be directed to settling ponds (Figure 3.1) for disposal after they have dried. Portion of the slimes will be incorporated into topsoil destined for pasture areas (Section 3.1.9) and the remainder will be incorporated into the tailings near the surface. Care will be taken to ensure that surface drainage is not impeded by unmixed slimes being left near the surface.

4.7.2.6 Topsoil - after spreading on tailings

Pasture species or a cover crop, as appropriate (Section 3.1.9) will be planted as soon as the topsoil is spread, thereby minimising the possibility of the soil surface drying out and generating dust. Temporary mesh fences will be used if necessary.

4.7.2.7 Concentrate heaps

(a) At the mine

Concentrate will be trucked regularly to the dry mill, thereby minimising the possibility of the concentrate drying out and generating dust.

(b) At the dry mill

A watering system will be installed at the concentrate stockpiles at the dry mill if dust generation proves to be a problem once operations commence.

4.7.2.8 Unsurfaced haul roads

Unsurfaced roads may generate dust within the mining area. These haul roads will be watered as required during dry windy weather. Equipment will be maintained on site by the proponent for this purpose. Water from bores will be used for this purpose in preference to using surface water, to avoid the risk of spreading dieback.

4.7.3 Other atmospheric pollutants

Dust will be the only particulate potential pollutant. Because only gravity, electromagnetic and electrostatic methods are used in the mining and separation of the heavy minerals, the only gaseous emissions will be from diesel trucks and other equipment and mill dryers.

The mill dryer will use coal, oil or LPG as fuel. Only water will be driven off during the drying process; dust will be collected before it can discharge to the atmosphere.

4.8 SOUND LEVELS

4.8.1 Calculations of sound levels (SL's) and criteria

Sound level measurements were taken at the Capel dry mill of Westralian Sands Ltd. and at the Cataby dredging operations of the Cooljarloo Joint Venture to provide data on which to base calculations of the potential impact of noise emanating from proposed mining and milling operations on surrounding residences at Beenup. This work is reported in full in Appendix VI. The sound levels calculated to reach the Beenup residences were compared with the criteria contained in the Regulations⁶ of the *Environmental Protection Act, 1986*, as given in Table 4.1.

⁶Noise Abatement (Neighbourhood Annoyance) Regulations, 1979

TABLE 4.1

Sound levels at Beenup residences

Time	Neighbourhood Category A-1	Neighbourhood Category A-2
(a) Monday to Friday, 7am to 7pm:	40 dB(A)	45 dB(A)
(b) Monday to Friday 7pm to 10pm, weekends and public holidays, 7am to 10pm:	35 dB(A)	40 dB(A)
(c) Always, 10pm to 7 am:	30 dB(A)	35 dB(A)

A-1 Current category

A-2 Likely category once project approval is given.

4.8.2 Impact assessment

4.8.2.1 Predicted sound levels at Beenup residences

(a) Sound levels from mining and milling operations

(i) Monday to Friday, 7.00 am to 7.00 pm

All calculated SL's at the residences are less than the current acceptable outdoor SL of 40 dB(A) and there will be no impact.

(ii) Monday to Friday, 7.00 pm to 10.00 pm and weekends and public holidays, 7.00 am to 10.00 pm

Most of the calculated SL's reaching the residences are between 35 and 39 dB(A). The current acceptable outdoor SL for this period is 35 dB(A). According to regulations, a 5 dB(A) excess is acceptable. There will therefore be no impact.

(iii) Always 10.00 pm to 7.00 am.

During this period, only the dredge and the dry mill will normally be operating fulltime. However breakdowns and dredge anchor moves during the night will occasionally necessitate the use of bulldozers on the mining area during the hours of 10.00 pm and 7.00 am and

concentrate will be transported from the mine to the mill periodically at night.

Most of the calculated SL's from the mining and milling operations are between 26 dB(A) and 30 dB(A). The current acceptable outdoor SL for this period is 30 dB(A). There is one case where the SL is 35 dB(A) and according to regulations, an excess of 5 dB(A) is acceptable. There will therefore be no impact from mining and milling operations during this period.

The occasional use of bulldozers at the mine and the periodical use of trucks between the mine and the mill during these hours may be expected to increase the SL's at the residences. Measurements will be taken under operating conditions to assess whether the actual SL's will exceed neighbourhood category A-2 SL of 35 dB(A) during these hours, plus a 5 dB(A) excess.

(b) Sound levels from road transport

The route to be taken by road transport vehicles travelling between Beenup and Sues Road will affect two residences (refer Appendix VI). These are near the intersection of Brockman Highway and Scott River Road. The SL's calculated for both of these residences is 49 dB(A). The Regulations permit the deduction of 12 dB(A) for intermittent noise and require an increase of 5 dB(A) for special characteristics, so the net SL at each house would still be 42 dB(A) which is above the expected acceptable level of 35 dB(A) during the hours of 10 pm to 7 am (Table 4.1).

4.8.3 Management measures

The calculations of the expected SL at the residences is based on noise emanating from road trains used at the Cooljarloo operation at Cataby. The noise levels of the actual trucks to be used at Beenup for haulage of the mineral product will be investigated prior to reconstruction of the Scott River Road. The appropriate management measures, which may include the re-alignment of the road intersection, and a noise barrier, will then be implemented if necessary.

4.9 VEGETATION AND FLORA

4.9.1 Vegetation

4.9.1.1 Vegetation communities on the mining area and dry mill/office site

The major vegetation communities occurring on these areas were found to occur in adjoining conservation areas and/or in the eastern half of Location 4264, as follows:

- ° Woodlands (Vegetation Codes 1.1, 1.2, 1.3, 1.4, 1.5, 1.6). 103 ha of these communities will be removed by mining. All of these communities, which occur on the western side of the mining area, are well represented in nearby areas of Scott National Park and State Forest.
- ° Low woodlands on sandier soils (Vegetation Codes 2.1, 2.2). 53 ha of these communities will be removed by mining. These support species which overlap with adjoining communities on sandier soils in the Reserves, Scott National Park and State Forest. An area of 3.5 ha of these communities also occurs on the eastern half of Location 4264.
- ° A series of low woodlands of Paperbark on the wetter soils (Vegetation Codes 2.3, 2.4, 2.5). An area of 23 ha of these communities will be removed by mining. They are all represented in the wetter depressions and drainage lines of the Scott National Park. An area of 7 ha also occurs on the eastern half of Location 4264.
- ° The heaths of *Banksia occidentalis* (Vegetation Code 3.1). A small (1.4 ha) area of this community occurs in the north-west corner of the Beenup survey area. It is reported to be possibly under threat in other parts of the Scott River plain from the spread of dieback and too frequent fires.
- ° Sedgeland and heaths on the wetter depressions. These are represented in nearby area of the Scott National Park. The most significant community from the conservation aspect is the low sedgelands community (Vegetation Code 4.3) which occurs in several parts of the Beenup survey area, including the eastern half of Location 4264, and on the Camping Reserve. 24.4 ha of this community will be removed by mining, but 77.6 ha will be remain in the eastern half of Location 4264.

4.9.1.2 Impact assessment

There are approximately 312 ha of remnant vegetation on the mining area. The woodlands occur extensively outside the mining area and are not under threat. The small area of *Banksia occidentalis* heath on the mining area is degraded through cattle using the low sandy ridges on which the heath grows as winter camps. The remaining communities of conservation value occur on the eastern half of Location 4264, which will be excluded from mining.

4.9.1.3 Management measures

The vegetation survey has revealed the conservation value of the vegetation remnants on the eastern half of Location 4264, 170 ha in extent. Mining is not planned on this land. It will not be affected by mining, as drawdown of the water table will be prevented by pumping makeup water into the dredge pond as required during the summer months.

4.9.2 Flora

A number of Gazetted Rare Plants, species on the Reserve Flora Priority List and species of interest were recorded on the Beenup survey area.

4.9.2.1 Species from the Gazetted Rare Flora List

Two Gazetted Rare Plant species were recorded: *Darwinia* sp. and *Lambertia orbifolia*. These two plants occurred in the eastern half of Location 4264, outside the proposed mining area, and the road verges on Governor Broome Road (Figure 2.6). This finding increases the conservation status of the eastern half of Location 4264.

4.9.2.2 Species from the Reserve Flora Priority List

Nine of these ten Reserve Flora species occurred in the eastern half of Location 4264 and therefore outside the proposed mining area. The remaining species, *Hypocalymma* aff. *cordifolium* (A.S. George 1177 3) occurred west of Scott River Road on the Beenup survey area and is on the proposed mining area. Apart from the Scott River area, this species is also known from the Northcliffe area.

4.9.2.3 Species of interest

Of the three species of interest, the new *Boronia* species occurred in the eastern half of Location 4264 and the other two occurred mainly in the western and north-western parts of the Beenup survey area. The second species of interest, *Hovea stricta* has also been recorded on the northern sandplains and from the

Busselton/Cape Naturaliste area; the third species of interest, *Verticordia lehmanii* also occurs in the Busselton/Scott River area.

The new genus (*Genus nov.*, aff. *Loxocarya* sp.) occurred in the wetland depressions and drainage lines of the western part of the Beenup survey area. Information on the distribution of the new genus must await more extensive botanical surveys in other parts of the region.

4.9.2.4 Impact assessment

Most of the species referred to above occur in the eastern half of Location 4264, as follows, which will be excluded from mining:

- ° Both Gazetted Rare Plants.
- ° Nine of the ten Reserve Flora species.
- ° One of the three Species of Interest.

The remaining species identified occur elsewhere. The extent of distribution of the new genus in other parts of the South west will require detailed botanical surveys similar to that carried out at Beenup.

4.9.2.5 Management measures

The above findings highlight the importance of the eastern half of Location 4264 in providing habitats for many of the plant species that require protection. The area is outside the proposed mining area. The proponent is holding discussions with CALM to develop appropriate management measures.

4.9.3 Dieback

4.9.3.1 Impact assessment

The presence of dieback (*Phytophthora cinnamomi*) has been identified on and off the mining area, where dead and dying plants were collected during the botanical survey. The dieback organism was identified on these specimens by officers from CALM. A detailed survey over the whole area was not carried out. The areas where dieback was identified are:

- ° The south west corner of the mining area.
- ° The north east half of Location 4264, not on the mining area.

It is evident that dieback exists in the area and the following management measures will be carried out to ensure that all appropriate measures are taken in an effort to contain the spread of dieback

4.9.3.2 Management measures

To enable a detailed dieback management plan to be incorporated into the mine management plan, the proponent will carry out a dieback survey over the mining area should approval to proceed be given and before operations commence.

It may be expected that certain basic management measures will be necessary to contain the occurrence of dieback on the mining area and prevent further spread. The proponent therefore undertakes to carry out the following actions:

- (a) The drainage will not be altered after mining. Drainage lines will be reconstituted in positions and flow directions similar to the pre-mining situation.
- (b) Methods for monitoring the presence of the dieback organism in the dredge pond and drainage channels will be researched.
- (c) Washdown facilities will be provided for vehicles moving between dieback affected and dieback free areas.
- (d) To prevent the spread of dieback to other parts of the south west, trucks transporting mineral products from the dry mill to Bunbury will not travel further south than the dry mill, i.e. they will not enter the mining area. These trucks will be loaded from storage bins at the dry mill on raised paved surfaces. They will travel to Bunbury on raised paved surfaces.
- (e) The vehicles of mine workers will be restricted to raised roads and raised parking areas.
- (f) Measures to control and contain any dieback in the areas of native vegetation to be returned after mining will be studied in the early years of mining when the rehabilitation will be largely in the form of pastures.

4.10 TERRESTRIAL VERTEBRATE FAUNA

4.10.1 Impact assessment

Apart from the two declared rare bird species discussed in Section 2.12, none of the birds, mammals, reptiles or amphibians recorded or expected to occur in the

Beenup survey area is rare or restricted. The primary impact of mining on the fauna of the minesite would be the physical removal of particular habitats when these areas are cleared in advance of mining. Cleared land and areas of remnant vegetation which have been severely degraded by grazing of their understorey occupies a major part of the mining area, (75-80%) and development of mining in these relatively depauperate habitats will have a negligible effect on the fauna. Clearing of the larger, ungrazed remnants will have a greater impact, but not to the extent that local and regional vertebrate populations will be placed under threat, as there are similar habitats in adjoining conservation areas, i.e. the National Park and the Camping Reserve.

There may be some short term, localised territorial disruption to fauna populations on the fringes of the Scott National Park and the Camping Reserve, brought about by displacement of more mobile species from the mining area. However, the National Park and Camping Reserve and indeed all other nearby areas of uncleared land, have been subjected to the long term effects of surrounding pastoral clearing and are still in relatively good condition as fauna habitats. The impact on the fauna of the Blocks surrounding the proposed mining area is also judged to be negligible.

Secondary impacts may be caused by such factors as dust and noise, changes in water supply and quality, and disruption of habitat by construction of access roads and other infrastructure.

4.10.2 Management measures

Planning and management programmes will be implemented to minimise the effects of primary impacts and avoid or minimise the effects of secondary impacts. The substantial remnants of native vegetation that presently occur on the mining area will be rehabilitated to native vegetation communities, which will return faunal habitats to these areas. (Refer Rehabilitation Programme - Section 3.1.9). The water courses on the mining area will be reconstituted after mining and the native plant communities presently growing in these areas will be re-established.

The following land management guidelines will be implemented before and during the operation, and afterwards as long as the Company is responsible for the management of the land. This will be until self-sustaining vegetation and faunal habitats are established to the satisfaction of EPA.

- ° Mined land will be rehabilitated in accordance with the programme outlined in Section 3.1.9.
- ° Clearing of native vegetation will be kept to an absolute minimum.

- ° Wherever possible, access roads and easements will follow existing tracks.
- ° An environmental awareness programme will be established for the Company's workforce. All personnel working on the project will be required to observe environmental guidelines both within the minesite and in adjoining areas.
- ° The return of flora and fauna on mined areas will be monitored periodically.

4.11 ARCHAEOLOGY AND ETHNOLOGY

4.11.1 **Impact assessment**

Archaeological and ethnographical investigations have been carried out over the project site and no sites of importance or significance to Aboriginal people were recorded within the boundaries of the project site. The Department of Aboriginal Sites at the Western Australian Museum has advised that should any sites be uncovered in the course of development the Department of Aboriginal Sites should be advised immediately (Appendix IX). There is therefore no impediment to the project proceeding within the terms of the Aboriginal Heritage Act, 1972-1980.

4.11.2 **Management measures**

The proponent agrees that, should any archaeological material be uncovered during the process of earthmoving, the Department of Aboriginal Sites of the Western Australian Museum will be notified, as outlined in the Act.

4.12 ECONOMIC IMPACTS

The economic impact of the development of the Beenup mineral sands project has been examined in terms of contribution to the South West regional economy and to the Augusta-Margaret River Shire economy in those cases where meaningful information has been available.

This analysis has been based on input-output multipliers developed by the W.A. Department of Resources Development in conjunction with the University of Western Australia, and which are specifically applicable to the mineral sands mining industry. It should be understood that the figures which are derived in this manner are not a precise forecast, but rather provide a reasonable indication of the likely economic effects. It should also be noted that the analysis takes no account of likely lead times or lags involved in the multiplier effects working

through the economy. In some cases it may be 1-2 years before the full effects become established.

Thus the multipliers provide order-of-magnitude estimates only. They take no account of slack capacity, and where induced effects are concerned, they tend towards over-estimation rather than underestimation. Consequently, they indicate the maximum level of beneficial impact likely due to flow-on effects.

4.12.1 **Employment effects**

The construction of the project is scheduled to be conducted over an 18-month period commencing in October, 1990. Workforce numbers are expected to peak at 200 workers over the four month period July-October, 1991, with the main bulk of the workforce being on-site during the period May-December, 1991. The build-up and drop-off in workforce numbers during this phase will give rise to abrupt changes in local employment levels.

The level of local employment opportunities generated by this phase will depend on the hiring policy of the contractor undertaking the construction and the availability of the required skills in the Shire labour pool. It is estimated that between 35% and 50% of the construction workforce skills needs could be obtained from the Shire labour pool.

The direct employment and flow-on employment expected to be generated by construction phase expenditure within the South West Region are given in Appendix X. A probable distribution of the employment opportunities between the Augusta-Margaret River Shire and the rest of the South West Region are also given.

The project will directly generate 115 permanent jobs during the operational phase of the project once steady-state production is reached. This is anticipated to occur immediately following plant commissioning in March-April, 1992. As indicated in Section 3, between 40% and 65% of this direct workforce requirement has the potential to be locally recruited given the skills which currently exist in the Shire. The project will provide substantial employment opportunities. It will also provide opportunities for people to move from part to full-time employment, and for people who are "under-employed" to gain full-time employment. It is understood that there is a measure of hidden unemployment in the rural and fishing sectors, and given that persons from such backgrounds usually have the right skills and aptitude to be trained and employed as plant operators, substantial opportunities will be provided for these persons.

Table 4.2 outlines the indirect, flow-on employment expected to be generated by the operational phase. Unlike the construction phase, these flow-on jobs are likely to be permanent in nature for the life of the project. As the table indicates the

consumption-induced jobs (those related to household spending) dominate, indicating a substantial number of jobs are expected to be created in the retail/wholesale and service sectors of the economy.

TABLE 4.2
Operational Phase - Employment Generation Estimates
South West Region

1.	Direct Employment	115	135*
2.	Flow-On Effects :		
	(i) Production-Induced	109	128
	(ii) Consumption-Induced	200	235
	(iii) Total Flow-On	309	363
3.	Total Employment Effect	424	498
4.	Employment Distribution		
	(i) AMR Shire	267	313
	(ii) Other South West Region	157	185

* Economic projections in this ERMP are based on an operational workforce of 115 persons. However latest projections indicate that there may be up to 135 permanent operational employees.

The project will have a significant positive effect on the economic base of the Augusta-Margaret River Shire, through the addition of a new industrial sector. This would, given the cyclical nature of the existing main economic sectors, provide an added support to the economy. Given the 20+ year mine life envisaged, the project will provide stable long-term employment opportunities, and add to career opportunities for some sections of the communities.

The wage levels likely to be offered by construction contractors during the construction-phase of the project are likely to be substantially higher than existing wage levels for comparable jobs within the Shire. This may, in spite of the short term nature of the employment offered, induce a level of labour turnover within the community. During the operational phase, wage levels will be only marginally higher than those available within the community, and this may encourage some turnover, although it is not expected to be substantial. A short-term tightening of the labour market is anticipated.

4.12.2 Output and income effects

Output effects refer to the changes in the value of output (i.e. the value of goods and services) produced by a firm, institution or government, which will be

generated as a result of expenditure on project construction, and by the production of mineral sands during the project's operational phase. The income effects refer to the impact of the project's construction and operation on household income in the economies identified.

The wage bill associated with construction and operation of the project will add to the economic well-being of the Shire and region. Direct wage payments during the construction phase are expected to total \$4.78M; and during the project's operational phase to be \$4.60 million annually (\$1989). In addition to the direct workforce wages payments, the flow-on income effects are expected to total \$12.43M over the construction period, and be \$6.058M annually during the operational phase within the South West Region. Table 4.3 details the expected household income effects.

TABLE 4.3

Household Income Generation
South West Region (\$1989)

	Total Construction Phase	Operational Phase (Annual)
Initial Stimulus	\$ 4.78M	\$ 4.660M
Production Induced Effects	\$ 6.93M	\$ 2.796M
Consumption Induced Effects	\$ 5.50M	\$ 3.262M
Total Flow-On Effects	\$12.42M	\$ 6.058M
Total Impact	\$17.21M	\$10.718M

As a result of linkages between the project and other industries during both the construction and operational phases, the project will generate benefits with respect to the value of output in other sectors of the economy.

The construction phase of the project will involve the expenditure of some \$104 million with some 25% of this being spent in the Augusta-Margaret River Shire, and an additional 12% elsewhere in the South West Region. In total, some 48% of project construction expenditure will occur in western Australia. Annual operating phase value of output is expected to average \$50.0 million (Australian dollars).

Table 4.4 details the expected output effects in the South West Region resulting from this regional expenditure.

TABLE 4.4

Output Effects
South West Region (\$1989)

		Total Construction Phase	Operational Phase (Annual)
Initial	Stimulus	\$ 39.14M	\$ 50.0M
Production-Induced Effects		\$ 24.66M	\$ 19.5M
Consumption-Induced Effects		\$ 16.83M	\$ 23.0M
Total Flow-On Effects		\$ 41.49M	\$ 42.5M
Total Output Effect		\$ 80.63M	\$ 92.5M

4.12.3 Effect on Government revenues

Both the construction and operational project phases will provide revenues for the Federal and State Governments.

Federal Government revenues will be derived principally from Company taxes and income taxes. Company tax will be paid at the appropriate level as determined by the Commissioner of Taxation. Income taxes will be paid from wages and salaries of the project's workforce during both project phases. Income taxes are likely to total approximately \$1.86M for the construction phase, and \$1.45M annually for the operational phase.

State Government Revenue will mainly comprise payroll tax payments, royalties, and revenues relating to services provided by semi-Government authorities such as the State Electricity Commission. It is estimated that mining royalties, payroll tax, fuel tax, and other revenues to the State Government will be in the order of \$7.05M per annum.

4.12.4 Effect on Shire finances

4.12.4.1 Impact assessment

The existing status of the Augusta-Margaret River Shire finances is discussed in Section 2.3. The advent of the proposed project and the growth in population which it will generate will place additional demands upon the Shire in terms of the provision or augmentation of facilities to service the needs of incoming population, and the maintenance and upgrading of roads used by the mine workforce and product transport. This will necessitate the Shire undertaking some

major investments to accommodate this growth. The ability of the Shire to finance a major increase in spending solely through rates revenue is doubtful.

It is desirable to have facilities in place prior to the population influx, so that potential social impacts arising from the lack of facilities are negated. This can pose an additional funding problem in that capital expenditures need to be made and debts serviced prior to the time when additional rate revenue to help fund the debt can be collected. A substantial burden is thus placed upon the existing ratepayers to fund the financing gap.

It is understood that the ongoing maintenance costs of the roads constituting the product transport route will be subject to an agreement to be negotiated by the parties concerned.

The mining company will also be required to pay rates to the Shire, in the same manner as other persons living and/or operating a business in the Shire. Whilst the rating formula to apply to the mine has yet to be determined, it is estimated that rates will be adequate to cover such items as the mine's share of maintenance to local roads used by the mine's workforce.

4.12.4.2 Management measures

The proponent is having discussions with the Shire to assess the extent of impact on the Shire, and management measures needed to compensate for any adverse impact.

4.12.5 Impact on tourism

Substantial concern has been expressed by residents and tourist operators that the project's operations will have a negative impact on the tourist industry. However experience in the Eastern States indicates that these fears are groundless. Heavy mineral mining operations have co-existed with tourist and recreational activities for decades, some prime examples being North Stradbroke Island in Queensland and the Myall Lakes area in New South Wales.

It has been found that:

- ° There has been no loss of amenity in these areas.
- ° Conflict between tourist traffic and mine traffic is negligible.
- ° The permanent mine workers are responsible members of the local communities and mix socially with holidaymakers and tourists.

Given the location of the project, in an area of the Augusta-Margaret River Shire which is not part of the normal tourist route, it is unlikely that project site operations will be a problem in this regard. They will be so located as to be hidden from view from major tourist roads, attractions, and tourist centres such as Augusta. The mining operation, however, may be encountered by the recreationalist or fisherman seeking to gain access to the wetlands and coastline of Flinders Bay, or Swan Lake at East Augusta, for example.

It is unlikely that the miners as a relatively small group in the community, will conflict with tourists and holiday makers any more so than other sectors of the community. During the tourist season, tourists in numerical terms far outweigh the local resident population.

It is possible that the mining operation may become a tourist attraction in its own right as has happened elsewhere in Australia, where public interest has been such that mining companies have instigated information tours and the like.

4.12.6 **Product transport effects**

Management of the Sabina Road - Capel transport route for the transport of product to Bunbury will be the responsibility of the Main Roads Department. This route has several economic advantages. Whilst data are not available to quantify these benefits in dollar terms, it is believed that they will be substantial in the long term.

The establishment of a new, all weather road access into the Augusta-Margaret River Shire using Sues Road as the key link, will enable people to travel more directly between the southern part of the Shire and Capel and centres to the north. This could have product transport cost advantages for all goods and services being moved by road.

The establishment of such a road link also provides an opportunity for the establishment of a specific heavy-haulage route into the Shire. By making it attractive for heavy traffic to use this route, the heavy traffic load on the other main access routes (the Bussell, Vasse and Brockman Highways) could be reduced. As these other main access routes are also important tourist roads, this would serve to lessen conflict with this traffic, as well as local traffic.

In terms of regional road planning and economics, the heavy-haulage route concept has merit in that the Beenup route could also service the Jangardup mine.

4.12.7 Balance of payments effects

The proposed project's operations will make a positive contribution to the country's export income to the extent of an average of \$50 million (\$1989) per year during the operating phase. No importation of goods is required during this phase. During the project's construction goods to the value of \$20 million will be imported. Hence the balance of payments effects will be positive, with the initial negative effect being overcome by revenues during the first year of the project's operation.

4.12.8 Agricultural production

The development of the mining project is not expected to lead to major changes in livestock numbers carried in the district. MDL has purchased some 937.3 ha of land from the farming community for its mining operation. The land is currently being leased back to the farmers for continuing agricultural production. It is envisaged that a proportion of this land will be available for agricultural use during the term of the mining operation. It is planned that a major part of the mined land will be restored to pasture for grazing by sheep and cattle after mining. The inclusion of slimes into the topsoil is expected to have a beneficial impact on the soil, resulting in increased production and lower fertiliser requirement through reduction of leaching losses.

4.13 SOCIAL IMPACT ASSESSMENT

This Section outlines the principal social impacts likely to arise as an outcome of the project's implementation. The form and magnitude of these effects are directly related to the size of the incoming workforce, the demographic characteristics of this workforce (and their families) and the existing social order within the Shire.

It is important to note when examining these matters that the Augusta-Margaret River Shire is currently undergoing substantial population growth due to the increasing importance of tourism, and the attraction of retirees and alternative lifestyle persons to the Shire. This growth has already initiated substantial change within the community, and if current population growth projections are realised, it will continue to do so well into the future. The advent of the proposed mining project will inject a number of newcomers into the Shire in a relatively short time span (approximately 2 years). It is the timing of this population injection which makes the project generated growth stand apart from the population growth trend evident in the Shire today.

4.13.1 Population generation estimates

This section examines the population likely to be generated within the Augusta-Margaret River Shire, where the effects are likely to be most significant. It should be noted that the estimates outlined here are indicative only, as it is not possible to accurately predict the labour market conditions and demographic characteristics of any newcomer population. The estimates contained here are based on characteristics exhibited by similar workforces in other mining projects in Australia.

4.13.1.1 Peak construction phase - Population

In developing these estimates it has been assumed that local recruitment will be 35% and that the incoming "newcomer" project workforce will total 130 persons out of a total of 200. It is also assumed that this level of local recruitment will take up 50% of the labour available locally, such that most of the flow-on employment opportunities will require persons to come into the Shire to take up the jobs created. It should be noted that this is a conservative approach and hence represents the maximum impact situation.

The estimated newcomer population profile is likely to comprise:

TABLE 4.5

Estimated Newcomer Population Profile - Construction Phase

Category	Numbers
Direct Project Workforce Component :	
newcomer workforce	= 130
family units	= 32
single person	= 98
direct population	= 239
children (kindergarten /preschool age)	= 9
children (primary school age)	= 32
children (secondary school age)	= 19

TABLE 4.5 (continued)

Estimated Newcomer Population Profile - Construction Phase

Category	Numbers
Flow-On Workforce Component :	
newcomer workforce	= 281
family units	= 120
single persons	= 99
direct population	= 454
children (kindergarten /preschool age)	= 21
children (primary school age)	= 73
children (secondary school age)	= 43

4.13.1.2 Operational phase population

During the operational phase, once a steady state production situation is reached, the project will employ 115 workers. This situation will apply from March-April 1992 onwards for the life of the mining operation as currently proposed.

The estimated newcomer population profile is given below for two cases - Case A for 65% local recruitment and Case B for 40% local recruitment :

TABLE 4.6

Estimated Newcomer Population Profile - Operational Phase

Category	Numbers	
	Case A (65%)	Case B (40%)
Direct Project Workforce Component		
newcomer workforce	40	69
family units	28	49
single persons	10	17
direct population	98	171

TABLE 4.6 (continued)

Estimated Newcomer Population Profile - Operational Phase

Category	Numbers	
	Case A (65%)	Case B (40%)
children (kindergarten/ preschool age)	5	9
children (primary school age)	18	31
children (secondary school age)	11	18
Flow-On Workforce Component		
newcomer workforce	80	95
family units	35	41
single persons	28	33
direct population	151	177
children (kindergarten/ preschool age)	6	7
children (primary school age)	22	26
children (secondary school age)	13	16

4.13.2 Housing provision

4.13.2.1 Project housing - Construction phase

During the construction phase of the project, it is intended that single status persons be accommodated in the on-site construction camp (Section 3.5.1). Hence, no external accommodation requirement will arise for this component. The married direct peak workforce component is expected to comprise 32 family units. These will be accommodated in a Company caravan park planned at Alexandra Bridge, which will eventually be handed over to the Shire Council for community use.

4.13.2.2 Project housing - Operational phase

Operational phase direct housing demand is expected to comprise 69 family dwellings and 11 x 2 BR units or flats for the single workers. Flow-on demand is expected to total 41 family dwellings and 22 x 2 BR flats or units.

As it is company policy for all workers to find their own accommodation during this phase, the appropriate housing for both the direct and flow-on workforces will be sought on the local market. It is probable that this demand will be concentrated in the two urban centres of Augusta and Margaret River, although a percentage of the incoming population is expected to seek housing elsewhere in the Shire to satisfy their lifestyle goals.

4.13.2.3 Impact assessment

The demand for accommodation for the married component of the construction workforce and the associated flow-on workforce will take the form of demand for temporary accommodation facilities. It is expected a majority will be seeking caravan park facilities, although rental houses and flats will also be sought especially by the flow-on population. The accommodation required is short-term in nature with the heaviest demand falling over a four month period from July to October, 1991.

Neither Margaret River nor Augusta has the ability at present to satisfy the likely demand for rental houses or flats, although both centres would have sufficient caravan park accommodation at that time of year to service likely demands. The demand is likely to be greatest in Augusta as it is the closest urban centre to the project site.

The operational phase demand is for long term, permanent accommodation totalling 110 dwellings and approximately 33 x 2 BR flats or units. This accommodation needs to be available in the first two months of 1992. It is estimated that the baseline population growth will require the provision of approximately 286 housing/accommodation units during the period 1989 to 1992. Added to this will be the project-related demand for 143 units. In terms of allotments, this equates to approximately 389 lots of which 15 would be unit sites.

When this demand is compared to the land availability situation, it would appear that the supply situation in Margaret River should meet the demand but in Augusta there may be a supply problem.

If a tight housing supply/demand situation continues in the Shire and current growth trends suggest this will occur, the added demand of the project could lead to an escalation of house/land prices. There is a need to ensure a small oversupply of both housing and land to maintain reasonable price levels.

4.13.2.4 Management measures

The primary means of alleviating any accommodation shortage is to instigate measures which will ensure that adequate serviced land and housing are available to meet the demand when it occurs. In this situation, the timing and magnitude

of the demand can be forecast with reasonable certainty. Once approval for the project is granted, ways in which the demand can be met will be investigated by the proponent in consultation with the Shire.

4.13.3 **Infrastructure provision**

The water supply and sewerage systems at Augusta will need to be upgraded to cater for the expected growth in population arising from both trend growth and the proposed project. Given the timing of the project, this is a matter which will require immediate attention if local serviced allotment demand is to be met. Consideration should also be given to extending Margaret River's sewerage system and to bring forward the completion date of the 10 Mile Brook water supply reservoir.

Telephone and electricity services are currently available in those localities likely to experience growth. As with the other utility services, foreknowledge and forward planning will ensure that both services can be provided when required to meet the needs of the incoming population.

4.13.4 **Product transportation**

The likely impacts associated with the transport of the product from Beenup to Bunbury, and management measures that are planned, are discussed in Section 4.3.

4.13.5 **Social infrastructure**

The newcomer population generated by the project is expected to comprise a mixture of young single persons and families in the young and middle life cycle stages. Typically, the community services needs for the young single, independent population are sporting and social facilities which cater for the young adult age group. The young family requires access to child health centres, family planning services, playgroups, childcare and pre-school centres, and a variety of information services relating to social welfare matters in particular. The middle family also places demands upon the general practitioners and other health and welfare services with a greater, regular use being made of dental facilities. In addition, education services, clinical guidance and counselling are often required, and library services are very much in demand.

The growth in permanent population attributable to the project is expected to account for approximately 42% of the Shire's overall resident population growth in the period 1989-92. After 1992, the project makes no further contribution to the population growth.

4.13.5.1 Education facilities

Project-related demand for school places is expected to be as follows:

TABLE 4.7

Project-related demand for school places

Type of school	Numbers	
	Construction Phase (Peak)	Operational Phase
Kindergarten/Pre-School	30	16
Primary School	105	57
Secondary School	62	34

This demand, coupled with that originating from trend growth, will necessitate an increase in the capacity of all three levels of educational provision in the Shire. As discussed, all schools have very little spare classroom capacity and most are in need of additional administrative and teacher preparation space at the present time. Measures will need to be put in place to not only cater for the short-term peak occurring in the second half of 1991, but to provide for the ongoing teaching needs of the permanent project population.

4.13.5.2 Medical facilities

The Shire's medical facilities are considered adequate to cater for the needs of the incoming workforce. The medical facility nearest to the Beenup project is located in Augusta. In emergency situations, the fastest route to this hospital would be via Scott River Road and East Augusta. Emergency procedures will be established to ensure quick access to medical facilities.

4.13.5.3 Recreational and Civic facilities

The Shire possesses a substantial range of both civic and recreational facilities, sufficient to cater for most community needs. The three items identified as being needed in the community were a Shire swimming pool, a community hall at Augusta, and a permanent police presence in Augusta. With the advent of the project, weight would be added to the demand for such facilities and services.

4.13.5.4 Social support facilities and services

The main social support services required for any population are access to legal aid; drug and alcohol rehabilitation; information services; community centres; neighbourhood houses; family financial, youth, marriage, personal and sex counselling; and sex, life skills and pre-marriage education.

As detailed in Appendix X the Shire contains the basis on which to build an effective social support system. The services provided, the community centre and the mobile counselling service cover most aspects to varying degrees. It is envisaged that as the Shire's population grows these services will need to be expanded in depth and scope.

4.13.5.5 Commercial facilities

The commercial facilities in the Shire are sufficient to cater for most convenience shopping needs. Comparison shopping opportunities will increase as the population grows and can support such facilities.

4.13.6 Social adjustment

The development of the proposed mine will generate some inevitable social adjustments within the community. The effects occasioned by population influx will tend to alter existing social networks as well as individual attitudes.

4.13.6.1 Construction phase

(a) Impact assessment

The existing pace and nature of life in Augusta, and to a lesser extent in Margaret River, may undergo some change during the construction phase. The peak construction related population will represent approximately 10% of the Shire's population, whereas the direct component of this population will represent some 240 persons or 130 newcomer workers. A proportion of this population is expected to locate in and around Augusta.

Social adjustment during the construction phase is anticipated to be similar to the seasonal influx of tourists. It can be expected that a proportion of the newcomer construction workers will have little or no interest in identifying with the Shire's communities, and little understanding of the behavioural standards and attitudes which prevail in the Shire. The incidence of social adjustment effects will also depend upon the attitudes of the local population towards change. Given the local acceptance of the seasonal tourist influx in Augusta and Margaret River, it would be reasonable to expect the local population to accept a degree of change.

(b) Management measures

Some solutions to these above social problems are available. Measures which may assist in lessening problems include :

- ° Employment of local persons where practical.
- ° provision of sufficient and adequate accommodation (in particular rental accommodation).
- ° encouragement of interaction between the local population and the construction population through specially arranged social and sporting activities.
- ° adequate locally-based welfare resources to cope with both emotional and practical problems.

4.13.6.2 Operational phase

(a) Impact assessment

The production phase will require social adjustments similar to those mentioned above for the construction phase situation. It is probable that some persons who come for the project construction will remain and gain employment in the project's operation.

Amongst the newcomer permanent population it may be expected that non-working women will experience the most difficulties in adjusting to a new life in a new location. Those in the workforce and children have socialising opportunities, whereas women who do not work may feel isolated and lonely in their new environment. Dislocation from established networks of family, friends and familiar environments is often central to the problem. Other problems faced by newcomers may also include lack of information about community services and support systems such as baby-sitting and the like.

Difficulties which may be faced by the existing Shire population may include difficulty adapting to different values, beliefs and behaviour patterns that newcomers may bring (although given the community's exposure to change over recent years this should not be a major new problem); a real or apparent loss of the "small town atmosphere" and suspicion or resentment of the abilities and talents of new residents which are apparent through their involvement in community or sporting organisations.

(b) Management measures

Some general measures which may assist the social adjustment problems discussed above include :

- ° Employment of local persons where practical.
- ° Timely provision of facilities and services needed by the incoming population.
- ° The establishment of a new residents information kit providing advice about access to services, etc.
- ° The provision of neighbourhood or community houses in appropriate locations.
- ° Concerted efforts by existing clubs and organisations to attract new members.
- ° Specially-organised activities to encourage social interactions.

As indicated earlier in this report, effective local authority management based on cooperation and coordination with community groups, government departments and services, and the project management, will greatly assist in accommodating and integrating the new population in a manner which is least disruptive to the existing community.

Conclusions

5.0 CONCLUSIONS

The Beenup deposit contains 20 million tonnes of heavy minerals which will support a major mining operation for in excess of 20 years. The operation will make a substantial contribution to the economic well being of the Shire, the State and the Nation. The generation of household income, including flow-on effects, will total \$17.21M for the construction phase and \$10.718M (\$1989) annually for the operational phase. Project expenditures including flow-on effects will total \$80.63M for the construction phase and \$92.5M (\$1989) annually for the operational phase. Both the construction and operational phases will provide revenues for the State and Federal governments. State government revenues will be in the order of \$7.05M annually. The value of additions to the State's infrastructure will exceed a total of \$20M (\$1989). The project will contribute an average of \$50M (\$1989) annually to the country's export income.

Employment during the 18 month construction phase will peak at 200 persons. Permanent operational employment has been calculated to be 115 persons, with a flow-on effect of 309; however the number of permanent operational employees is now expected to reach 135 persons.

These economic benefits will be achieved at minimal cost to the environment. The proposed mining method does not use any chemicals and produces no toxic wastes, and the mined land will be returned to its pre-mining land use when rehabilitation is completed.

The main environmental issues that were identified are associated with transport, hydrology, native vegetation, rehabilitation, dieback and social issues. Each of these issues has been addressed in detail throughout the ERMP. Stringent environmental management commitments will be adopted by the proponent to ensure that any adverse effects are either avoided or minimised.

The rate of mining, as proposed in this document, cannot be increased without further major capital expenditure and would require a further submission to the EPA. The proponent is not considering secondary processing anywhere in Western Australia at this stage due to prevailing economic conditions and the fact that new technology that is available elsewhere in the world is not for sale and has extremely high power consumption. The ilmenite produced at Beenup is not suitable for synthetic rutile feed.

Summary of
Environmental
Management
Commitments

6.0 **SUMMARY OF ENVIRONMENTAL MANAGEMENT COMMITMENTS**

If approval for the project is granted, the proponent will carry out the following actions before, during and after the proposed operation, according to the particular requirements of each commitment, to the satisfaction of the EPA.

6.1 **CONSTRUCTION PHASE**

6.1.1 **Accommodation for temporary workforce**

During the peak construction period, temporary single persons quarters, recreation facilities and messing facilities will be provided adjacent to the dry mill site. Accommodation for married personnel will be provided via existing commercial caravan parks and, subject to Shire Council agreement, at a caravan park to be constructed at the old Bullers Mill site adjacent to the Alexandra Bridge. This caravan park will be handed over to the Shire Council at the conclusion of the construction phase for management as a community facility.

6.2 **MINING**

6.2.1 **Environmental awareness**

An environmental awareness programme will be established for the Company's workforce. All personnel working on the project will be required to observe environmental guidelines both within the minesite and in adjoining areas.

6.2.2 **Groundwater**

The mining operation will be designed to avoid substantial drawdown of the water table; if water table drawdown does occur during the summer months, it will be minor and confined to the immediate locality of the dredge pond. During summer, if required, makeup water will be supplied to the dredge pond from several bores in the Lesueur Formation at a depth of 150 to 200 m.

6.2.3 **Surface water**

Existing surface drainage channels that are encountered by the mining operation will be temporarily diverted around the dredge pond. These channels will be established at least 12 months prior to requirement, to enable vegetation to regenerate and stabilise. Silt traps will be constructed on major drainage channels, downstream of the mining operation. Where practical, water from the slimes dam

will be decanted and returned to the dredge pond. Providing turbidity is at an acceptable level, excess decant water from the slimes dam will be discharged into existing drainage channels (during the winter wet season).

6.2.4 **Slimes disposal**

Slimes will be directed to settling ponds for disposal after they have dried. A portion of the slimes will be incorporated into the topsoil destined for pasture areas and the remainder will be incorporated into the tailings near the surface.

6.2.5 **Minimisation of disturbance**

Clearing of native vegetation will be kept to an absolute minimum. Wherever possible, access roads and easements will follow existing tracks.

6.2.6 **Site preparation**

The treatment of vegetation and soil on land in advance of mining will be as described in Section 3.1.9.2 of this ERMP.

6.2.7 **Aboriginal artefacts**

Should any archaeological material be uncovered during the process of earth moving, the Department of Aboriginal Sites of the Western Australian Museum will be immediately notified.

6.2.8 **Dust control**

The generation of dust from areas such as topsoil, tailings, concentrate heaps and haul roads will be controlled as necessary by the control measures detailed in Section 4.7.2 of this ERMP.

6.2.9 **Flora and vegetation of conservation value**

The eastern half of Location 4264 will be excluded from mining.

6.3 **REHABILITATION**

The type of vegetation to be returned to the mined area will be as drawn up after consideration of the recommendations by the final land use Work Party and the Community Consultative Group viz:

- (a) 72% agriculture, including possible community purposes, eg. a commercial tree crop.

- (b) 13% rehabilitation of the main remnants of native vegetation back to native vegetation.
- (c) 11% planting of native plants along major water courses, to assist in stabilising the soil and absorbing fertiliser nutrients leached from farming activities.
- (d) 4% planting of a buffer zone of native tree and understorey species along the southern boundary, adjacent to the Scott National Park.

Rehabilitation procedures will be as listed in Section 4.2.2.

6.4 MINERAL PROCESSING

6.4.1 Water supply

The water supply for the dry mill will be obtained from two bores in the Lesueur Formation at a depth of 150 to 200 m, which will not affect the water table nearer the surface. Much of the water in the plant will be recycled and the discharge of excess water is not planned. As a precaution, a silt trap will be constructed downstream of the settling dam.

6.4.2 Waste disposal

Sand and other waste products which are removed from the concentrate in the mineral processing will be returned to the minesite for disposal. The disposal of other wastes such as garbage and workshop waste will be disposed of at an approved disposal area within the Shire.

6.4.3 Visual amenity

The dry mill and office will be screened from the road by plantings of indigenous trees and shrubs.

6.5 TRANSPORT OF MINERAL PRODUCT

6.5.1 Transport route

The selection of the preferred transport route, the upgrading of parts of this route as required and the conditions under which the mineral product will be transported will be as described in Section 4.3.2 of this ERMP.

6.5.2 **Noise mitigation**

Noise levels at the intersection of Scott River Road and Brockman Highway will be reduced to acceptable levels if necessary by the use of measures outlined in Section 4.8.3 of this ERMP.

6.6 **CONTROL OF THE SPREAD OF DIEBACK**

6.6.1 **Dieback survey**

To enable a dieback management plan to be incorporated into the mine management plan, a detailed dieback survey will be carried out over the entire mining area, after approval to proceed is granted and before operations commence.

6.6.2 **Drainage**

The drainage on the mining area will not be altered after mining. Existing drainage lines will be reconstituted after mining in positions and flow directions similar to the pre-mining situation.

6.6.3 **Control measures**

Vehicles moving from infected to uninfected areas will be washed down. Trucks transporting mineral products from the dry mill to Bunbury will not travel further south than the dry mill. The access of vehicles of mine workers to the mining area will be restricted to raised gravel surfaced roads and raised gravel parking areas.

6.6.4 **Further studies**

Measures to control and contain any dieback in native vegetation areas to be returned after mining, will be studied in the early years of mining, when the rehabilitation will be largely in the form of pastures.

6.7 **AUDIT OF GREENHOUSE GASES**

Commitments to reduce the emission of greenhouse gases to as low as practical will be as outlined in Section 4.5 of this ERMP.

6.8 MONITORING

Monitoring will be undertaken in the following areas and the results reported as appropriate to the Department of Mines, the Department of Conservation and Land Management and the Environmental Protection Authority. The results from various monitoring programmes will be reviewed regularly in relation to the appropriate management programme and the management programme will be modified as necessary.

6.8.1 Groundwater

The number of bores being monitored will be increased and during the initial years, these bores will be monitored on a weekly basis.

6.8.2 Surface water

Monitoring of the water quality of the Blackwood and Scott Rivers will continue on a regular basis. The major drainage channels on and leaving the mining area will also be monitored regularly.

6.8.3 Flora and vegetation

A buffer strip within the Scott National Park, in that section where the Park is contiguous with the mining area, will be botanically surveyed before mining commences and monitored annually thereafter.

6.8.4 Rehabilitation

The progress of rehabilitating areas will be monitored regularly and reported annually.

6.8.5 Dieback

Methods for monitoring the presence of the dieback organism in the dredge pond and drainage channels will be researched. Other parts of the mining area will be monitored for dieback as required, dependent on the results of the dieback survey. The buffer strip referred to in Section 6.7.3 will also be monitored for the presence of dieback.

6.9 ECONOMIC

6.9.1 **Employment**

The proponent will advertise all permanent positions in the local newspaper, in keeping with the policy of employing suitably qualified local residents where possible.

Electrical and mechanical apprenticeships offered by the proponent will be available for suitable local school-leavers.

Where competitive with alternative suppliers, local business activities will be supported.

The proponent is an equal opportunity employer.

6.9.2 **Infrastructure**

The capital cost of infrastructure for the project will be borne by the proponent, in conjunction with other major users of the infrastructure facilities.

Upon obtaining approval for the project, agreement will be reached with the Shire to ensure that the Shire is not financially disadvantaged by the project.

6.9.3 **Agricultural production**

Areas of the pastoral land (937.3 ha), currently owned by MDL, that are not committed to the mining operation, will remain available for agricultural production. Post mining areas of rehabilitated pasture will be made available for agricultural use as soon as is practical.

6.9.4 **Tourism**

The potential for tours of the operation will be investigated in conjunction with the Augusta-Margaret River Tourist Bureau. Any funds generated from the tours will be for the benefit of the Tourist Bureau or local charities.

6.10 SOCIAL

6.10.1 **Workforce**

Suitably qualified local residents will be employed where possible. This will provide direct interaction between existing residents and employees new to the area. The

proponent will provide the necessary training for plant operators, rather than rely on obtaining personnel who already have the appropriate work skills.

6.10.2 **Accommodation**

During the construction phase, single person's quarters will be provided on site to minimise pressure on existing rental accommodation.

The viability of constructing a caravan park for use by married persons during the construction phase, and then handing the management of the facility over to the Shire Council, will be further investigated.

Consultation with the Shire and the Beenup Consultative Group will continue, to determine means of minimising the impact of the incoming construction and permanent operational workforce on existing housing.

6.10.3 **Social infrastructure**

The need for additional social facilities to meet current population growth and the increase in population due to the project will be investigated in conjunction with the Shire Council and the Beenup Consultative Group.

It is hoped that the Beenup Consultative Group will play an active role in assisting newcomers to assimilate to their new environment.

MDL personnel currently involved in consultation with the community will continue to be involved through the construction phase and into the operational phase, to maintain continuity of the consultative process.

Figures



PERTH
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BEENUP PROJECT

INDIAN
OCEAN

MANDURAH

PINJARRA

DALE

PRESTON

BUNBURY

CAPE
NATURALISTE

BUSSELTON

CAPEL
SHIRE

DONNYBROOK

BUSSELTON SHIRE

VASSE

MARGARET
RIVER

AUGUSTA -
MARGARET RIVER
SHIRE

Blackwood

NANNUP

BRIDGETOWN

BLACKWOOD

NANNUP SHIRE

MANJIMUP

CAPE
LEEWIN

Scott. R.

AUGUSTA

**BEENUP
PROJECT**



SOUTH WEST STATISTICAL BOUNDARY



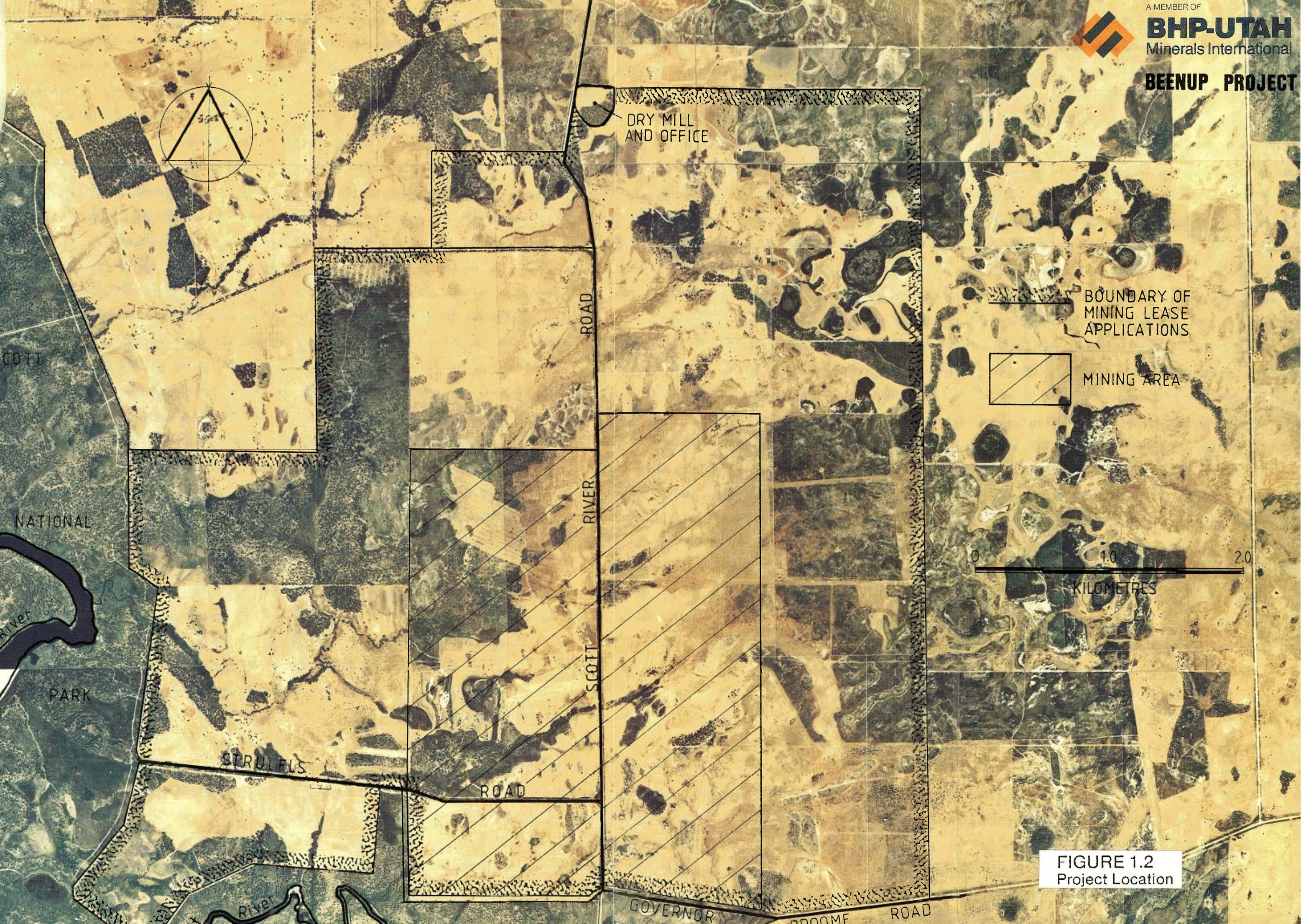
STATISTICAL SUBDIVISION BOUNDARIES — E.G. VASSE



LOCAL AUTHORITY BOUNDARIES

POINT
D'ENTRECASTEAUX

FIGURE 1.1
Location Map



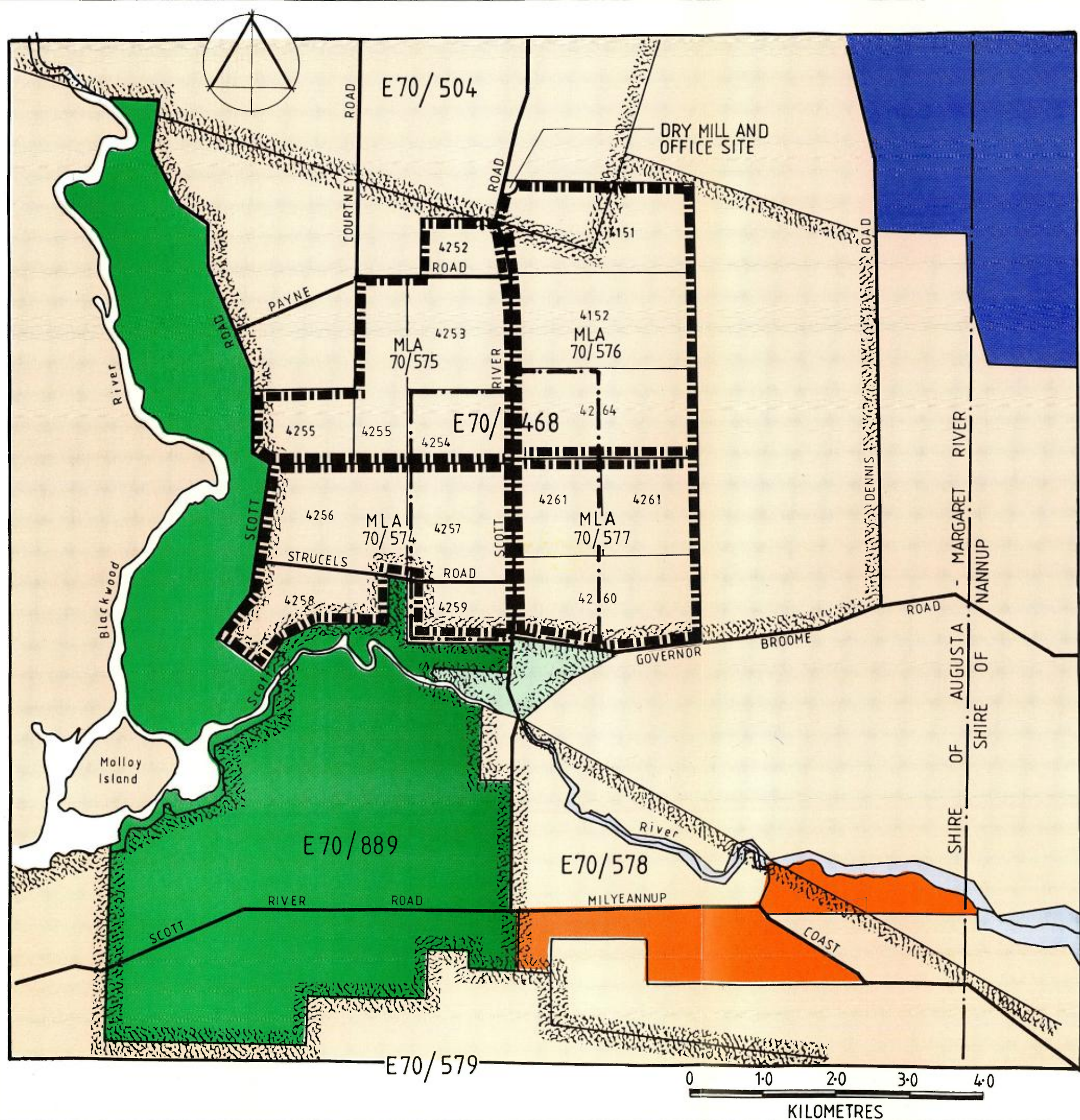
BOUNDARY OF
MINING LEASE
APPLICATIONS



MINING AREA

0 1.0 2.0
KILOMETRES

FIGURE 1.2
Project Location



- PRIVATELY OWNED LAND
- SCOTT NATIONAL PARK
- CAMPING RESERVE 12951
- STATE FOREST
- PASTORAL LEASE
- VACANT CROWN LAND
- BOUNDARY OF EXPLORATION LICENCE
- BOUNDARY OF MINING LEASE APPLICATION
- BOUNDARY OF PROPOSED MINING AREA

FIGURE 2.1
 Land Tenures

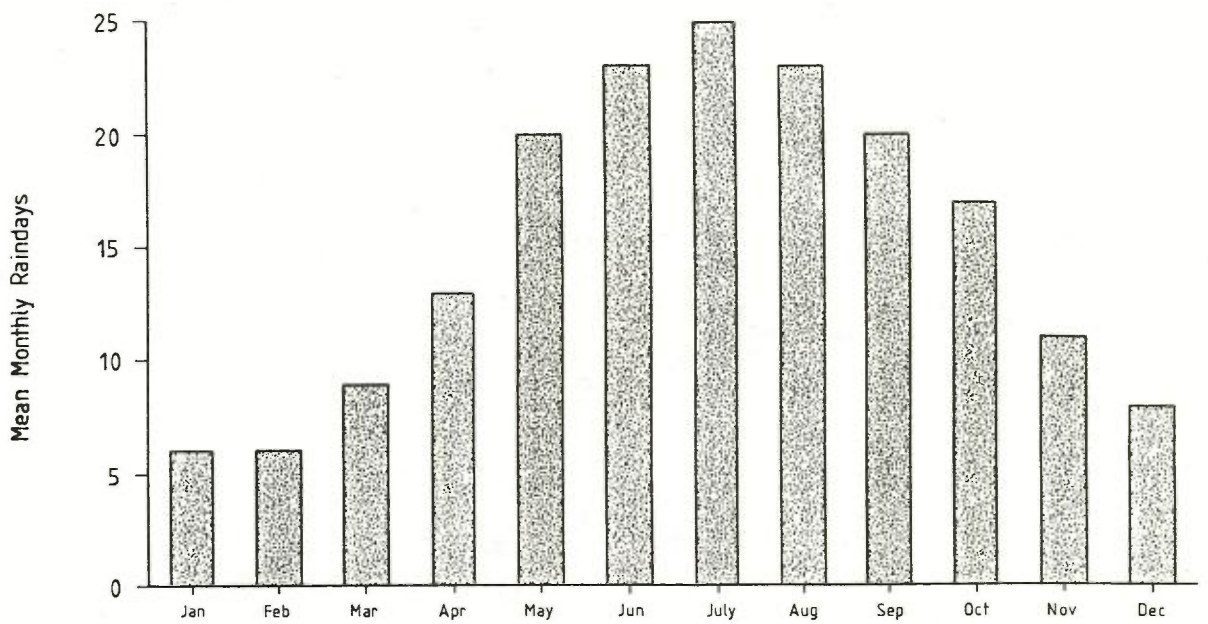
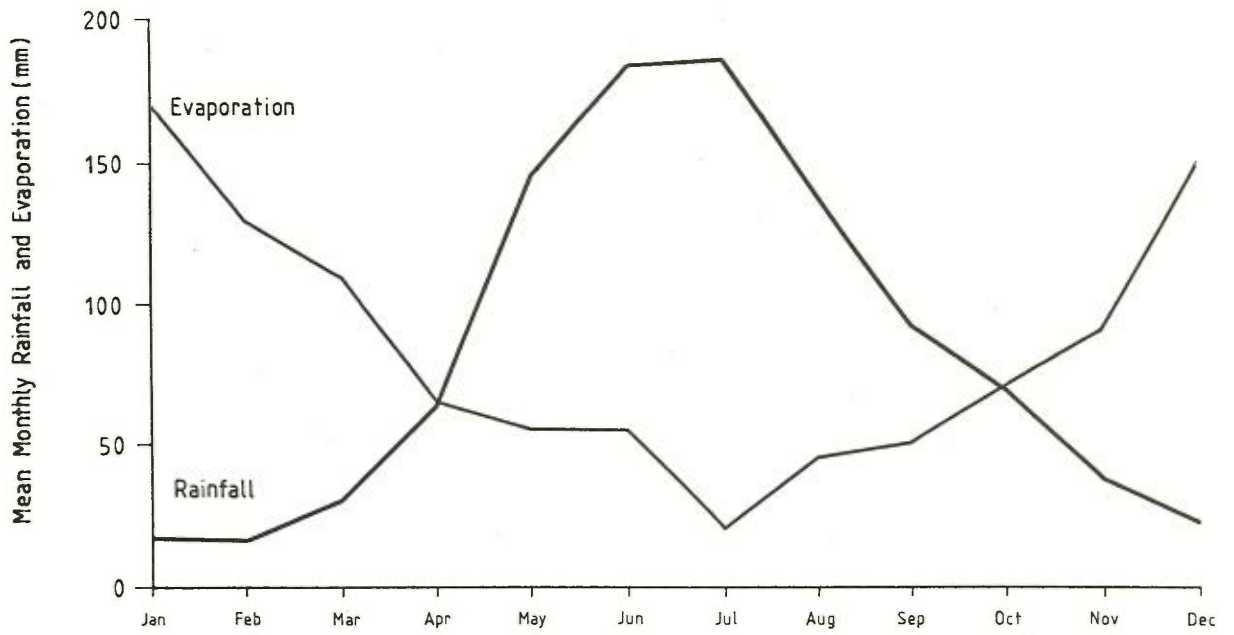
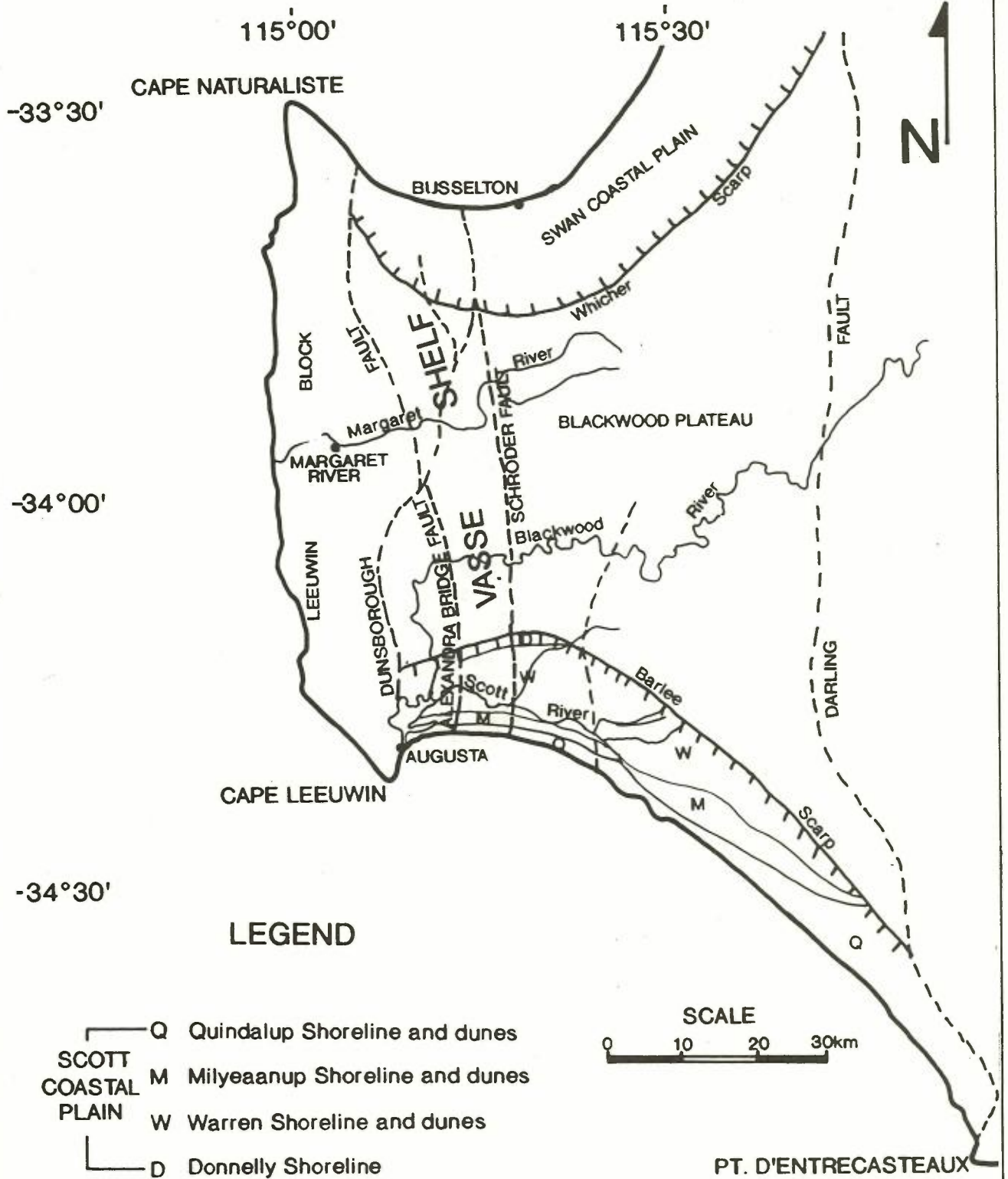


FIGURE 2.2
 Rainfall and Evaporation, Augusta



BEENUP PROJECT



LEGEND

- Q Quindalup Shoreline and dunes
- SCOTT COASTAL PLAIN M Milyeaanup Shoreline and dunes
- W Warren Shoreline and dunes
- D Donnelly Shoreline

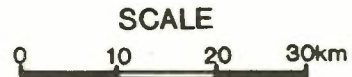
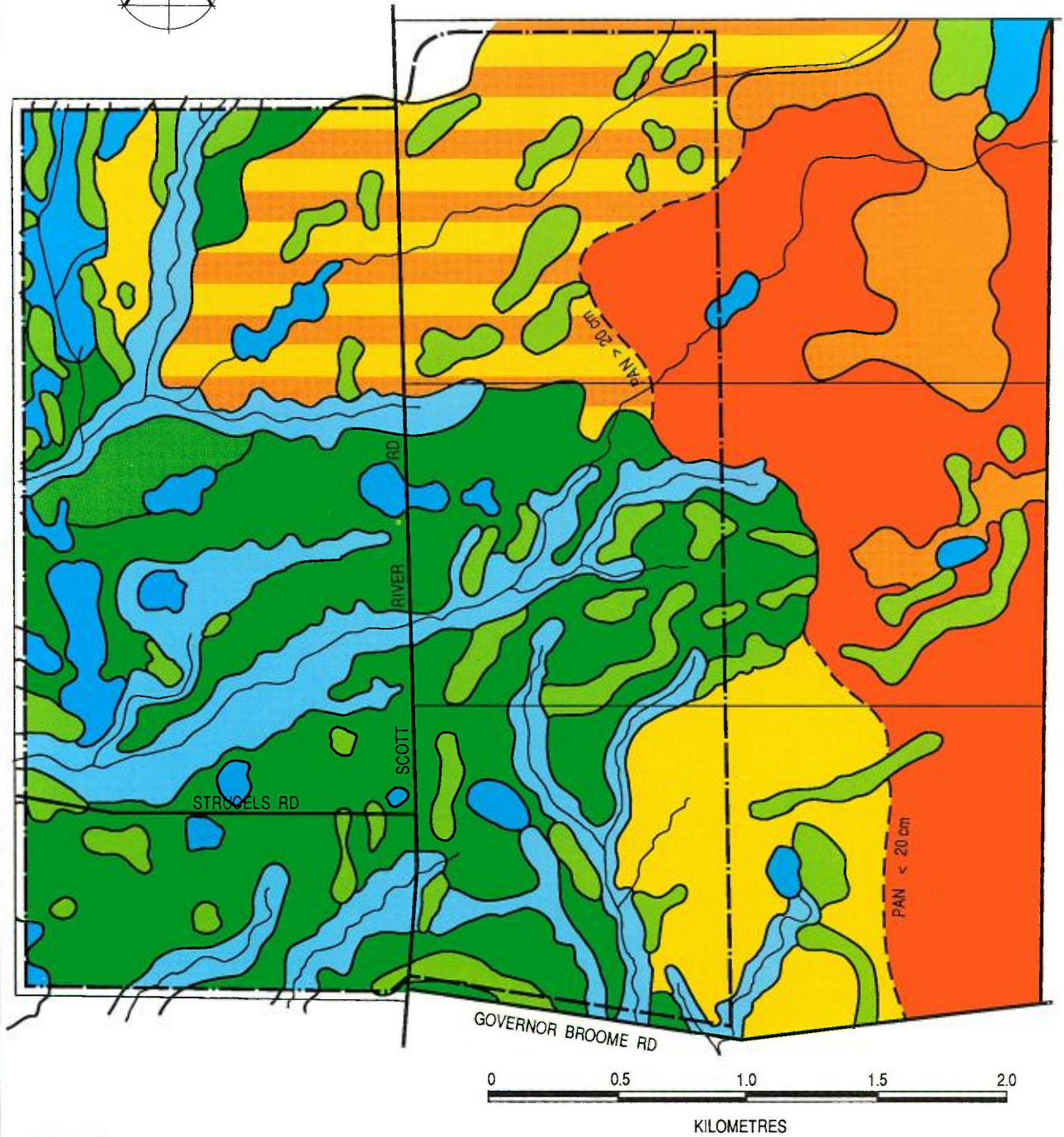
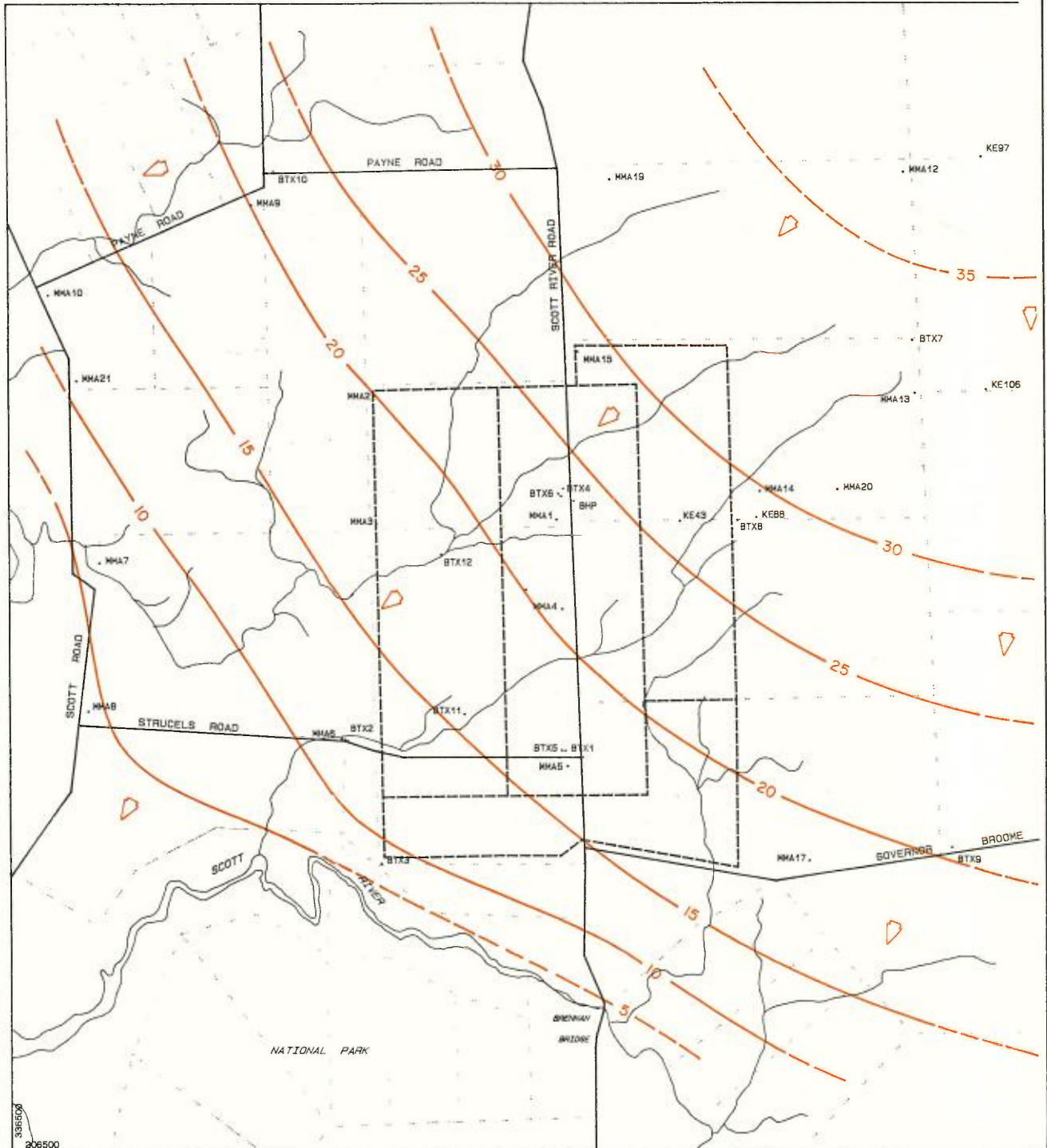


FIGURE 2.3
Major Geological and
Geomorphological Features of the
Southern Perth Basin



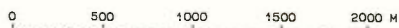
- | | | |
|--|------------------------|--|
| | RED-BROWN | } SANDY SOILS OVER IRON PAN
GAS <1M |
| | GREY | |
| | YELLOW-BROWN | |
| | DEEP (>1M) SANDY SOILS | } SANDY SOILS |
| | GRAVELLY YELLOW EARTHS | |
| | LOW DUNES (>2M) | |
| | SWAMPS | |
| | DRAINAGE LINES | |
| | MINING AREA | |

FIGURE 2.4
Soils



- LEGEND:
- PORTION BOUNDARIES
 - PERIMETER OF PROPOSED MINING AREA (DREDGE BLOCKS)
 - - - WATER TABLE CONTOURS (metres AHD)
 - MMA EXPLORATION BORE SITE
 - ▷ GROUNDWATER FLOW DIRECTION

NOTES:
IMPACT HAS BEEN DETERMINED BY SUBTRACTING WATER LEVELS
CALCULATED FOR DREDGING FROM WATER LEVELS DETERMINED
FOR PRISTINE CONDITIONS - STEADY STATE



DRAWN SCALE 1:30000

FIGURE 2.5
Local Water Table Interpolated from
Borehole Measurements

BEENUP PROJECT



- 1.1 OPEN FOREST OF EUCALYPTUS MARGINATA - EUCALYPTUS CALOPHYLLA.
- 1.2 WOODLAND OF EUCALYPTUS MARGINATA - EUCALYPTUS CALOPHYLLA - BANKSIA SPP.
- 1.3 OPEN FOREST OF EUCALYPTUS MARGINATA - EUCALYPTUS CALOPHYLLA - EUCALYPTUS PATENS.
- 1.4 OPEN FOREST OF EUCALYPTUS MARGINATA - EUCALYPTUS PATENS - BANKSIA LITTORALIS.
- 1.5 OPEN FOREST EUCALYPTUS MARGINATA - EUCALYPTUS CALOPHYLLA - MELALEUCA PREISSIANA.
- 1.6 OPEN FOREST OF EUCALYPTUS MARGINATA - EUCALYPTUS CALOPHYLLA - AGONIS FLEXUOSA.
- 2.1 LOW OPEN WOODLAND OF BANKSIA ATTENUATA - BANKSIA ILICIFOLIA - EUCALYPTUS MARGINATA.
- 2.2 LOW WOODLAND OF AGONIS FLEXUOSA - BANKSIA ILICIFOLIA - EUCALYPTUS MARGINATA.
- 2.3 LOW OPEN WOODLAND OF MELALEUCA PREISSIANA.
- 2.4 LOW OPEN FOREST OF MELALEUCA PREISSIANA - AGONIS JUNIPERINA.
- 2.5 LOW OPEN WOODLAND OF MELALEUCA PREISSIANA AGONIS SPP.
- 3.1 OPEN HEATH OF BANKSIA OCCIDENTALIS.
- 3.2 CLOSED HEATH TO SCRUB OF MIXED PROTEACEAE - MYRTACEAE SPP.
- 3.3 OPEN HEATH OF MIXED PROTEACEAE - MYRTACEAE SPP., MODIFIED ROAD VERGE.
- 3.4 OPEN HEATH OF MIXED MYRTACEAE SPP, MODIFIED ROAD VERGE.
- 4.1 TALL SEDGELANDS OF LEPTOCARPUS SPP.
- 4.2 SEDGELANDS OF LEPTOCARPUS SPP.
- 4.3 LOW SEDGELANDS OF CYPERACEAE - RESTIONACEAE SPP.
- 4.4 SEDGELANDS OF JUNCUS PALLIDUS.
- CLEARED
- MINING AREA

FIGURE 2.6
Vegetation



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BEENUP PROJECT

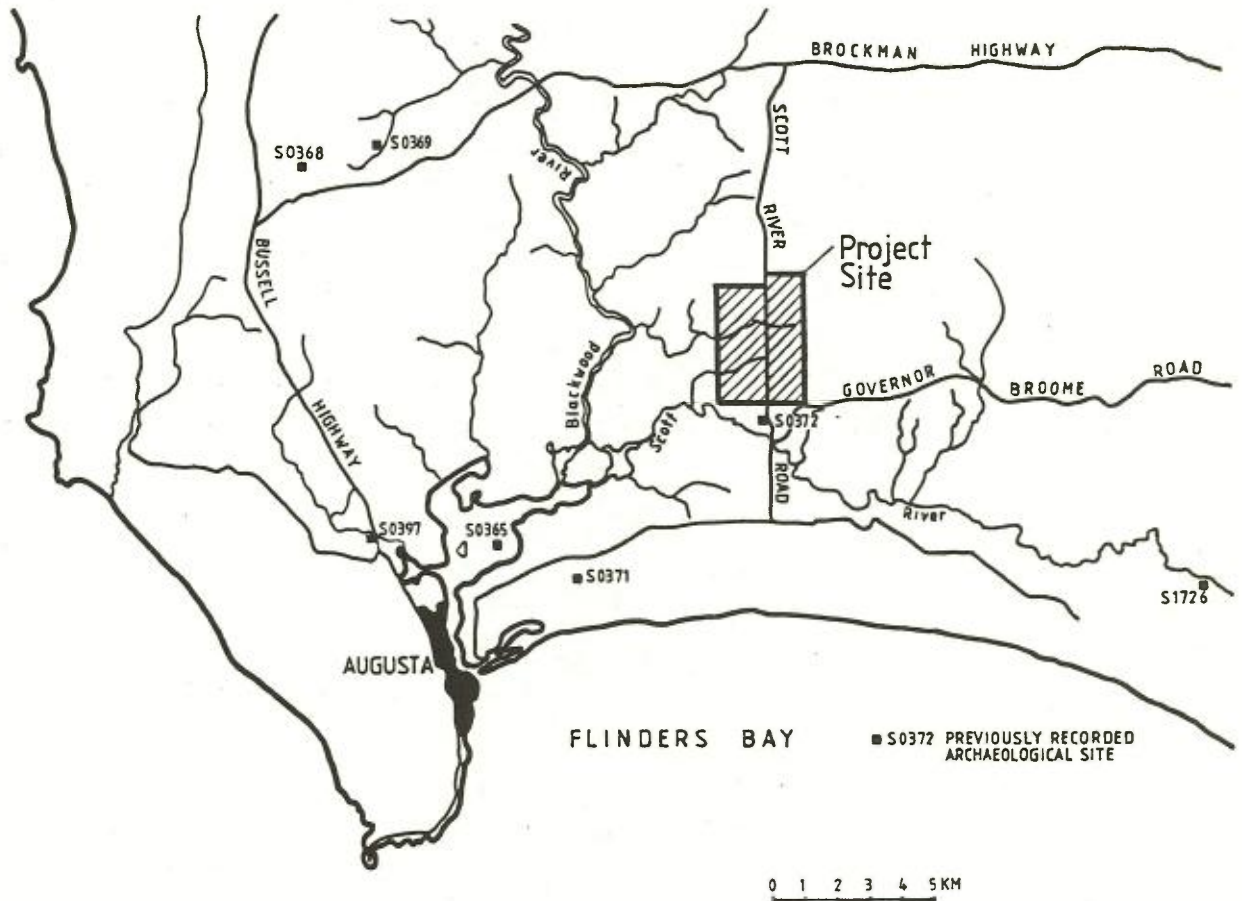
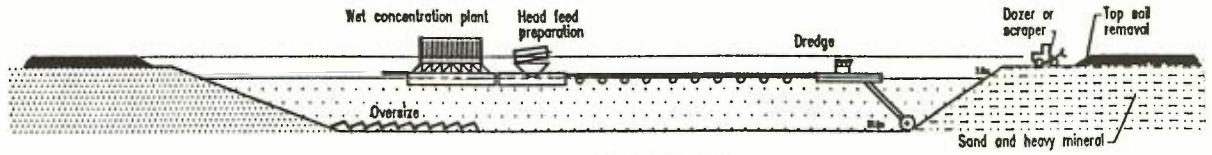
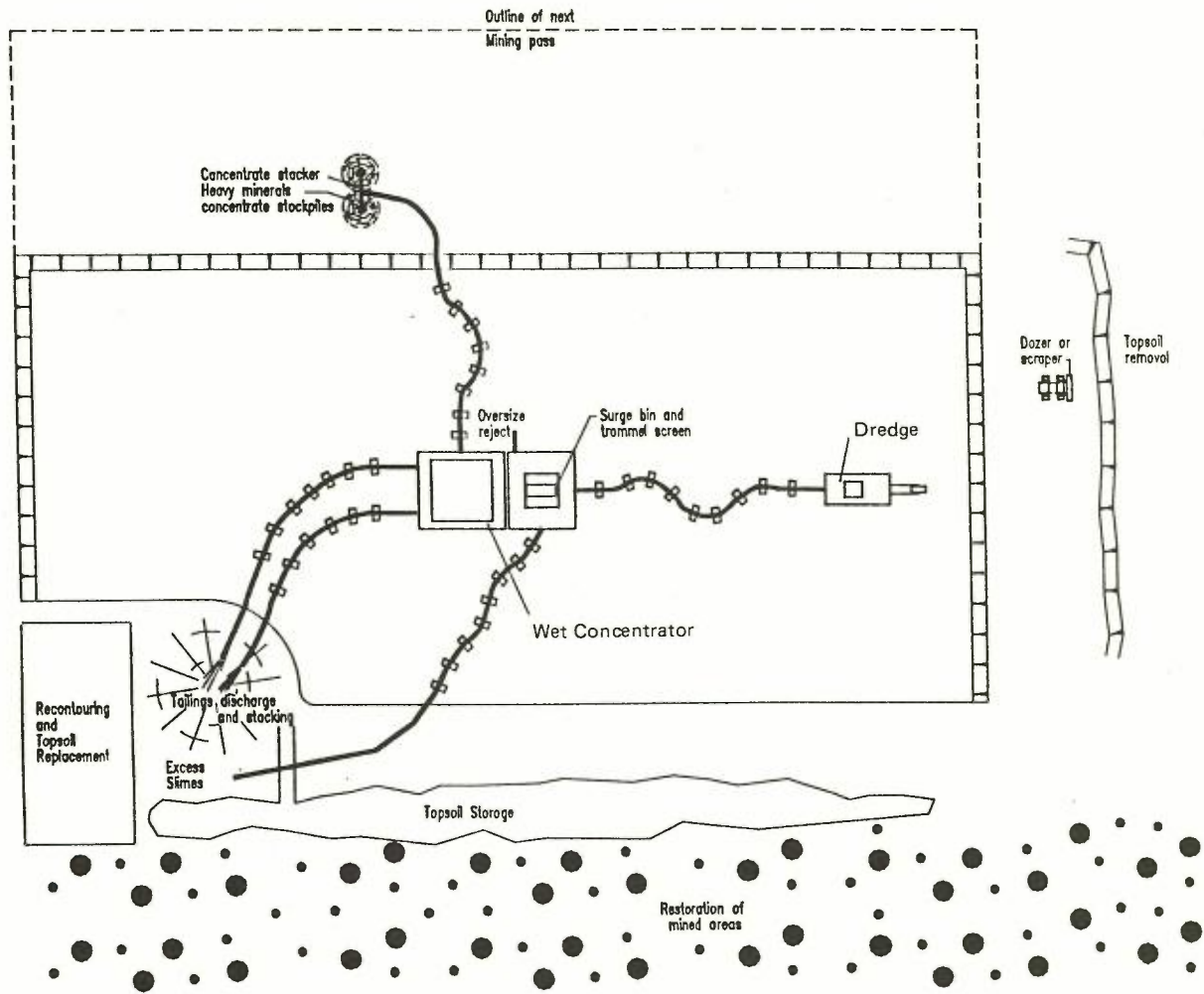


FIGURE 2.7
Previously Recorded
Archaeological Sites



Sectional view



Plan view

FIGURE 3.1
 Mining Plant —
 Dredge and Concentrate System



BEENUP PROJECT

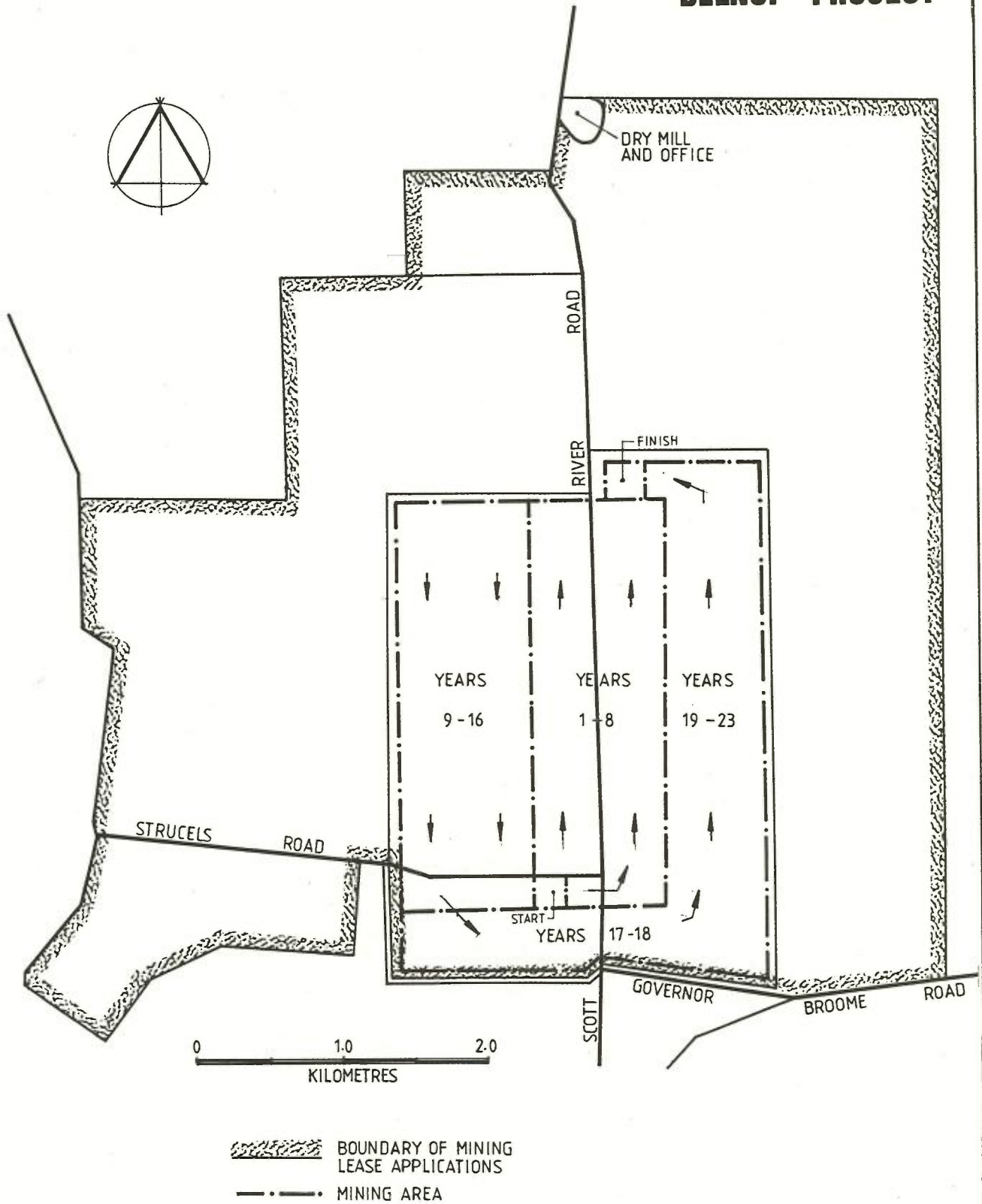
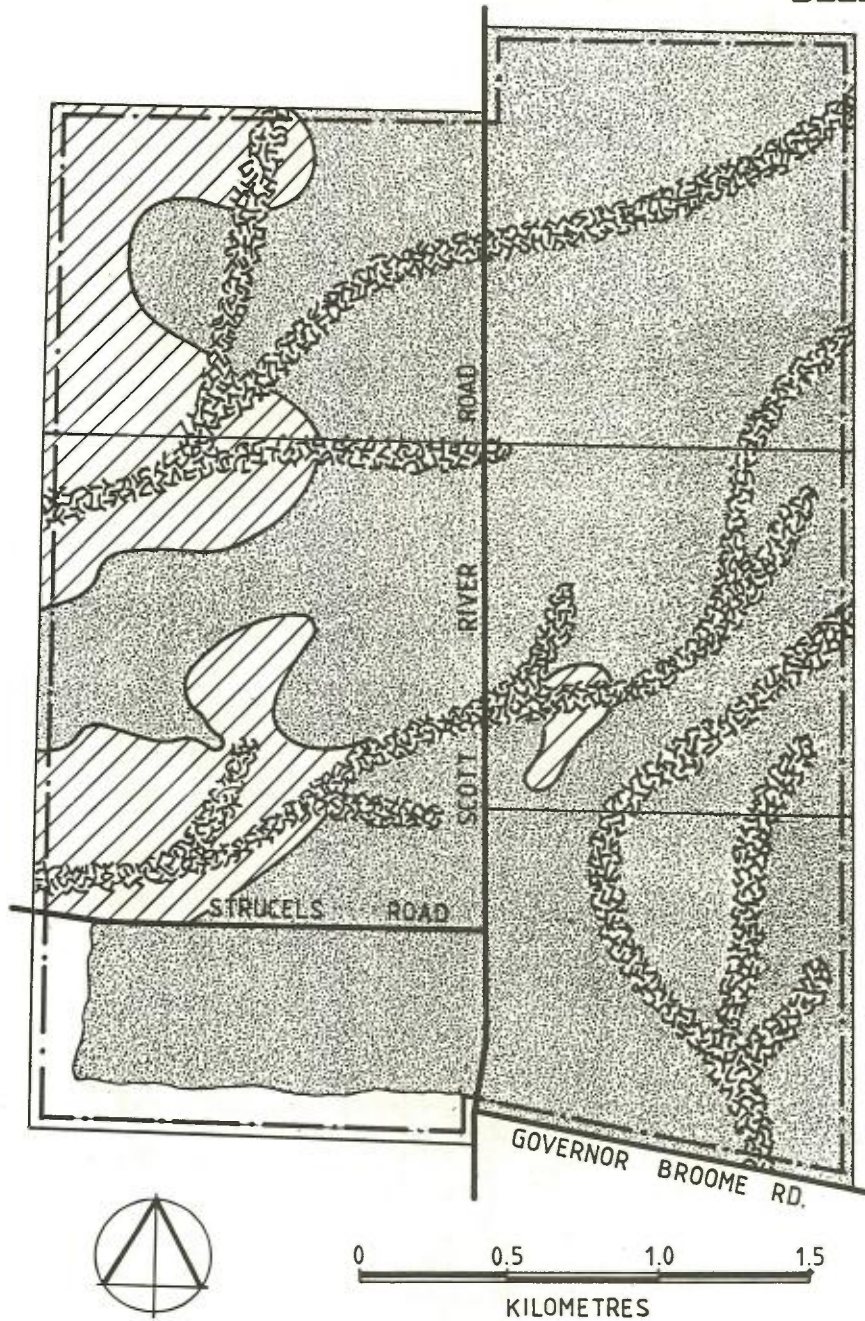


FIGURE 3.2
Conceptual Mining Plan



BEENUP PROJECT



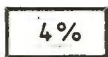

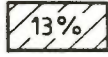


-  4% BUFFER STRIP OF RANDOM, SELECTED NATIVE TREES FROM AREA.
-  11% 50 - 60 m WIDE STRIP OF NATIVE PLANTS ALONG MAJOR WATER COURSES.
-  13% REHABILITATION OF MAIN REMNANTS OF VEGETATION. (APPROX. AREAS.)
-  72% AGRICULTURE. (INCLUDING POSSIBLE COMMUNITY USE.)
-  BOUNDARY OF MINING AREA

FIGURE 3.3
Rehabilitation Plan

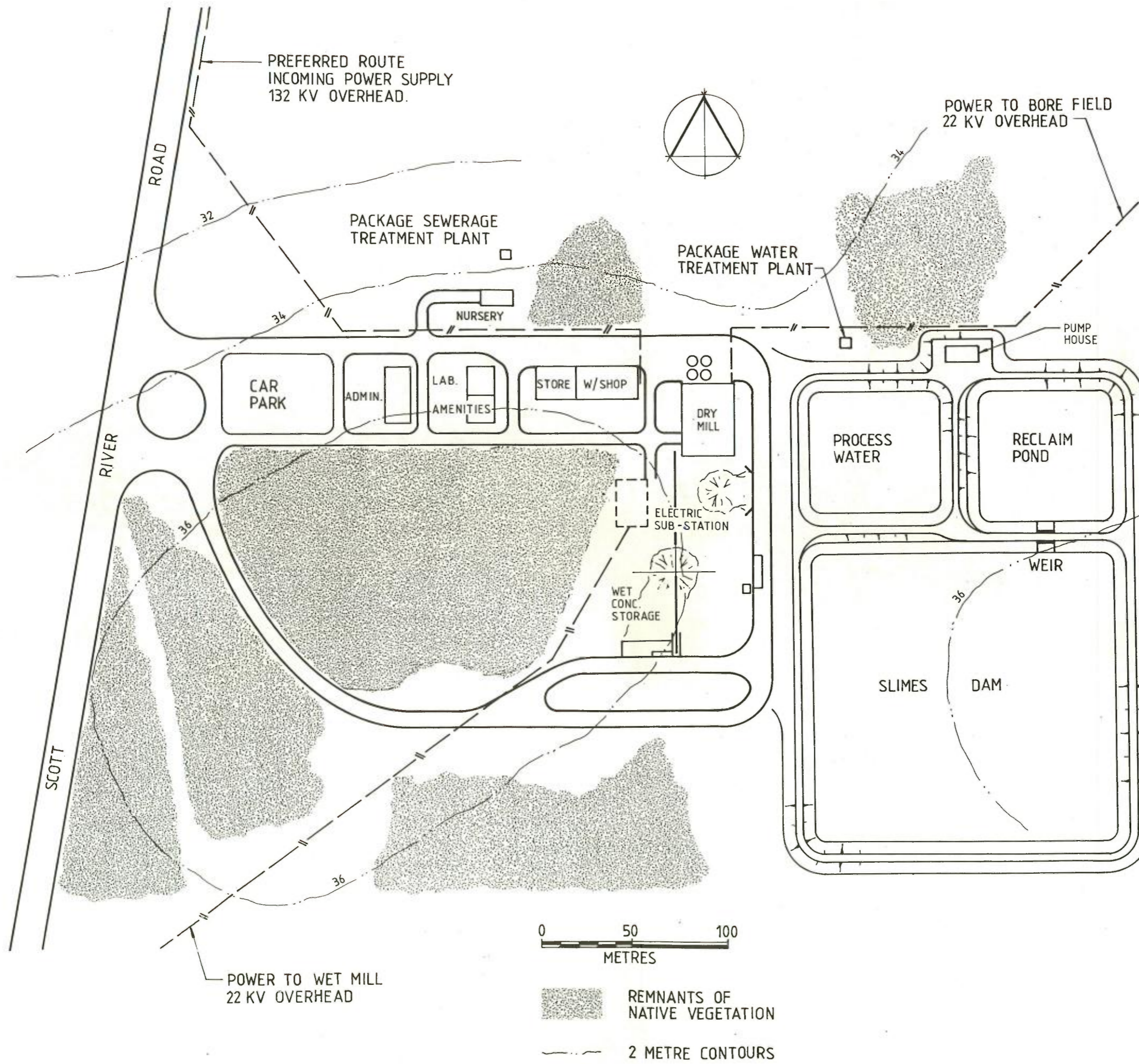


FIGURE 3.4
 Dry Mill and Office Area



BEENUP PROJECT

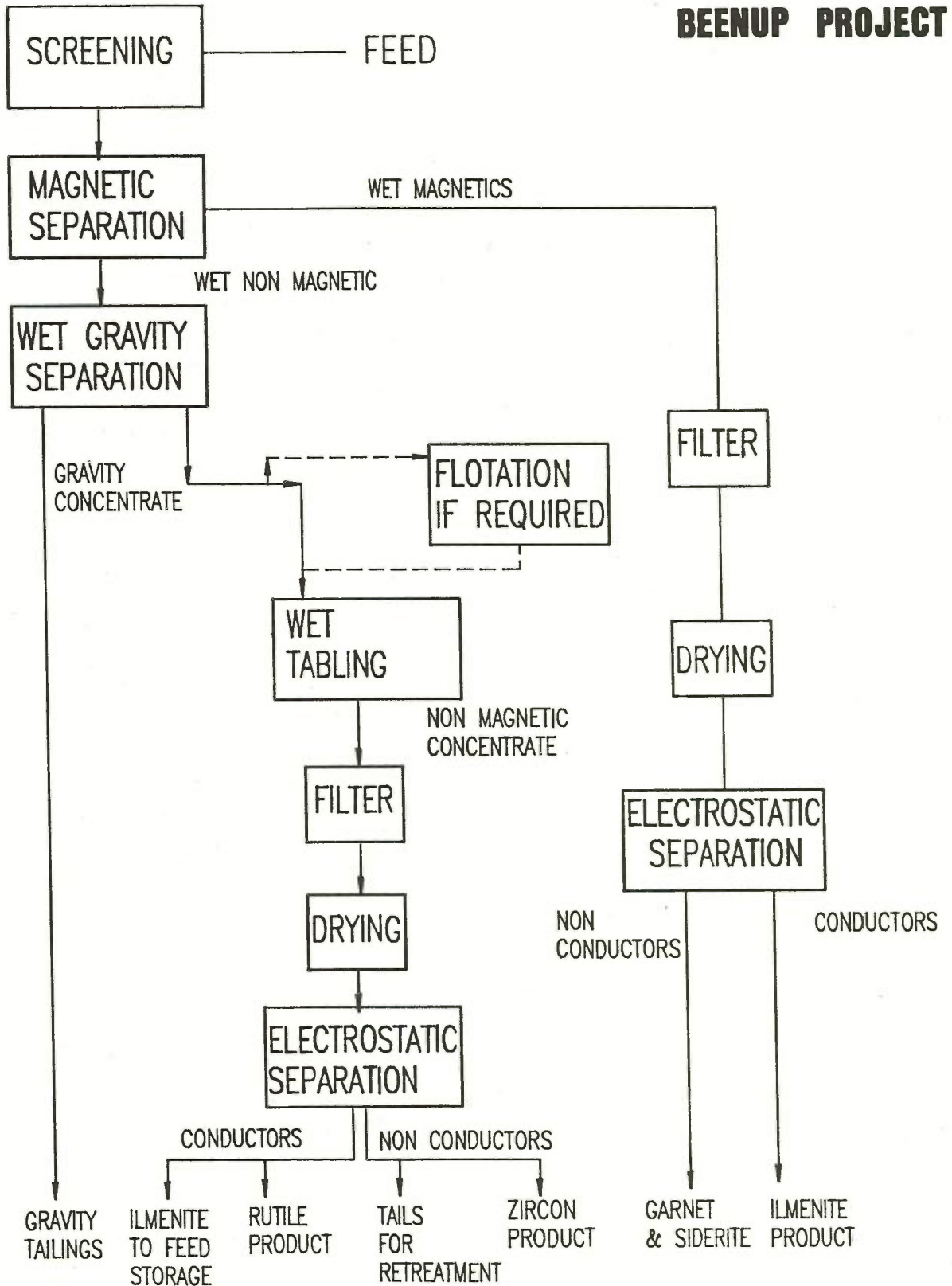
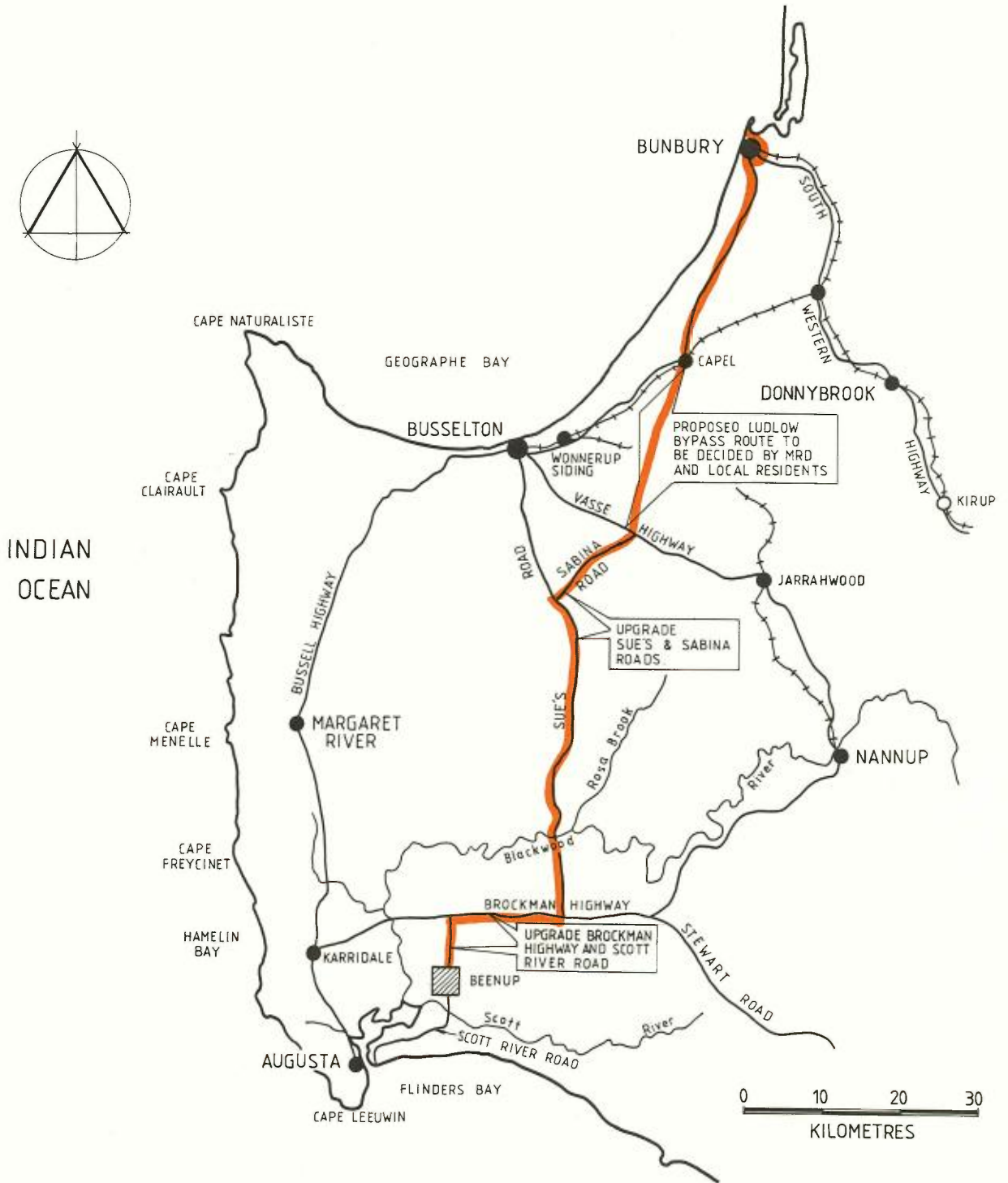
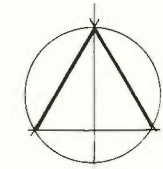


FIGURE 3.5
Minerals Separation Flow Chart



BEENUP PROJECT



LEGEND

- EXISTING MAJOR ROADS
- - - EXISTING RAILWAY
- ROAD FROM BEENUP TO BUNBURY VIA SUE'S ROAD

FIGURE 3.6
Preferred Transport Route



BEENUP PROJECT

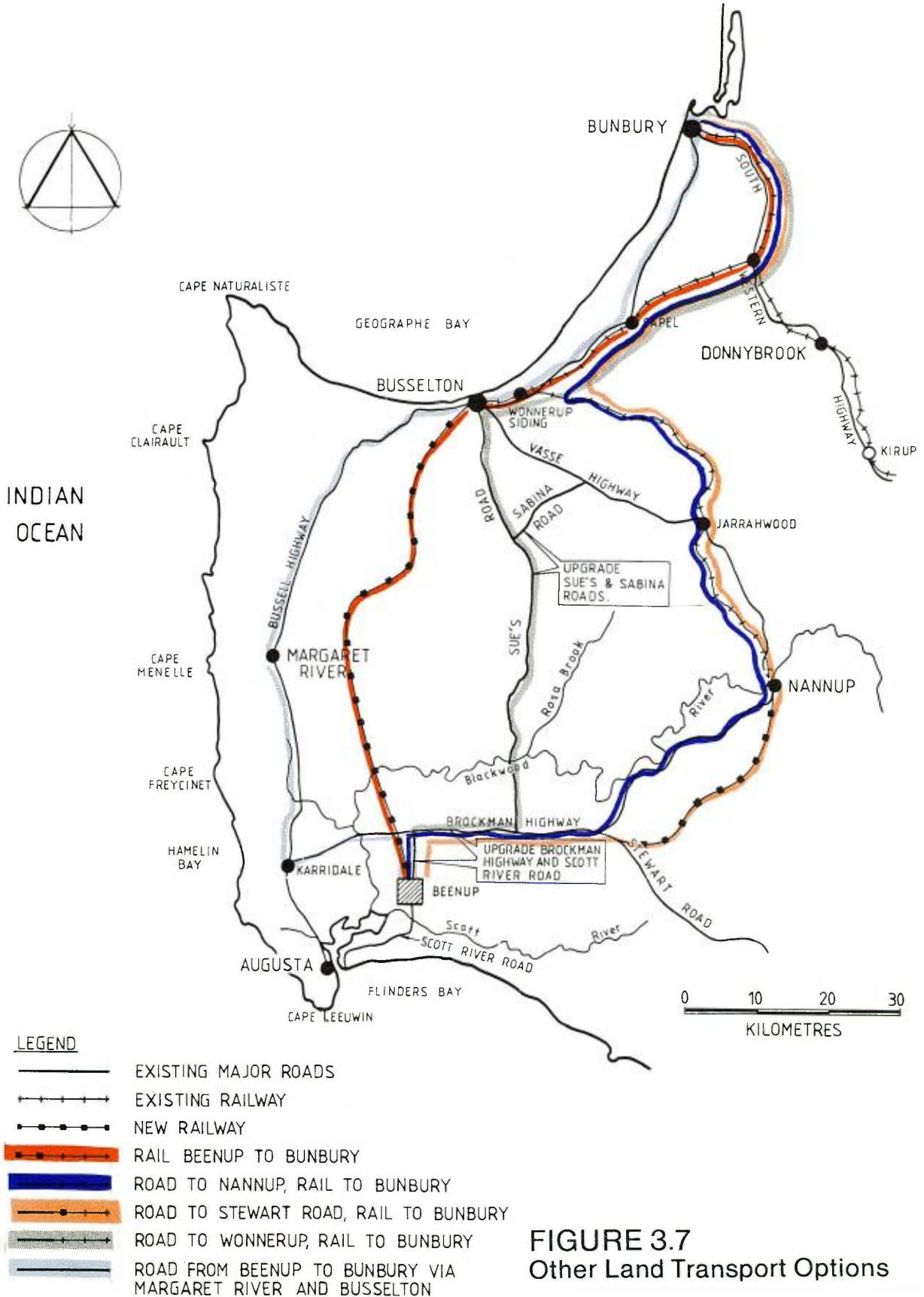


FIGURE 3.7
Other Land Transport Options



BEENUP PROJECT

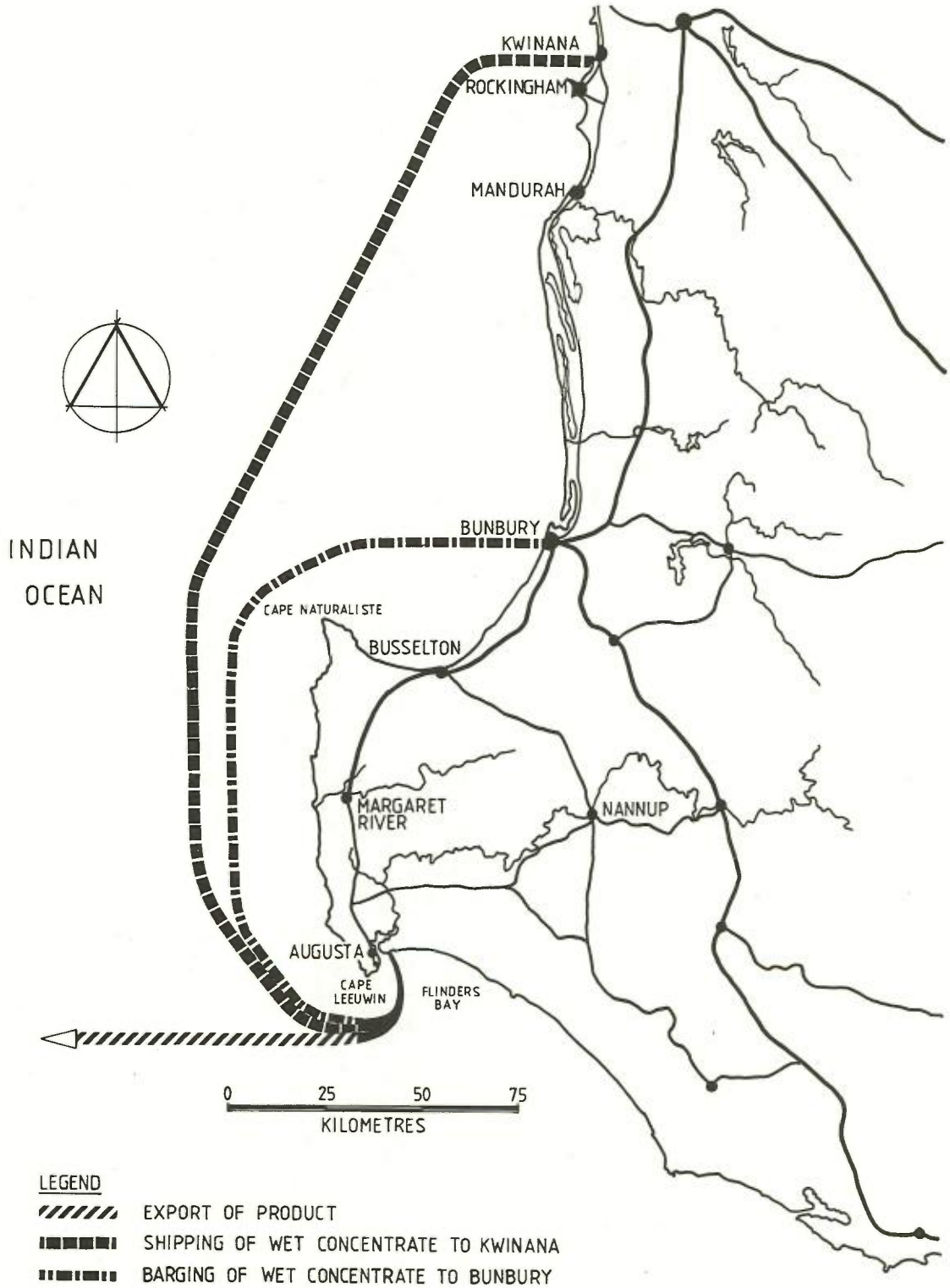


FIGURE 3.8
Sea Transport Options



FIGURE 4.1
Woodland rehabilitation, New South Wales



FIGURE 4.2
Wet heath rehabilitation, New South Wales



BEENUP PROJECT

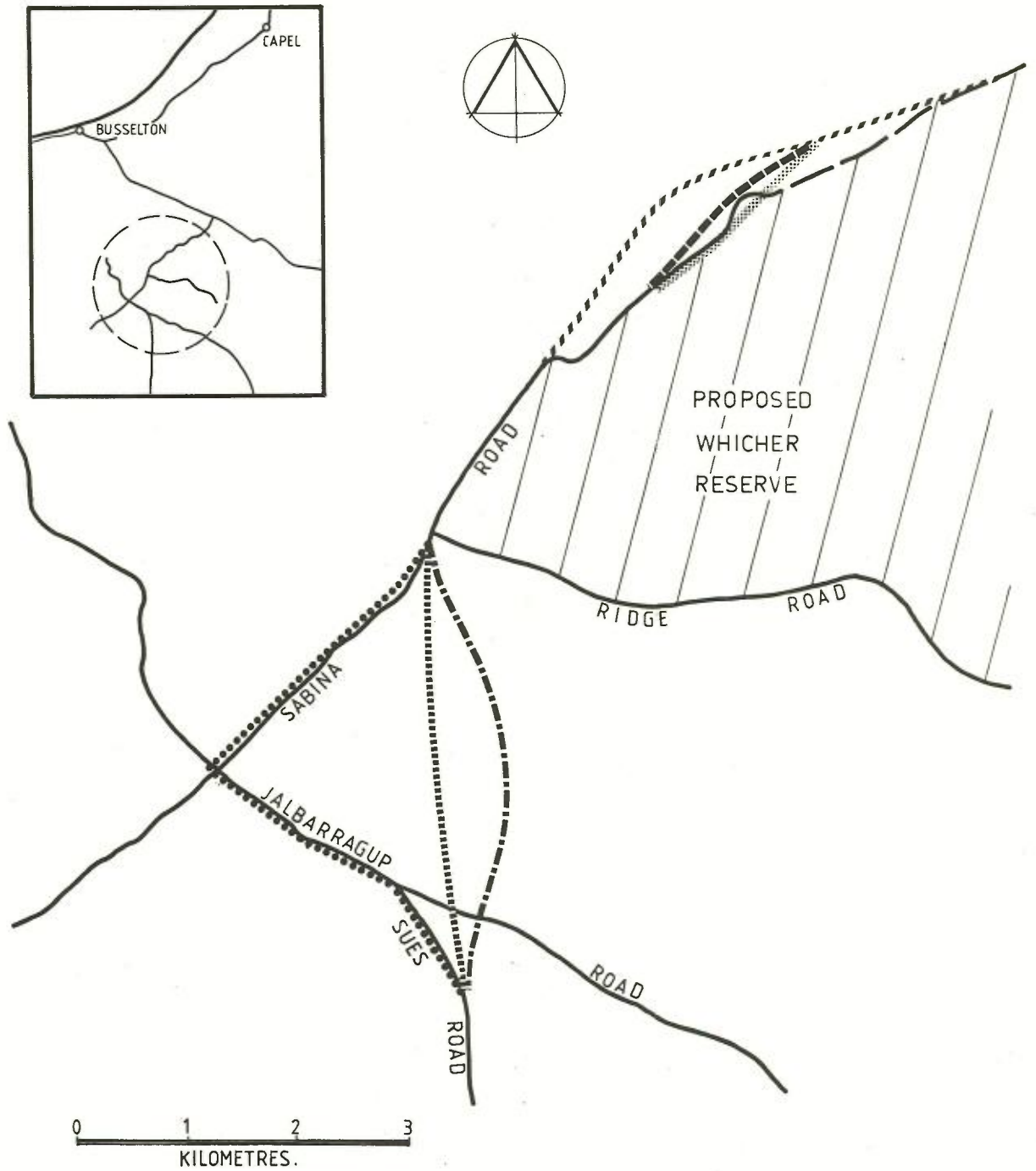


FIGURE 4.3
Transport Route Options,
Sabina Road

Appendices

- I EPA Guidelines
- II Surface wind analysis, Augusta
- III Soils
- IV Hydrology and hydrogeology
- V Radiation levels
- VI Sound levels
- VII Flora and vegetation
- VIII Terrestrial vertebrate fauna
- IX Archaeology and ethnography
- X Socio-economic aspects
- XI Report on the activities and recommendations of
The Beenup Final Land Use Work Party
- XII Community consultation programme
- XIII Abbreviations
- XIV Glossary

Appendix I

**PROPOSED BEENUP HEAVY MINERALS MINE
EPA GUIDELINES FOR AN ENVIRONMENTAL REVIEW
AND MANAGEMENT PROGRAMME (ERMP)**

These guidelines may be amended if a joint State-Commonwealth environmental assessment is necessary by virtue of the Commonwealth's Environment Protection (Impact of Proposals) Act applying to the project through, for example, the requirement for export approval.

SUMMARY

This section should contain a clear and concise summary of the proposal, existing environment, the magnitude and extent of environmental impacts and the planned environmental safeguards and management.

1. INTRODUCTION

This section should include:

- background and objectives of the proposal;
- details of the proponent;
- why the document has been prepared;
- location, size, scope and timing of the proposal;
- regional overview of existing and proposed sand mining operations and future heavy mineral prospects in the lower south west; and
- relevant legislative requirements and approval processes (State and Commonwealth).

2. NEED FOR PROPOSAL

The broad costs and benefits of the project to the company and community may be described in a general way. These should be described at local, state and national levels.

3. THE PROPOSAL

The document should provide descriptions of all the various components of the development and should also cover the various stages, from site preparation through to decommissioning, as well as covering operational aspects such as overburden handling and ore transport. Auxiliary services such as power and water

supplies and labour requirements should also be described. The following should be included:

- detailed map of the site, deposits and surrounding land tenures;
- description of mineral deposits and exploration;
- details of the mining operation including rehabilitation;
- any plans for on-site mineral concentration or processing;
- transportation proposals including routes, upgrading proposals and sources of construction material;
- secondary concentration or off-site processing proposals in Western Australia;
- details of project infrastructure including the workforce, water and electricity supplies and waste treatment (including sewage); and
- prospects for future downstream developments such as development of a sulphate route processing plant or other processing options.

Where there are in-built environmental controls or safeguards as part of the project design, they should be described as part of the proposal and cross-referenced in the later discussion of environmental management.

As rehabilitation will be a key part of the project, it can either be considered as a separate issue or integrated into the various project components.

4. **KEY ISSUES**

Particular emphasis should be placed on the following key issues for this proposal:

- the relationship of this proposal to others in a regional context;
- impact on ground and surface water quality and levels including the Blackwood and Scott Rivers (consider especially turbidity and dieback in discharged mine water);
- relationship between on-site activities and off-site impacts (due to water table changes for example);
- surrounding land uses, especially Scott National Park and surrounding agricultural activities;
- dieback control and protection of any rare flora and fauna;
- transportation of raw materials, products and the workforce;
- potential impacts on the coastal and marine environments;
- rehabilitation and final land use;
- social impacts on the local populations of the shires in which mining and transportation will occur;
- greenhouse audit and offsets.

5. EVALUATION OF ALTERNATIVES

The evaluation of alternatives should demonstrate to the reader how choices on location, technology, techniques, transportation etc., have been proposed so as to protect the environment. A description should be given of how the proposal has developed and the degree to which development alternatives have been examined or changed as a result of public or government suggestions. The public consultative process should be described here.

Consideration of alternatives should be integrated throughout the document as well. For example, consideration of alternative environmental management proposals should demonstrate their consequences on potential environmental impacts. As such this would be best discussed in the environmental management section.

Special attention should be given to the discussion on alternative options for:

- mining and mineral processing techniques;
- rates of production and project development;
- mine site rehabilitation, in particular end land use;
- electricity supply and transmission corridors;
- water supply and management of excess water;
- ore transportation routes, upgrading proposals and sources of construction materials; and
- workforce accommodation.

When alternatives are rejected or selected, the factors which led to that decision should be clearly identified. The environmental and social costs and benefits of alternative options should be discussed, principally for the ore transport options.

The aim of this section is to lead the reader through the thought processes which led to the desired proposal and to outline the factors which control its present form.

The differing environments affected by alternative transportation options should be recognised. Particular attention should be paid to sensitive terrestrial, coastal and marine environments which might be differently affected by alternative transportation modes. A matrix approach could be adopted to consider the environmental and social effects of each alternative on each aspect of the environment.

6. EXISTING ENVIRONMENT

This section should provide an overall description of the environment and an appraisal of the physical and ecological systems likely to be affected by all aspects of the proposal. It should concentrate on the significant aspects of the environment subject to potential impact from the development. Only the habitats, resources and potential resources which could be influenced by the project should be described. Excessive descriptions which are irrelevant to the impact of the proposal tend to detract from the document. Maps and aerial photographs of physical and biotic features, including drainage and vegetation types, should be included.

Discussion of the region within which the project is situated should be provided before discussing the project site. Conceptual models or diagrams could be provided to illustrate and synthesise the interactions between the physical and biological aspects of the habitats and resources discussed.

In particular, the aspects of the terrestrial, aquatic, estuarine, coastal and marine environments relevant to, or impacted by mining, transport links, mineral processing and project workforce, should be discussed. A good understanding of the local meteorology, soils and geology, land use, groundwater and biota and their interaction with existing water resources, levels of dust and other possible pollutants, including radionuclides if any, should be demonstrated for the mine, workforce accommodation, transport corridor and ship loading facilities.

It is important to consider the conservation status of flora and fauna which may be affected and the relationships between the project and adjacent land uses, especially Scott National Park and surrounding agricultural activities. The significance of surface and groundwater resources of regional significance should be discussed.

Discuss the physical and biological processes which maintain the various habitats and resources. The proposal should consider fisheries and their usage in this section. Assess the resilience of these habitats and resources to natural and man-made pressures, particularly with regard to dieback disease and changes to ground and surface waters.

The discussion of the human environment should include information on land use and planning, features and sites of cultural and scientific interests including any historical, archaeological or ethnographic sites. Also, infrastructure, public and private utilities, facilities and social aspects should be considered. Landscape and aesthetic values should also be described. The assessment of the social environment should include identification of groups potentially affected by the proposal.

A description should be provided of the public participation and consultation activities undertaken by the proponent in preparing the ERMP. Description and objectives of the activities undertaken and details of the groups involved should be included.

A summary of the concerns raised by individuals and groups should be provided. This section should be cross referenced with the "Environmental Management" section which should clearly indicate how each of these concerns has been addressed.

7. ENVIRONMENTAL IMPACTS

The proposal will impact on some aspects of the environment, and it is necessary to discuss the individual impacts and then synthesise these so as to show the overall effect on the total environment. This is necessary for two reasons: firstly, to allow the reader of the document to draw conclusions on whether the proposal is environmentally acceptable, and secondly, to show what management programmes can be devised to manage environmental impacts.

Impacts should be described in a way which allows testing of the prediction made in the ERMP against future monitoring data. Consideration should be given to both the long and short-term effects of project development and operation where the environment may be significantly altered.

Potential impacts on all aspects of the environment should be considered. A thorough evaluation of the hydrological and botanical impact, including the potential for the spread of *Phytophthora* pathogens, should be provided. Discuss the effects of the project and associated population on the existing environment, including any archaeological, ethnographic or heritage aspects, the existing local population and any existing or proposed nature conservation areas. Impacts on the terrestrial, coastal and marine environments should be considered separately. Any impacts on natural resources, including fisheries should be evaluated.

This section should show the overall effect of the proposal on the total ecosystem and surroundings of the area. It will be necessary to address the impacts on the individual environmental components before a final overall synthesis can be made. In all cases where an assessment is made, the criteria employed to assess impacts should be clearly stated. Wherever possible, effects should be quantified and uncertainties highlighted. Use figures and tables or matrices wherever necessary for clarity. The synthesis should also include an assessment of the significance and timing of the various impacts identified. It may be useful to examine construction impacts separately from operational decommissioning impacts.

The major components of the proposal and their interactions with specific environments should be set out in separate sections (eg. consider the implications of an offshore loading facility on the marine environment).

The evaluation of the social impact of the project should cover the overall and incremental impact on the communities in which mining and transportation will occur.

The assessment should include:

- ° Social costs and benefits of the proposal.
- ° Impact of increased workforce.
- ° Assessment of additional housing requirements.
- ° Impact of existing services.
- ° Impact of increased transport activity.

8. ENVIRONMENTAL MANAGEMENT AND MONITORING

An environmental management programme should be developed and cross-referenced to the synthesis of environmental impacts previously outlined. The objectives, scope and details of the programme should be described. Assignment of responsibility for environmental management should also be stated and commitments given.

The need for any additional long term monitoring of baseline conditions should be considered.

It will be essential to discuss the proposed management programme in relation to current practice elsewhere in Western Australia and Australia for various aspects of the proposal. A description of research programmes that would provide information on the means of rehabilitation and management of the environment should be included in this section.

Emphasis should be placed on mechanisms to identify and monitor social impacts and on the development of management and mitigation measures relevant to the impacts identified in section 7.

Emphasis should be given to mechanisms for adapting the environmental management programme in response to results from a comprehensive monitoring programme. The monitoring programmes should be designed to test predictions

made in the ERMP as well as to facilitate protection and management of the environment.

The procedures for reporting results of monitoring and environmental management to the appropriate authorities should be outlined. Also summarise, and where necessary detail, management commitments described in this and earlier sections.

Proposals for additional research on aspects of the environment and its management peculiar to the Beenup area should be discussed (eg. dieback control, rare species management, rehabilitation).

9. CONCLUSIONS

Conclusions on the overall impact of the proposal (including the role of ameliorative measures) should be stated together with an assessment of, and reasons for, the environmental acceptability of the project.

10. SUMMARY OF ENVIRONMENTAL MANAGEMENT COMMITMENTS

Environmental management commitments should be summarised and numerically listed in this section.

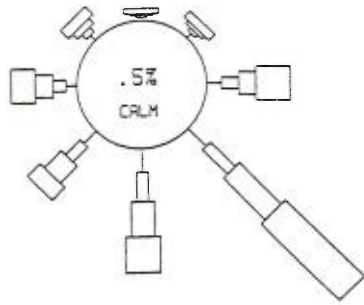
Commitments should clearly address each of the outstanding environmental and social issues. They should be of the form "The proponent will...carry out...(action) at...(time) at... (location) to the satisfaction of... (the EPA).

11. REFERENCES

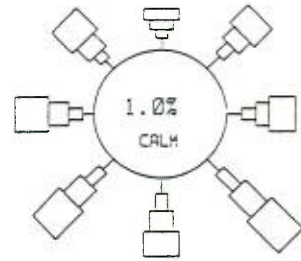
- Bibliography and Abbreviations
- Provide lists of references cited and abbreviations used
- Glossary
- Provide definitions of technical terms used. Also define and explain units of measurement which may not normally be understood by the interested layman.
- ERMP Guidelines
- Guidelines which have been approved by the EPA should be reproduced in the document.

Appendix II

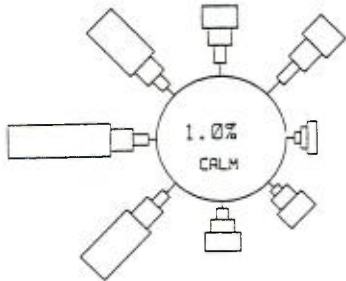
SURFACE WIND ANALYSIS



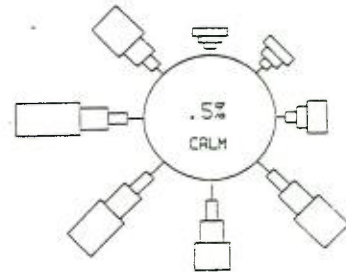
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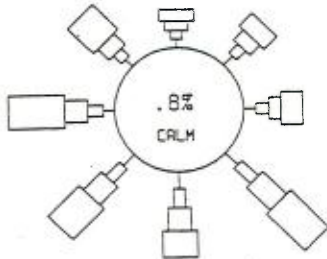
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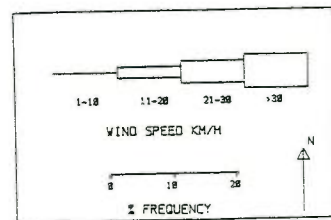
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WIND ROSE
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SPRING



WIND ROSE
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ANNUAL



BUREAU OF METEOROLOGY - SURFACE WIND ANALYSIS

PERCENTAGE OCCURRENCE OF SPEED VERSUS DIRECTION BASED ON 32 YEARS OF RECORDS

FIRST YEAR : 1957

LAST YEAR : 1988

NUMBER OF MISSING OBSERVATIONS (AS PERCENTAGE OF MAXIMUM POSSIBLE) : 0.02 %

STATION : 009518 AUGUSTA (CAPE LEEUWIN)

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* OCCURRED BUT LESS THAN 0.5 PERCENT

PRODUCED BY M.I.S.S. 29/ 3/89

BUREAU OF METEOROLOGY - SURFACE WIND ANALYSIS

PERCENTAGE OCCURRENCE OF SPEED VERSUS DIRECTION BASED ON 32 YEARS OF RECORDS

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STATION : 009518 AUGUSTA (CAPE LEEUWIN)

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PRODUCED BY M.I.S.S. 29/ 3/89

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34 22 S, 115 08 E 22.0 M ELEV

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N	:	*	*	*	1	1	*	*	3				
NE	:	1	1	1	2	1	*	*	7				
E	:	1	2	4	3	4	2	1	17				
SE	:	1	2	5	5	4	2	1	20				
S	:	1	2	3	3	2	1	1	13				
SW	:	1	2	3	4	4	2	1	17				
W	:	*	2	3	4	2	2	1	14				
NW	:	1	1	2	2	1	1	*	8				
ALL	:	7	11	21	24	19	12	6					

NO. OF OBS. 960

DECEMBER 0900 HOURS LST

		SPEED (KM/HR)											
CALM:		1	6	11	21	31	41	51	A				
		TO	TO	TO	TO	TO	TO	TO	&	L			
DIRN:		5	10	20	30	40	50	UP	L				
N	:	*	*	*	*	*	*	*	1				
NE	:	*	*	1	1	1	*	*	5				
E	:	1	2	4	4	4	2	*	18				
SE	:	2	4	6	9	5	3	1	30				
S	:	2	2	4	4	2	1	*	15				
SW	:	1	2	3	4	2	1	*	14				
W	:	1	1	2	4	2	1	1	11				
NW	:	*	1	1	2	1	*	*	6				
ALL	:	8	12	22	27	18	9	4					

NO. OF OBS. 990

SEPTEMBER 1500 HOURS LST

		SPEED (KM/HR)											
CALM:		1	6	11	21	31	41	51	A				
		TO	TO	TO	TO	TO	TO	TO	&	L			
DIRN:		5	10	20	30	40	50	UP	L				
N	:	*	*	*	1	*	*	*	3				
NE	:	*	*	*	*	*	*	*	1				
E	:	*	*	1	*	*	*	*	2				
SE	:	1	3	4	4	3	2	*	16				
S	:	1	3	4	3	2	1	1	15				
SW	:	1	2	4	4	3	3	2	19				
W	:	1	2	4	5	5	4	4	24				
NW	:	*	1	3	4	3	4	3	19				
ALL	:	5	11	19	22	17	15	11					

NO. OF OBS. 960

OCTOBER 1500 HOURS LST

		SPEED (KM/HR)											
CALM:		1	6	11	21	31	41	51	A				
		TO	TO	TO	TO	TO	TO	TO	&	L			
DIRN:		5	10	20	30	40	50	UP	L				
N	:	*	*	1	*	*	*	*	1				
NE	:	*	*	*	*	*	*	*	1				
E	:	*	*	1	*	*	*	*	2				
SE	:	1	2	4	5	4	2	1	20				
S	:	1	3	4	5	2	1	1	17				
SW	:	1	3	5	6	3	2	2	21				
W	:	1	2	3	6	4	4	3	22				
NW	:	*	*	3	4	2	3	2	15				
ALL	:	4	10	20	27	16	13	10					

NO. OF OBS. 992

NOVEMBER 1500 HOURS LST

		SPEED (KM/HR)											
CALM:		1	6	11	21	31	41	51	A				
		TO	TO	TO	TO	TO	TO	TO	&	L			
DIRN:		5	10	20	30	40	50	UP	L				
N	:	*	*	*	*	*	*	*	1				
NE	:	*	*	*	*	*	*	*	1				
E	:	*	*	1	*	*	*	*	2				
SE	:	1	2	5	7	6	6	3	30				
S	:	1	3	5	6	3	2	1	20				
SW	:	1	1	5	5	3	2	1	18				
W	:	*	2	3	5	4	3	2	18				
NW	:	*	1	1	3	2	2	1	10				
ALL	:	3	9	20	26	19	14	8					

NO. OF OBS. 960

DECEMBER 1500 HOURS LST

		SPEED (KM/HR)											
CALM:		1	6	11	21	31	41	51	A				
		TO	TO	TO	TO	TO	TO	TO	&	L			
DIRN:		5	10	20	30	40	50	UP	L				
N	:	*	*	*	*	*	*	*	*				
NE	:	*	*	*	*	*	*	*	*				
E	:	*	*	*	*	*	1	*	2				
SE	:	1	2	5	9	7	8	4	36				
S	:	1	3	7	8	4	2	1	26				
SW	:	1	3	4	6	2	1	*	17				
W	:	*	1	3	4	3	2	1	13				
NW	:	*	*	1	1	2	1	*	6				
ALL	:	4	10	20	28	17	15	6					

NO. OF OBS. 992

* OCCURRED BUT LESS THAN 0.5 PERCENT

PRODUCED BY M.I.S.S. 29/ 3/89

Appendix III

SOILS

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SOILS

by

W.M. McArthur

1.0 INTRODUCTION

The Beenup area is partly covered by a 200 m x 200 m grid (KA series) and the soil profile was described at each of the 280 grid points.

In addition inspections were made at 200 m intervals in the eastern part which is not covered by the KA series grid. Soil inspections were made by boring a hole to a metre where possible; in many cases an iron pan occurred at less than 1 m and, in fact, often formed the surface. The soil was described in terms of colour and texture and gravel content for each identifiable horizon. Colour is given by reference to the Munsell Soil Colour charts where colour is defined in terms of hue (spectral colour), value (darkness), and chroma (purity of colour). Seven samples were taken for chemical analysis. Each sample consisted of about 50 bulked cores, taken from 0-10 cm. Sub-samples were taken for analysis.

2.0 SOILS WITH IRON PAN WITHIN 1 m.

These soils vary greatly in depth over very short distances; iron pan is often outcropping or at less than 10 cm but in places, especially in the western part of the unit as mapped, the depth is commonly 40-60 cm. The soils also vary in colour and may be dominantly grey, yellow-brown, or red-brown. The textures are usually sand or sandy loam but occasionally rise to sandy clay-loam in the deeper profiles. The phases have been recognised on the basis of colour.

2.1 THE RED-BROWN PROFILES

- 0 Dark reddish brown (5 YR 3/3) sandy loam
- 5 Reddish brown (5 YR 4/3) sandy loam
- 15 Yellowish red (5 YR 4/6) sandy loam
- 20 Ferruginous pan.

Profiles usually associated with pan outcrop and varying up to 30 cm deep.

III-2

2.2 THE GREY PROFILES

- 0 Very dark greyish brown (10 YR 3/2) loamy sand
- 10 Dark grey (10 YR 4/1) sand
- 20 Grey (10 YR 5/1 - 10 YR 5/2) sand
- 40 Grey with some rusty mottles
- 50 Ferruginous pan

Profiles may vary from 30 to 90 cm in depth and sometimes do not have a mottled sub-soil. Textures are always sandy.

2.3 THE YELLOW-BROWN PROFILES

- 0 Dark brown (7.5 YR 3/2) loamy sand
- 10 Brown (7.5 YR 4/3) loamy sand
- 20 Yellowish brown (7.5 YR 4/6) sandy loam
- 40 Bright yellowish brown (7.5 YR 5/6) sandy loam
- 50 Ferruginous pan

Profiles vary in depth up to about 60 cm and may be associated with pan outcrop. Textures may be sand or loamy sand throughout; ferruginous gravel sometimes occurs in the horizon above the pan; rusty mottles may be present in lower horizons.

3.0 THE GENTLY UNDULATING SANDY TERRAIN

This land occurs mainly in the western part of the area where it forms the interfluves between the shallow drainage lines. The soils are mainly sandy throughout, with a weakly developed podsol profile, and with no pan within a metre of the surface.

e.g.

- 0 Very dark grey (10 YR 3/1) loamy sand
- 5 Very dark greyish brown (10 YR 3/2) loamy sand
- 15 Dark greyish brown (10 YR 3/2) sand
- 40 Greyish brown (10 YR 5/2) sand
- 50 with brown mottles
- 70 Brown (7.5 YR 5/4) sand
- 90 with some dark grey-brown mottles
- 110 continuing.

Profiles may vary in colour of the lower horizons from brown to dark grey.

4.0 THE GRAVELLY YELLOW EARTH SOILS

These are a minor group, occurring in only one mappable area, but occasionally seen on the banks of the shallow drainage lines.

e.g.

- 0 Dark brown (7.5 YR 3.2) Loamy sand; slt fe gravel
- 10 Brown (7.5 YR 4/2) sandy loam; slight fe gravel
- 25 Yellowish brown (7.5 YR 5.4) sandy loam; slight fe gravel
- 40 with few yellow mottles
- 60 Yellowish brown (10 YR 5/6) sandy clay-loam slt. gravel
- 80 Brownish yellow (10 YR 6/6) sandy clay loam
- 100 continuing.

Profiles may vary in gravel content with some having no gravel; colours may be brown (7.5 YR) throughout; mottling is usual in the lower horizons.

On the southern boundary two small areas (KA261, 256) have brown or red-brown sandy clay subsoils; these and a small area just north of Strucels Road (KA172) resemble the laterite soils which are common just north of the area.

5.0 THE DUNES AND HUMMOCKS

Theses are low mounds of sand, usually linear, occurring sporadically over the area. They have a well developed podsol profile.

e.g.

- 0 Dark greyish brown (10 YR 4/2) sand
- 15 Greyish brown (10 YR 4/2) sand
- 30 Light greyish brown (10 YR 6/2) sand
- 50 Grey (10 YR 6/1) sand
- 110 continuing with organic pan at 150-200 cm.

Profiles vary in depth to organic pan which may be at 70 cm. Also there may be some brown mottles in the lower horizons.

6.0 THE SWAMPS

These are shallow depressions which form part of the drainage system in a very poorly drained landscape. The soils have in common a high water table (<1 m) in May and would have free water during the greater part of the wet season.

The main soil is sandy throughout, sometimes with coarse grit, and with an organic stained subsoil.

e.g.

- 0 Very dark grey (10 YR 3/1) loamy sand
- 10 Dark grey (10 YR 4/1) gritty loamy sand
- 30 Grey (10 YR 5/1) gritty sand
- 50 Brown (10 YR 5/3) gritty sand
- 70 Dark brown (10 YR 4/3) gritty sand
- 80 Water table

Profiles vary considerably in profile characteristics. Colours are sometimes very bright (eg. 10 YR 6/8) in the subsoil; organic pan may occur within a metre; Some swamps have a highly organic (peaty) surface and may have a loam or sandy loam texture.

7.0 THE DRAINAGE LINES

These are broad and shallow and, though they are mainly swampy, most have a defined water channel. In many cases the channel has eroded down to the ferruginous pan. The soils are similar to those of the swamps (5).

e.g.

- 0 Very dark greyish brown (10 YR 3/2) loamy sand
- 10 Dark greyish brown (10 YR 4/2) sand
- 30 Greyish brown (10 YR 5/2) sand
- 40 With some dark grey mottles
- 50 Dark brown (10 YR 4/3) sand (organic staining)
- 70 Dark brown (10 YR 3.3) sand
- 80 Water table

Profiles may vary in colour of subsoil (eg. 7.5 YR 3/2); textures may rise to sandy loam; some profiles are gritty throughout.

8.0 ANALYTICAL RESULTS

The results of the soil analyses and analytical methods are set out in Table III-1. The results show generally that the surface soil (0-10 cm) has a fairly high level of plant nutrients but this is probably associated with organic matter. Six of the samples are sandy and one (no.7) is a sandy loam.

- ° Reaction (pH) in CaCl_2 is very low throughout and reflects the influence of organic matter in these unbuffered soils. The highest value is pH 4.6. The values are near the critical lower levels for efficient operation of some *Rhizobium* spp.
- ° Organic matter. The levels of organic carbon and of nitrogen are very high as would be expected under the clover pasture regime. The carbon-nitrogen ratio (about 20) is rather high and indicates that much of the organic material is undecomposed.
- ° Exchangeable cations. The total sum of cations is generally very low. Exchangeable aluminium and calcium are the dominant ions and these are closely associated with organic matter. Exchangeable aluminium levels are not sufficient to cause toxicity.
- ° Phosphorus concentrations are variable with three samples (2,3 and 6) indicating that this element could be limiting to growth; three samples (1,4 and 5) have almost luxury levels. This difference may be due to different practices by farmers, with some applying superphosphate in the autumn and others in spring. A level of 5 ppm may be just adequate in a sandy soil which has very low sorption capacity.
- ° Potassium levels are adequate or marginal but certainly not at luxury levels. It is expected that potassium would be rapidly leached under the rainfall in this area (about 980 mm, 9 months wet season, and 180 wet days). Also most of the soils are waterlogged for several months each year.
- ° Copper and Zinc. Analyses indicate that these elements have been added with superphosphate and are adequate for plant growth and animal health. Sample no.6 is the only one which may be marginal.

III-6

TABLE III-1

Results of chemical analysis of Beenup soils

Determinand	Unit	Sample no.						
		1	2	3	4	5	6	7
pH		4.2	4.1	3.9	4.3	3.8	4.0	4.6
OrgC	%	2.4	3.6	4.6	2.8	3.0	3.2	2.5
N	%	0.14	0.15	0.20	0.19	0.15	0.13	0.15
Al	m.e./100g	0.65	0.05	0.05	0.65	0.2	0.1	0.15
Ca	m.e./100g	1.5	5.3	6.1	2.4	3.4	4.1	2.0
Mg	m.e./100g	0.3	0.8	0.9	0.45	0.4	0.8	0.6
Mn	m.e./100g	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
K	m.e./100g	0.05	0.15	0.15	0.1	0.05	0.05	0.1
Na	m.e./100g	0.1	0.15	0.2	0.15	0.1	0.1	0.15
P	ppm	27	7	5	22	21	7	14
K	ppm	35	56	58	49	23	31	39
Cu	ppm	1.6	1.8	1.5	3.0	1.8	0.5	0.8
Zn	ppm	0.7	1.2	1.0	2.4	1.5	0.5	1.0

Sample no.Soil type

- | | |
|---|--|
| 1 | Type 1c - shallow sands over iron pan |
| 2 | Type 2 - deep grey sands |
| 3 | Type 2 - deep grey sands |
| 4 | Types 1b and 1 c - shallow sands over iron pan |
| 5 | Types 1c and 2 - deep and shallow sands |
| 6 | Types 1c and 2 - deep and shallow sands |
| 7 | Type 1a - shallow red-brown sandy loam |

III-7

Methods:

pH (CaCl ₂)	pH (1 : 5) in 0.1M CaCl ₂
OrgC (W/B)	Organic Carbon C, Walkely and Black method
N (total)	Nitrogen N, total
Al (BaCl ₂)	Aluminium Al, extracted in 0.1 BaCl ₂
Ca (BaCl ₂)	Calcium Ca, extracted in 0.1M BaCl ₂
Mg (BaCl ₂)	Magnesium Mg, extracted in 0.1M BaCl ₂
Mn (BaCl ₂)	Manganese Mn, extracted in 0.1M BaCl ₂
K (BaCl ₂)	Potassium K, extracted in 0.1M BaCl ₂
Na (BaCl ₂)	Sodium Na, extracted in 0.1M BaCl ₂
P (HCO ₃)	Phosphorus P, extracted in 0.5M NaHCO ₃ (1:100)
K (HCO ₃)	Potassium K, extracted in 0.5M NaHCO ₃ (1:100)
Cu (AmOx)	Copper Cu, extracted in 0.2M ammonium oxalate
Zn (AmOx)	Zinc Zn, extracted in 0.2M ammonium oxalate

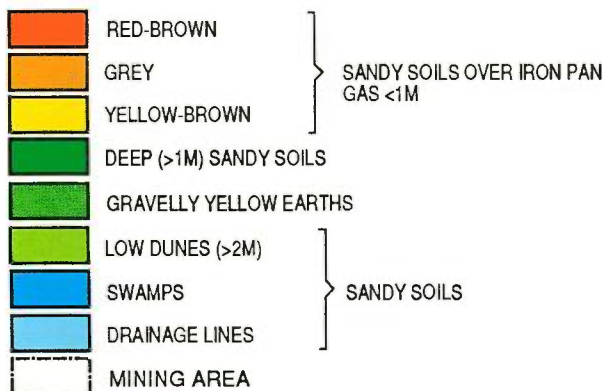
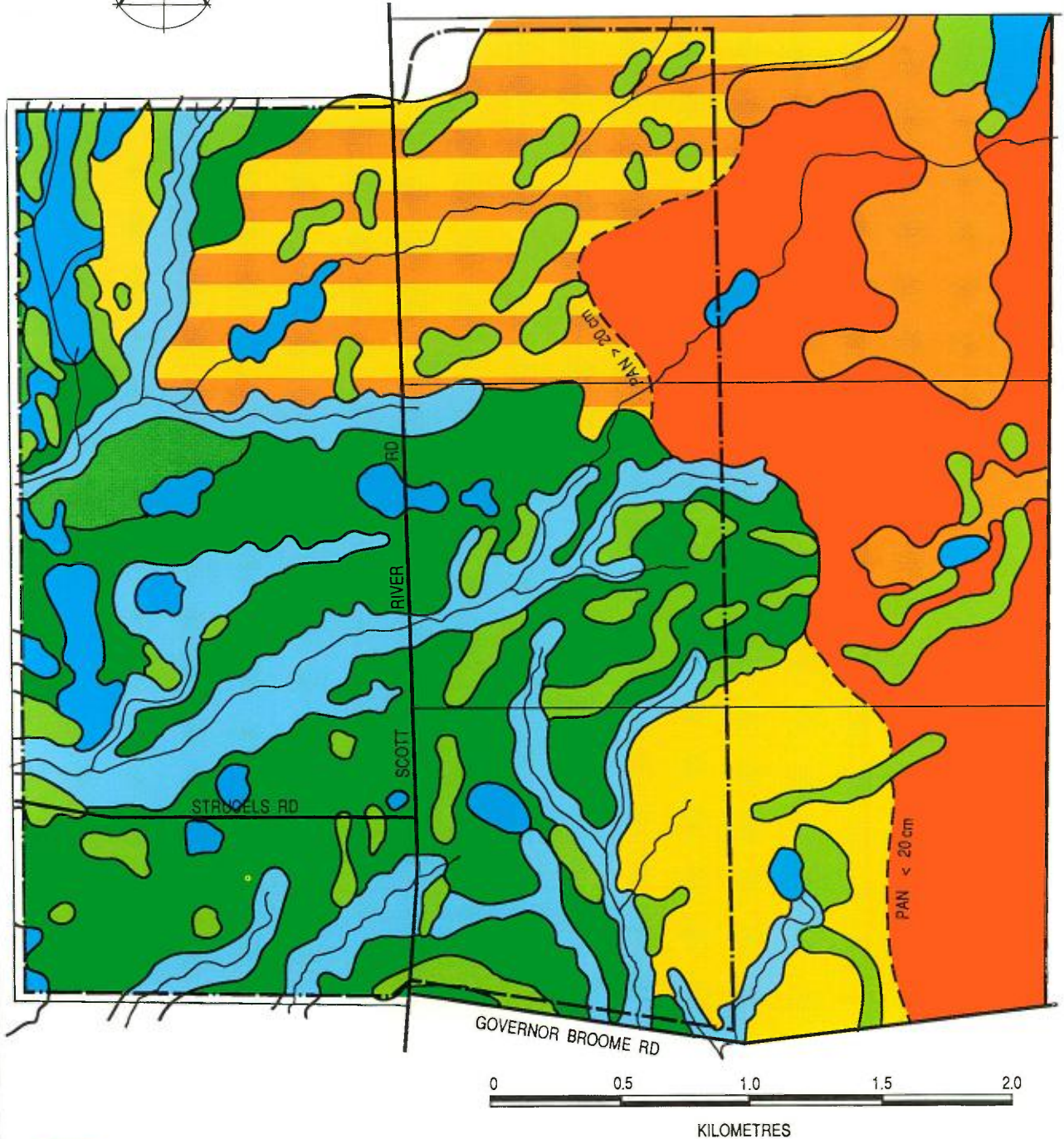


FIGURE III-1
Soils

Appendix IV

HYDROLOGY AND HYDROGEOLOGY

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HYDROLOGY AND HYDROGEOLOGY

by

Mackie Martin & Associates Pty. Ltd.

1.0 BACKGROUND

The mining of mineral sands most commonly involves dredging operations below the water table. Source water for such operations is derived almost entirely from porous storage within coastal sand deposits - excavation initiates seepage and as the pond is deepened, lateral inflows occur from more permeable sand horizons thus maintaining a ponded water level.

Exposure of the groundwater table to the environment provides a mechanism for rainfall and runoff to add water to dredge ponding, resulting in a rise in pond levels and flow back into aquifer systems due to the increased water heads. Conversely, the process of evaporation tends to act like a pump on the aquifer, resulting in a loss of water. As a result, the hydrodynamics of a dredging scheme are constrained by numerous variables including rainfall, evaporation, seasonal change, aquifer hydraulics, dredge pumping etc.

Mackie Martin & Associates (groundwater engineers & earth scientists) have been commissioned by Lewis Environmental Consultants on behalf of Mineral Deposits Limited to undertake an assessment of the hydrologic systems in the immediate vicinity of Beenup. Of particular importance to this study is the measurement of prevailing conditions and the likely impact of mining. In order to address these issues, it has been necessary to review the regional geology and local stratigraphy, identify surface and groundwater mechanisms and to develop a computer based model to explore the impact of dredging and to assess management options.

2.0 LOCATION AND GEOLOGICAL SETTING

The proposed mine site is located some 17 km northeast of Augusta in the south west region of Western Australia. This area falls within the Scott Coastal Plain, an extensive undulating plain comprising alluvial sands and silts deposited by the migration of the Blackwood and Scott Rivers in the course of geological evolution (see Figure IV-1). Changing flow and depositional cycles together with a prograding coastline combined to develop an intercalated sequence ranging from clays and silts to coarse sands.

Sediment succession is thick and ranges in age from Palaeozoic to Recent with a sequence of Pleistocene (or Late Tertiary) to Holocene dune and fluvio/shoreline deposits included. Heavy minerals are associated with fluvial deposits.

2.1 LOCAL STRATIGRAPHY

Over the course of site investigations undertaken by MMA, a total of 21 shallow exploratory piezometer sites were drilled (MMA series) and 14 test pumping bores were drilled (BTX series). Locations of drill sites are included on Figure IV-1. These bores, in addition to the BHP stratigraphic drilling (labelled with KE prefix) have helped define the local geology.

In the vicinity of the proposed mine site the stratigraphy comprises mostly silty and fine grained sands with occasional very coarse sand lenses, all dipping gently towards the coast. Continuity of layers can be mapped locally but on a more regional scale, both the intercalated nature and the likelihood of facies changes making recognition difficult.

Natural gamma emission geophysical logs obtained at groundwater exploration bore sites clearly show the variability of silt and clay materials.

Surficial units to depths of about 5 metres are generally more silty and indurated although neither the silt nor the induration (coffee rock) shows regional continuity.

3.0 HYDROLOGIC SYSTEM

Components of the local hydrologic system include surface waters (rainfall and runoff) and subsurface waters held in aquifer storage (infiltration and groundwater). Both are intimately connected with rainfall infiltration providing seasonal recharge to the aquifers, and groundwater migration slowly toward the rivers where riverbank seepage returns groundwater to the surface water system.

The hydrologic budget pertaining to dredging operations necessitates a consideration of rainfall, infiltration and runoff, dredge pond pumping, wet plant water usage and infiltrated returns (beneath tailings and slimes), evaporation, and aquifer recharge and losses through natural processes. Each component is discussed below.

3.1 RAINFALL AND RUNOFF

The region receives an average annual rainfall of about 1000 mm with most rains occurring during the winter months from May through September. In summer months high evaporation rates exceed rainfall by a significant margin.

Rainfall data are presented for 5 regional gauging stations at Figure IV-2. These locations include Alexandra Bridge, Cape Leeuwin, Manjimup, Margaret River and Springfield (Augusta). A regular seasonal cycle is observed as well as predictable yearly maximums and minimums (relatively low variance). High and low rainfall years are correlated through all stations (eg. 1970, 1974, 1988).

The areal variability of rainfall data has been assessed statistically by correlating individual station data on a monthly basis; a correlation matrix has been calculated and is provided in Table IV-1. A correlation coefficient of 1.0 indicates maximum similarity as is expected when a station is correlated against itself (identical data). A value of 0.5 suggests low correlation. Figure IV-3 presents a scatter diagram of monthly rainfalls for the Cape Leeuwin and Alexandra Bridge gauging stations. Variations in rainfall volumes received at each station are mostly indicated above 75 mm/month.

TABLE IV-1

Rainfall correlations for 5 gauging stations

Rain gauge		Cape L.	Alex Br.	Manjimup	Marg. R.	Spring
Cape L.	3	1.0	0.94	0.90	0.95	0.94
Alex. Br.	3		1.00	0.91	0.99	0.93
Manjimup	3			1.00	0.92	0.95
Marg. R.	3				1.00	0.93
Spring.	3					1.00

Correlation coefficients for the period 1970 - 1989

Reference to Table IV-1 indicates that all coefficients are greater than 0.9 while Alexandra Bridge and Margaret River show almost identical records with a coefficient of 0.99.

Whilst gauging data are unavailable for the proposed minesite, the high correlation of regional rainfall data and the proximity of the Alexandra Bridge gauging

IV-4

station suggest that similar rainfalls will be received within the general mine site area. Accordingly, Figure IV-4 presents the expected mean seasonal distribution of rainfall and evaporation.

Reference to this plot and in particular, the almost inverse relationship between rainfall and (potential) evaporation, suggests rainfall will exceed evaporation only for the period May through September.

A graph of the relationship between rainfall intensity, frequency and duration (IFD) has been generated for the area and is provided as Figure IV-5 (I.E.A., 1987) for design purposes. Expected catchment flows (through the mine area) for a 1 in 50 year recurrence interval calculated from this graph are included as Table IV-2.

TABLE IV-2

Catchment yields for a 1 in 50 year storm recurrence

Duration (hrs)	Intensity (mm/hr)	Volume (Ml/ha)	Catchment Total (Ml x 102)
0.5	58	0.29	5.51
1.0	36	0.36	6.84
2.0	23	0.46	8.74
3.0	17	0.51	9.69
6.0	12	0.72	13.68
12.0	7.3	0.87	16.53

Catchment area is calculated at 1900 ha.

High intensity events occurring during winter periods are likely to translate into runoff, whilst during summer and autumn such events would be infiltrated through relatively dry surface sands and runoff is likely to be minimal.

3.2 EVAPORATION

Evaporation exceeds rainfall (on average) during the period October to April with December through February typically exhibiting high potential evaporation.

Figure IV-4 shows mean monthly evaporation figures for the area. These data are calculated from actual evaporation isohyets supplied by the Commonwealth Bureau of Meteorology which are based upon available Class A pan evaporation

data. Pan estimates are often higher than observed rates for lakes and ponds. This is due to the relatively low capacities and shallow depths of pan devices. Corrections have been applied to attain the expected actual evaporation presented in Figure IV-4.

3.3 INFILTRATION

Figure IV-6 illustrates the difference between rainfall and evaporation on the yearly cycle. Clearly net accessions to the regional water table will occur in winter. With the onset of rains, the water table can be expected to rise rapidly. The prevailing groundwater levels are generally measured within 1 or 2 metres of surface and levels can therefore be expected to break surface and initiate runoff. This is consistent with field observations, the rapid rise being attributed to the presence of relatively silty and low porosity, low permeability material near surface.

Shallow perching of groundwater is noted to occur in areas of induration (coffee rock). These iron cemented layers are restricted in areal extent and act as a temporary base to infiltrating rainfall. In regions dominated by relatively permeable sands, water table accession is more pronounced. Rainfall infiltration will cease when the shallow formations become saturated and the water table rises to the surface. This results in large areas of ponding and inundation, leading to runoff along existing drainage patterns. This can persist until late spring. The whole system serves to re-distribute surface (and subsurface) waters through a process of runoff and re-infiltration down grade.

Monitoring of the water table has been conducted during the period May 1988 to January 1990 to assess the extent of fluctuations in response to rainfall. Figure IV-7 indicates typical responses where rises of about 1.5 metres are generally observed over most of the area; piezometer measurement locations are shown on Figure IV-1. This data, together with more extensive water table data collected at numerous shallow bore sites during May 1988, has been used to interpolate the prevailing water table geometry. Figure IV-8 illustrates this geometry where a mounding is seen to occur in the north east part of the area. This region has little or no developed drainage and represents a topographical divide between the Blackwood River to the north (and west) and the Scott River to the south. Subsurface flows are inferred outward from this area towards the rivers with the latter acting as regional hydraulic sinks, accepting and transporting seepage and runoff (see schematic arrows on Figure IV-8).

The volume rainfall acceding to the water table is controlled by several factors including the porosity and permeability of shallow materials, the depth to the water table, the extent of rainfall and the rate of evaporation. Typical seasonal water level variations of 1.5 metre are noted across the site. Assuming a

maximum effective porosity of 5% for shallow clean sands, this rise corresponds to an infiltration rate of about 6% of total rainfall.

Areas of very silty sand and areas of induration would offer lower permeability and porosity and hence infiltration is expected to be significantly less in these areas (as low as 1%) while runoff will be much higher.

4.0 AQUIFERS

Water enters the hydrogeologic system as rainfall, migrates through it under hydraulic grades defined by the water table, and departs the system as surface runoff or as riverbank seepage along the Blackwood and Scott Rivers.

Aquifers through which groundwater migrates provide intergranular storage in sand and silty sand units to depths in excess of 50 metres. Storage and permeability differ both vertically and horizontally however the system tends to act as a single unconfined aquifer with the upper surface (water table) at atmospheric pressure. Continuity in the curvature of the water table (as measured and presented in Figure IV-8) also suggests a single aquifer. Localised confinement by overlying more clayey layers may produce a discrete increase in aquifer pressures.

4.1 WATER QUALITY

Surface and groundwater quality in the region has been monitored over the period May 1988 through January 1990. Data have been collected from the Blackwood and Scott Rivers, 15 shallow monitoring bores and from 12 completed exploration bores. Sample locations are given on Figure IV-1. Additional chemical data have been compiled during drilling and test pumping operations.

All samples have been analysed for pH and conductivity, with complete analyses having been carried out on samples collected from the exploration bores. A summary of trends and surface/subsurface water characteristics are discussed in this document.

Surface water monitoring has been undertaken at two locations. Blackwood River samples were collected from Alexandra Bridge, and samples from the Scott River at Brennans Bridge. The Alexandra Bridge water is dominated by tidal influence and as a result the recorded salinity ranged up to 18000 mg/l, approximately half that of sea water. Water Authority records have been sourced and a gauging point at Darradup selected as being more representative of river water quality. Representative analysis of stream water samples are presented in Table IV-3.

TABLE IV-3

Water sample analyses from Blackwood and Scott Rivers

	Blackwood River (Darradup)	Scott River (Brennans Bridge)
pH	7.7	6.2
Cond. (fs/cm)	3080.0	223.0
TDS (mg/l)	1803.0	129.0
Ca (mg/l)	42.0	5.0
Mg (mg/l)	95.0	4.0
Na (mg/l)	474.0	32.0
K (mg/l)	6.0	2.0
HCO ³ (mg/l)	146.0	15.0
SO ⁴ (mg/l)	53.0	11.0
NO ³ (mg/l)	0.36	1.0
PO ⁴ (mg/l)	0.02	not detected
Cl (mg/l)	979.0	55.0
SiO ² (mg/l)	8.0	2.0

Note: Darradup is located approximately 40 km upstream of Sues Bridge. These results confirm brackish water in the Blackwood River and good quality water in the Scott River. The difference in water quality is mainly a function of land clearing for agriculture. The Blackwood catchment has had extensive development upstream, while the Scott River water quality reflects minor catchment clearing. As a consequence, water quality in the Scott River is considered to be more significant in terms of project constraints.

Comprehensive records of stream salinity are presented for both rivers. Figure IV-9 plots total salt annual variation from 1955 until 1989. The impact of land clearing is clearly evident on the water quality in the Blackwood River. The period up to 1975 demonstrates a moderate rise in flow weighted average total salt concentration to 1500 mg/l, followed by a marked increase to 3500 mg/l between 1976 and 1989. This rise correlates with additional clearing in respect of sub-catchments to the Blackwood.

In comparison, the Scott River demonstrates a consistently low salinity trend between 1969 and 1989.

Aquifer waters show minor variability in salinity and total chemistry.

IV-8

Groundwater samples obtained during construction of test bores indicate some variation in salinity in the vertical plane with discrete thin zones giving increased concentrations locally. This reflects hydraulic variations in lithology. Sections of moderate to high hydraulic conductivity are characterised by low salinity waters, while less permeable sections produce a groundwater with slightly higher salinity.

The bulk water quality yielded during test pumping is characterised by a low salinity groundwater. This has been confirmed by detailed measurement of salinity during test pumping. Table IV-4 presents a time series of total salts (salinity) during test pumping at bore BTX2. Bores BTX3 to BTX6 returned similar trends.

TABLE IV-4

Variation in total salt, pH and temperature during pumping at BTX2

Pumping time (Minutes)	Salinity mg/l	pH	Temp. °C
20	540	3.5	18.5
50	527	3.6	18.5
140	520	3.6	18.5
292	514	5.6	18.5
410	507	5.0	18.5
533	520	5.1	18.5
1020	507	5.8	18.5
1501	488	6.8	18.5
3015	472	6.0	18.5
4038	478	6.6	18.5
5454	475	5.9	18.5
6024	475	6.4	18.5
7357	475	6.2	18.5
8581	470	6.3	18.5

Groundwater samples were collected from 12 exploration bore sites during the course of field studies. These waters were submitted to NATA registered laboratories for determinations of a complete range of ionic and radiometric species.

Results are summarised in Table IV-5.

In addition to the analytical results provided in Table IV-5, a comprehensive suite of minor and trace elements were determined. These are presented in Table IV-6.

TABLE IV-5

Summary of water sample analyses from 12 bore sites

Sample Point and date	pH	Cond.	TDS	Ca	Mg	Na	K	HCO3	Cl	SO4	NO3	Fe	Gross alpha	Gross beta	Gross beta (K corrected)
BHP Nov 88	6.1	520	210	2.7	9.3	72	3.4	26	130	6.6	.5	11.0			
Nov 88	6.1	520	260	2.2	9.8	71	3.3	27	120	6.8	3.0	13.0			
BTX1 May 89	5.9	316	282	1.9	6.3	56	7.0	24	105	8	1.2				
Jan 90	3.7	238	266	5.4	9.8	24.6	6.6	24.6	46	16.6		0.26	180	840	645
BTX2 May 89	5.5	787	541	3.0	21.5	141	7.2	24	290	16	0.8				
Jan 90	5.8	871	536	3.8	22.0	138	7.1	21.1	265	19.1	0.9	<0.3	<100	940	730
BTX3 May 89	5.8	373	209	1.5	7.0	67.5	6.0	30	130	4	0.4				
Jan 90	5.9	413	247	6.3	11.8	58.1	7.6	51.5	106	8.5	<0.1	0.6	200	790	565
BTX4 May 89	5.7	382	259	1.8	9.0	69	4.5	25	140	10	1.1				
Jan 90	5.5	477	267	1.6	10.0	73.9	4.8	22.1	135	7.0	<0.1	<0.3	140	570	428
BTX5 May 89	5.7	355	293	1.9	7.3	66.5	6.9	30	115	15	0.8				
Jan 90	3.7	409	315	12.3	14.9	29.3	10.5	40	62	39.0		1.45	<100	770	459
BTX6 May 89	5.6	358	211	1.7	8.0	64.5	3.9	20	125	6.0	0.8				
Jan 90	5.4	430	190	12.1	8.8	65.6	3.1	17.3	118	6.6	<0.1	0.04	<100	550	458
BTX7 Jan 90	5.6	633	360	3.5	15.5	81.2	12.9	78.5	148	67.6	<0.1	<0.03	<100	1100	718
BTX8 Jan 90	5.5	683	436	17.0	12.6	68.3	55.1	9.0	138	08.0	23.0	<0.03	660	4500	2869
BTX9 Jan 90	5.4	460	243	0.9	8.3	66.5	5.6	31.2	120	14.4	<0.1	4.80	<100	380	214
BTX10 Jan 90	5.4	401	244	4.8	11.8	55.5	2.7	14.1	104	33.0	<0.1	0.80	<100	370	290
BTX11 Jan 90	5.0	326	206	0.7	4.6	53.3	5.0	7.0	98	2.7	<0.1	0.06	260	690	542
BTX12 Jan 90	5.3	321	157	2.6	7.4	47.5	4.4	8.2	90	13.7	<0.1	1.94	150	440	310

IV-10

TABLE IV-6

Chemical analyses of minor and trace metals

Sample Point	Ag mg/l	Al mg/l	As mg/l	Ba mg/l	Cd mg/l	Co mg/l	Cr mg/l	Cu mg/l	Fe mg/l	Mn mg/l	Mo mg/l	Ni mg/l	Total P mg/l	Pb mg/l	Y mg/l	Zn mg/l
BTX1	<0.01	0.25	<0.03	<0.02	<0.01	<0.01	<0.01	<0.02	0.26	0.01	<0.02	<0.02	6.00	<0.02	<0.02	<0.02
BTX2	<0.01	<0.05	<0.03	0.18	<0.01	<0.01	<0.01	<0.02	<0.03	0.32	<0.02	<0.02	<0.05	<0.02	<0.02	<0.02
BTX3	<0.01	<0.05	<0.03	0.05	<0.01	<0.01	<0.01	<0.02	0.60	0.10	<0.02	<0.02	<0.05	<0.02	<0.02	<0.02
BTX4	<0.01	<0.05	<0.03	0.10	<0.01	<0.01	<0.01	<0.02	<0.03	0.29	<0.02	<0.02	<0.05	<0.02	<0.02	<0.02
BTX5	<0.01	0.40	<0.03	<0.02	<0.01	<0.01	<0.01	<0.02	1.45	0.03	<0.02	<0.02	8.10	<0.02	<0.02	<0.02
BTX6	<0.01	<0.05	<0.03	0.05	<0.01	<0.01	<0.01	<0.02	0.04	0.20	<0.02	<0.02	<0.05	<0.02	<0.02	<0.02
BTX7	<0.01	0.25	<0.03	0.12	<0.01	<0.01	<0.01	<0.02	4.80	0.14	<0.02	<0.02	<0.05	<0.02	<0.02	<0.02
BTX8	<0.01	<0.05	<0.03	<0.02	<0.01	<0.01	<0.01	<0.02	<0.03	0.12	<0.02	<0.02	<0.05	<0.02	<0.02	<0.02
BTX9	<0.01	0.15	<0.03	0.06	<0.01	<0.01	<0.01	<0.02	0.80	0.12	<0.02	<0.02	<0.05	<0.02	<0.02	<0.02
BTX10	<0.01	<0.05	<0.03	<0.02	<0.01	<0.01	<0.01	<0.02	0.06	0.02	<0.02	<0.02	<0.05	<0.02	<0.02	<0.02
BTX11	<0.01	0.50	<0.03	0.07	<0.01	<0.01	<0.01	<0.02	1.94	0.10	<0.02	<0.02	<0.05	<0.02	<0.02	<0.02
BTX12	<0.01	<0.05	<0.03	0.06	<0.01	<0.01	<0.01	<0.02	<0.03	0.17	<0.02	<0.02	<0.05	<0.02	<0.02	<0.02

IV-12

All samples indicate good quality groundwater of low salinity, consistent with rainfall origins and dominant in sodium chloride and bicarbonate. BTX2 and BTX8 exhibit higher TDS values than most other samples and may be influenced by a more discrete zones of lower permeability material where waters have extended residence times.

Comparison with National Health and Medical Research Council guidelines for drinking water quality in Australia, suggests that all groundwaters are generally suitable for potable purposes. Iron levels are relatively high in almost half of the groundwater samples and would require treatment if the water was intended for domestic purposes. The guidelines are tabulated and presented as Table IV-7 for further reference.

TABLE IV-7

Guidelines for drinking water quality

Constituent	Acceptable Quality
pH	6.8 - 8.5
TDS	1000
Ca	75
Mg	50
Na	300
Fe	0.3
Mn	0.1
Cl	400
SO ₄	400
NO ₃	45
F	1 approx
Zn	5
Cr	0.05
Cd	0.005
CN	0.1
As	0.05
Pb	0.05
Hg	0.001
Se	0.01
Al	0.2
Cu	1
Ba	1
Ag	0.5

Guidelines For Drinking Water Quality in Australia (1987) - NH & MRC
Concentrations in mg/l except pH

A number of comments are applicable to these analytical results.

- ° Groundwater quality is consistent over time and, as expected, does not exhibit marked seasonal variations. The aquifer system is recharged annually by rain water which rapidly infiltrates to the groundwater system. As a result groundwater quality both locally and regionally will not be impacted by mining operations.
- ° No surface waters will be released from any area actively being mined, ensuring no discharge of process water to the Blackwood or Scott Rivers.
- ° Iron levels are relatively high and would require treatment if the water was intended for domestic purposes. The groundwater will only be used during the mining cycle and as such it would be expected that the iron will naturally oxidise and precipitate as ferric hydroxide within the dredge pond or tailings areas. This process occurs as the reduced iron (ferrous state) combines with oxygen from the atmosphere.
- ° Gross alpha and gross beta emissions for samples BTX1 to BTX12 display a range of values, consistent with groundwater sourced from a mineralised zone. Gross beta values are only detectable to a limit of 370 mBq/l and require correction for potassium content. Once these features are taken into account (Table IV-5), the levels reduce close to a nominated value recommended for drinking water by the NH&MRC guidelines (<100 mb/l). However as this water is not being used as a potable source of supply, the guidelines are rather arbitrary. They do however illustrate the radiation levels naturally occurring in regional aquifer systems. The radiation may be sourced from remnant thorium, deposited in hydrolyzate sediments. As this element is relatively stable in the natural decay sequence, the measured values are considered to represent the solubility constraints of the mineral.
- ° Nitrate values from bores BTX1, BTX5 and BTX8 (sampled in January 1990) are above background levels. This may be attributed to localised agricultural contamination or to reduced species in the natural organic materials. As the pH is low for those samples exhibiting high nitrate levels, the latter source is most likely.

- ° Total phosphorus is generally low except in BTX1 and BTX5. Recorded values are 6 and 8.1 mg/l respectively. Both bores are located at the same site, indicating that localised agricultural fertiliser contamination is the most probable source.

4.2 AQUIFER PROPERTIES

Aquifer hydraulic properties differ between the cleaner sands and the more silty sections. Typical hydraulic conductivity values of 5 to 30 m/day can be expected for clean sands while values as low as 0.0005 m/day are likely in the shallow indurated and cemented zones as well as the deeper silt beds. Hydraulic conductivity determined from pumping tests will reflect the average (or bulk) permeability over the tested interval (which will correspond to the screened section).

Bore testing has been conducted at 13 locations to assess the likely water transmission capacity. These tests have involved pumping at constant abstraction rates with simultaneous measurement of the decline in the water table (conventional pumping tests), followed by observation of the rate of recovery of water levels. Results have been analysed using computer based sensitivity analysis techniques (MMA; 1988 and MMA 1989) and are summarised in Table IV-8.

Pumping tests indicate a bulk conductivity of about 1.0 m/day and a specific yield of about 0.007 (0.7% effective porosity). In an hydraulic sense, these parameters indicate that water is not yielded or transmitted easily through the aquifer. Although some sections of clean sands were encountered in most test bores, measured hydraulic conductivity confirms their discontinuous nature and the presence of finer silt and clay size material throughout the profile. Induced depressurisation from boreholes, dredge ponding etc. will be restricted in radius of impact. Conversely, water table response to infiltration (a function of the porosity) will be rapid.

In addition to field hydraulic testing, a number of aquifer samples have been tested using falling head permeameter apparatus (flood compaction). Results are presented in Table IV-9.

TABLE IV-8

Summary of aquifer hydraulic properties

Bore	Depth (m)	Pumping Rate (kl/day)	Transmiss. (kl/day/m)	Bulk Perm. (m/day)	Estimated Storage Coefficient
BHP	58.0	215	90.0	0.4	0.013
BTX1	20.0	95	7.2	0.9	-
BTX2	24.5	345	45.6	1.9	-
BTX3	24.0	86	6.9	2.3	-
BTX4	41.0	270	34.5	1.6	0.002
BTX5	41.0	310	52.9	2.5	0.003
BTX6	58.0	400	9.8	0.2	0.003
BTX7	28.0	3	>0.6	0.02	-
BTX8	25.4	7	19.3	0.8	-
BTX9	27.0	11	5.2	0.2	-
BTX10	19.0	4	>1.1	0.06	-
BTX11	21.0	6	>0.5	0.02	-
BTX12	25.4	5	0.4	0.02	-

Transmiss. = transmissivity,
Bulk perm = Bulk permeability

TABLE IV-9

Summary of permeameter testing on discrete samples

Bore	Depth (m)	Permeability (discrete) (m/day)	Sample Composition
BTX7	9.0	1.6	SAND: fine, well sorted
BTX7	12.0	2.2	SAND: fine, well sorted
BTX7	17.0	0.6	SAND: fine, some clay
BTX7	22.0	16.2	SAND: medium to coarse
BTX8	9.0	5.8	SAND: fine to medium
BTX8	11.0	1.3	SILT: fine to medium
BTX3	15.0	1.1	SILT: with clay
BTX3	16.0	15.5	SAND: medium to coarse
BTX3	18.0	3.3	SAND: medium to coarse
BTX3	22.0	1.5	SAND: fine to medium
BTX9	14.0	1.0	SAND: fine to coarse
BTX9	27.0	45.0	SAND: fine to coarse
BTX10	13.0	0.8	SILT: and v.fine sand
BTX11	14.0	10.7	SAND: fine to v.coarse
BTX11	24.0	4.6	SAND: medium to v.coarse
BTX12	4.0	23.3	SAND: silty in places
BTX12	10.0	0.5	SILT: clayey + minor sand
BTX12	14.0	31.5	SAND: medium to v.coarse
BTX12	19.0	4.1	SAND: fine to coarse
BTX12	22.0	27.0	SAND: medium to coarse
BTX12	25.0	34.9	SAND: medium to coarse

Falling head permeameter apparatus used for testing.

Permeameter testing has been conducted for reconstituted (disturbed) samples under flood compaction. Results are therefore considered to reflect the absolute maximum hydraulic conductivity possible and *in situ* values will be lower due to overburden pressures and increased density/compaction. Tests indicate values in the range 0.5 to 45 m/day with a mean value of 11 m/day. Higher values (more permeable sections)

correspond to cleaner coarse sand horizons while lower values equate to silty sands and silts.

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5.0 GEOHYDROLOGY OF MINING

Dredging operations require a pond of sufficient size to support the dredge and wetplant, and with sufficient area to permit efficient dredge advance working both the shallow and deeper horizons. The volume of water retained in the pond must also provide adequate storage capacity to meet plant demand. The operation of this pond, the maintenance of water levels and the management of groundwaters depend intimately upon the aquifer system and upon prevailing seasonal weather conditions.

5.1 DREDGE POND WATER CIRCUIT

A dredging system with submerged reach of up to 50 metres will draw sand and silt material into the wet plant together with raw pond water. After processing, coarse tails will be dispatched to a tailings area at the side of the pond while fines will be dispatched to a slimes pond. Pumping of slurry and process water by the dredge and loss of water in production of concentrate, initiates a fall in pond levels as water is withdrawn from storage. This subsequently induces a differential head between the pond and the aquifer which in turn induces flow from aquifer storage into the pond and lowers the local water table. The lowering of the water table occurs with an exponential gradient away from the pond perimeter ie. steep gradients adjacent to the pond and shallow gradients in more distant areas. When the plant is shut down, the pond will initially continue to make water from the aquifer, and via water return from tails and slimes. Additional return from tailings/slimes after the pond level reaches the local water table will create a positive pond head, forcing flow back into the aquifer.

In the tailings area, process water will be returned to the pond via direct runoff and via vertical seepage through the tailings material. In the slimes area, process water will be permitted to still and fines (clay and silt size particles) will settle to the bottom of the pond thus developing a relatively impermeable

membrane and inhibiting vertical seepage. Cleaner waters will be decanted and pumped back to the dredge pond.

Approximate pond dimensions, exposed tails and slimes areas together with water consumption figures for the proposed operation may be summarised:

Typical pond area = 20 to 40 ha
 Proposed slimes area = 5 ha
 Expected tails area = 15 ha

Dredge uptake & raw water = 9.51 Megalitres per hour (MI/hr)

Pond return (from wet plant) = 1.77 MI/hr

Tailings = 4.27 MI/hr

Slimes = 3.43 MI/hr

Water loss to concentrate = 0.03 MI/hr

In addition to these volumes, further gains and losses to the system can be expected through rainfall and runoff:

Winter water loss to evaporation = 0.02 MI/hr

Summer water loss to evaporation = 0.10 MI/hr

Water gain from winter rainfall = 0.13 MI/hr

Water gain from summer rainfall = 0.02 MI/hr

The above figures serve to identify those components of the water budget which are likely to have greatest impact on the aquifer system. The process of production of concentrate consumes a predictable volume of water but greatest gains and losses to the operation are mostly attributed to the processes of rainfall and evaporation, both of which, are constrained by the physical dimensions of ponding and slimes/tails areas and by the seasonal conditions.

5.2 REGIONAL IMPACT

A computer based numerical model allows accurate simulation of expected conditions and assessment of the impact of changing hydrogeological parameters (incorporating spatial and temporal variability).

A distributed parameter finite element type scheme has been adopted (AQUIFEM, Wilson et.al. 1979) for the purpose. Using this approach, the region has been

discretised into a number of triangular elements each capable of simulating rainfall infiltration, aquifer transmission properties, and the lowering of pond water levels. These are assembled into a regional grid comprising 1003 triangular elements described by 535 nodes at their respective vertices, illustrated in Figure IV-10.

The finite element mesh is graded from coarse elements representing regional conditions to a finer mesh in the areas requiring greater detail over the proposed mine site. Within the mine site the mesh has been designed to evaluate groundwater management options around the perimeter (finer elements) whilst maintaining sufficient detail at dredge pond locations.

Southern and western boundaries of the modelled area have been located along the Scott and Blackwood Rivers respectively and nodes have been assigned constant piezometric head (ie. surface water levels are not expected to change significantly with time in response to tidal and or seasonal influences).

To the east and north, the nodes are either rising stream boundaries (surface water flow is generated from these nodes when the water table reaches surface) or regional flow line (streamline) boundaries where aquifer flow may occur along (parallel to) the boundary but not across it. In calibrating the model to simulate prevailing field measured conditions, the expected average aquifer properties have been assigned to each element, ie.;

$$\begin{aligned}\text{Hydraulic conductivity} &= 1 \text{ m/day,} \\ \text{Specific yield} &= 0.007.\end{aligned}$$

An aquifer base has been assigned at approximately 50 metres below ground level with the water table fluctuating at atmospheric pressure. Groundwater influx to maintain the hydraulic gradients measured in the area (Figure IV-8) is supplied by infiltrating rainfall. The net recharge to the shallow aquifer system has been adjusted in the model to obtain agreement with the measured water table geometry, having regard for seasonal variation in rainfall and evaporation.

Figure IV-11 illustrates modelled regional water table contours for early winter conditions. A mounding occurs in the north eastern part of the area and subsurface flows are directed towards the rivers. Contours reasonably equate to field measured conditions shown on Figure IV-8.

Figure IV-12 indicates modelled seasonal fluctuation in the water table for selected monitoring bore sites. Water levels are observed to rise rapidly with the onset of winter rains and in areas along drainages, the levels break surface, runoff is initiated and infiltration no longer occurs. The calibration process indicates that prevailing infiltration rates are of the order of 2% of rainfall in

autumn and early winter, falling to almost zero by early spring as the water table rises and runoff peaks.

Individual monitoring bore data presented in Figure IV-12 suggests groundwater fluctuations are matched by the numerical model, however some discrepancies in absolute levels are noted. The initial water level recorded at MMA9 is approximately 1.3 metres below the simulated level for May 1988. This corresponds to the influence of initial conditions in the numerical model, with simulated levels matching monitoring data over the second half of the 18 month calibration period. Absolute levels are a function of local aquifer conditions while numerical results will be affected by the local grid definition. Given the reasonable match between regional groundwater contours and seasonal trends it may be assumed that the numerical model reliably emulates the water balance and response to groundwater fluxes.

6.0 IMPACT PREDICTION

The model has been used to assess likely impact of mining operations on the regional water table. As noted previously, net gains to the water table will occur from rainfall (and runoff) entering the dredge pond or infiltrating through shallow sands while losses will occur mainly through evaporation from exposed water surfaces (pond, slimes and tails) and concentrate production.

The impact of dredging operations on the hydrogeologic system, is seasonally dependent.

Table IV-10 summarises the pond water balance under average rainfall and evaporation assuming a 30 hectare pond size. Rainfall is translated into monthly water gains in the system while evaporation is translated into monthly water losses. Calculated pond level changes assume minimal time lag in return of tailings and slimes waters to the dredge pond.

Zero balance of the pond water budget occurs at the end of April and in September ie. the cumulative processes of rainfall, evaporation and process water usage are balanced.

During average summer (deficit) months, evaporative and process water losses amount to 432 MI. This corresponds to a maximum fall in the pond level (30 ha) of less than 0.3 metres per month as indicated in the last column. Over winter months, only 160 MI is contributed directly from rainfall after accounting for process water and thus, an imbalance of 272 MI prevails. This volume is almost equivalent to the total annual losses from concentrate production - estimated at 288 MI. This net annual loss of water (estimated for average rainfall and evaporation) corresponds to a pond elevation change (decline) of

0.91 metres. Offsetting this pond decline will be groundwater inflow to the pond. Thus on average, the actual annual pond water level decline, without makeup water, would be less than 0.91 metres.

Predicted water level decline has been calculated from the numerical model, assuming groundwater is removed from the dredge pond as a function of the net evaporative loss (Table IV-10). At the end of summer, the total decline is less than 0.4 metre, with impact confined well within one kilometre of the dredge pond. Figure IV-13 shows the location of the 0.1 metre water level decline contour prior to the onset of winter rains.

TABLE IV-10

Pond seasonal water balance for shallow dredging operations

Month	Mean Regional Rainfall (mm)	Pond Volume Excess (Ml)	Tails Volume Excess (Ml)	Slimes Volume Excess (Ml)	Regional Evap. (Potential) (mm)	Pond Volume Loss (Ml)	Tails Volume Loss (Ml)	Slimes Volume Loss (Ml)	Concentrate Losses (Ml)	Total Of Fluxes (Ml)	Change in Pond Level (m)
Jan	17	5.10	2.55	0.85	140	42.00	21.00	7.00	24.00	-85.50	< -0.28
Feb	16	4.80	2.40	0.80	130	39.00	19.50	6.50	24.00	-81.00	< -0.27
Mar	30	9.00	4.50	1.50	110	33.00	16.50	5.50	24.00	-64.00	< -0.21
Apr	63	18.90	9.45	3.15	65	19.50	9.75	3.25	24.00	-25.00	< -0.08
May	145	43.50	21.75	7.25	50	15.00	7.50	2.50	24.00	23.50	< +0.07
Jun	183	54.90	27.45	9.15	25	7.50	3.75	1.25	24.00	55.00	< +0.18
Jul	187	56.10	28.05	9.35	25	7.50	3.75	1.25	24.00	57.00	< +0.19
Aug	138	41.40	20.70	6.90	40	12.00	6.00	2.00	24.00	25.00	< +0.08
Sep	91	27.30	13.65	4.55	50	15.00	7.50	2.50	24.00	-3.50	< -0.01
Oct	69	20.70	10.35	3.45	80	24.00	12.00	4.00	24.00	-29.50	< -0.10
Nov	37	11.10	5.55	1.85	100	30.00	15.00	5.00	24.00	-55.50	< -0.18
Dec	22	6.60	3.30	1.10	150	45.00	22.50	7.50	24.00	-88.00	< -0.29

Pond volumes (excess and loss) determined for 30 ha exposed pond, 15 ha wet tails surface area and 5 ha slimes dam.

Equivalent Change in Pond Level refers to absolute monthly water level changes assuming no inflow from regional aquifers.

6.1 WATER TABLE MANAGEMENT

As discussed, the depth of mining of shallow sands is a function of dredge reach (up to 50 metres) and the seasonal fluctuation of the water table. The impact of such operations on the regional water table will be entirely related to pond seasonal (and process water) losses as defined above in Table IV-10.

During the period May through August, sufficient rains are received to maintain pond water levels at a zero impact level. Indeed excess waters will need to be pumped to storage/waste. From September onwards, the deficit in the water balance will induce a small but steady decline in the water table creating an impact of somewhat less than 0.3 metres per month at the pond perimeter. On a month by month basis this will result in a negligible impact at a distance of several hundred metres from the pond, however the longer term cumulative water level decline would propagate away from the mined area. Figure IV-13 shows the location of the 0.1 metre drawdown contour at the end of summer under average climatic conditions.

To achieve zero impact, it will be necessary to supply make up water to the dredge pond at a monthly rate consistent with identified losses. These losses are summarised in Table IV-11 (last column), incorporating a 15% allowance for seasonal variation on design flows (accounting for variations in local climatic conditions in the absence of detailed local evaporation data).

Makeup water can be obtained during summer months by the diversion of runoff into the dredge pond, or by decanting the stilling reservoir and/ or augmenting via the installation of several boreholes. Bores will be completed in the Lesueur Formation at a depth of between 150 and 200 metres where good quality water with sufficient yield is expected.

The impact of groundwater withdrawal from within this deep section of the aquifer system will not adversely affect water levels in the shallow aquifer. Intercalated clays and silts located above the pumping zone will effectively confine depressurisation to these lower horizons.

TABLE IV-11

Make up water requirements for dredge operation

Month	Total of Fluxes (MI/month)	Total of Fluxes (MI/day)	Design Flows (+15%) (of fluxes) (MI/day)
Jan	-85.50	-2.76	3.2
Feb	-81.00	-2.89	3.3
Mar	-64.00	-2.06	2.4
Apr	-25.00	-0.83	1.0
May	23.50	0.76	0.0
Jun	55.00	1.83	0.0
Jul	57.00	1.84	0.0
Aug	25.00	0.80	0.0
Sep	-3.50	-0.11	0.1
Oct	-29.5	-0.95	1.1
Nov	-55.5	-1.85	2.1
Dec	-88.0	-2.84	3.3

Note: Design flows make provision for some seasonal variance.

6.2 SURFACE WATER MANAGEMENT

The general lease area is relatively flat lying and dissected by three shallow first order drainages which rise in the north east of the site (higher ground along the drainage divide) and discharge to the south and south west into the Scott and Blackwood Rivers. The widespread occurrence of shallow sands and silty material provides for infiltration to the groundwater system and relatively low runoff during the early part of the rainy season. The water table rises rapidly in response to infiltration and within a month, runoff is generally initiated. This runoff is sustained throughout much of the wet period with more than 80% of rainfall estimated to drain to the river.

Drainage sections vary from broad (shallow) stable profiles on the higher ground to narrower slightly steeper but generally stable sections in the south west. Flows within these drainages are seasonally dependent with zero flow during summer periods and peak flows during winter. Flat lying ground induces localised

inundation during higher intensity rainfall, and surface saturation may persist as swampy and boggy ground through spring. Depth of water in these areas has been observed at more than 1 metre. Most of the area has dried out by summer and some hard pan is evident.

Dredging operations will migrate across the various drainages in the normal course of operations. In areas of mining close to the site perimeter, temporary diversions of drainage will be made to other drainage depressions. Rain falling on the pond which is not required for mining operations will be pumped to the stilling reservoir from where it will be discharged to the natural drainage after settling. Water may also be retained in this reservoir for use during peak summer evaporation periods to supplement dredging operations. Rehabilitated areas will be reshaped to approximate original drainage where appropriate.

Local diversions will be excavated around slimes and tailings areas to maintain or improve site drainage.

Under-road drainage will be installed on access roads.

7.0 WATER MONITORING

Monitoring of regional water tables is presently conducted on a quarterly basis. While this is sufficient to establish the seasonal water table movements, it is recommended that additional monitoring bores be installed and measurements intensified to weekly during the early stages of mine development. In addition, several continuous recording data loggers should be strategically located and all data assimilated to assess the aquifer response to dredging.

Diverted surface water (to alternate drainages) will be permitted to free drain however, waters directed to the dredge pond or released from the stilling reservoir will be monitored to ensure particulate matter (silt load) is equivalent to, or lower than natural drainage water loads.

A new monitoring station will be established on the Blackwood River downstream of the mine site.

After the first two years of operations, a relatively accurate understanding is expected to evolve in terms of the relationship between seasonal weather patterns, runoff, infiltration, dredging operations and aquifer water tables. Numerical modelling of the scheme will be upgraded at this time to assist in managing operations.

8.0 CONCLUDING REMARKS

The current study has been undertaken to assess the implications of dredging on the regional water table and to quantify the water balance and water quality relating thereto.

In determining water demands, it has been necessary to review local rainfall and evaporation, to undertake analyses to determine likely gains and losses attributed to these components, and to assess the relative impact on groundwater systems using a computer numerical model.

For shallow sand mining, the water circuit comprises gains to the pond, tails and slimes area due to rainfall, and losses to the circuit due to evaporation and concentrate production. The following points are noted:

- ° Rainfall is generally uniform over the region with exceptionally high correlations between local gauging stations;
- ° Groundwater quality is consistent over time and, as expected, does not exhibit marked seasonal variations. The aquifer system is recharged annually by rain water which rapidly infiltrates to the groundwater system. As a result groundwater quality both locally and regionally will not be impacted by mining operations.
- ° Rainfall exceeds evaporation during winter months while evaporation exceeds rainfall during summer months with a zero balance occurring at the end of April and in September. Gains and losses are approximately balanced in the annual cycle.
- ° For dredging, plant water uptake is proposed at a rate of 9.5 megalitres (MI) per hour of which most will be returned to the dredge pond via wet plant spill, and via tails and slimes returns. Concentrate production will consume 35 KI/hour or 0.8 MI/day of dredge pond water.
- ° Losses to the water circuit after accounting for rainfall, evaporation and process water are 2.8 MI/day during summer months falling to zero losses (and showing net gains) during winter. Additional water from other sources is therefore required to meet these losses in order to prevent a fall in dredge pond water levels during summer - a design supply of 3.2 MI/day is proposed.
- ° Make up water may be obtained through provision of on site storage which accumulates surplus runoff during winter, or from water bores

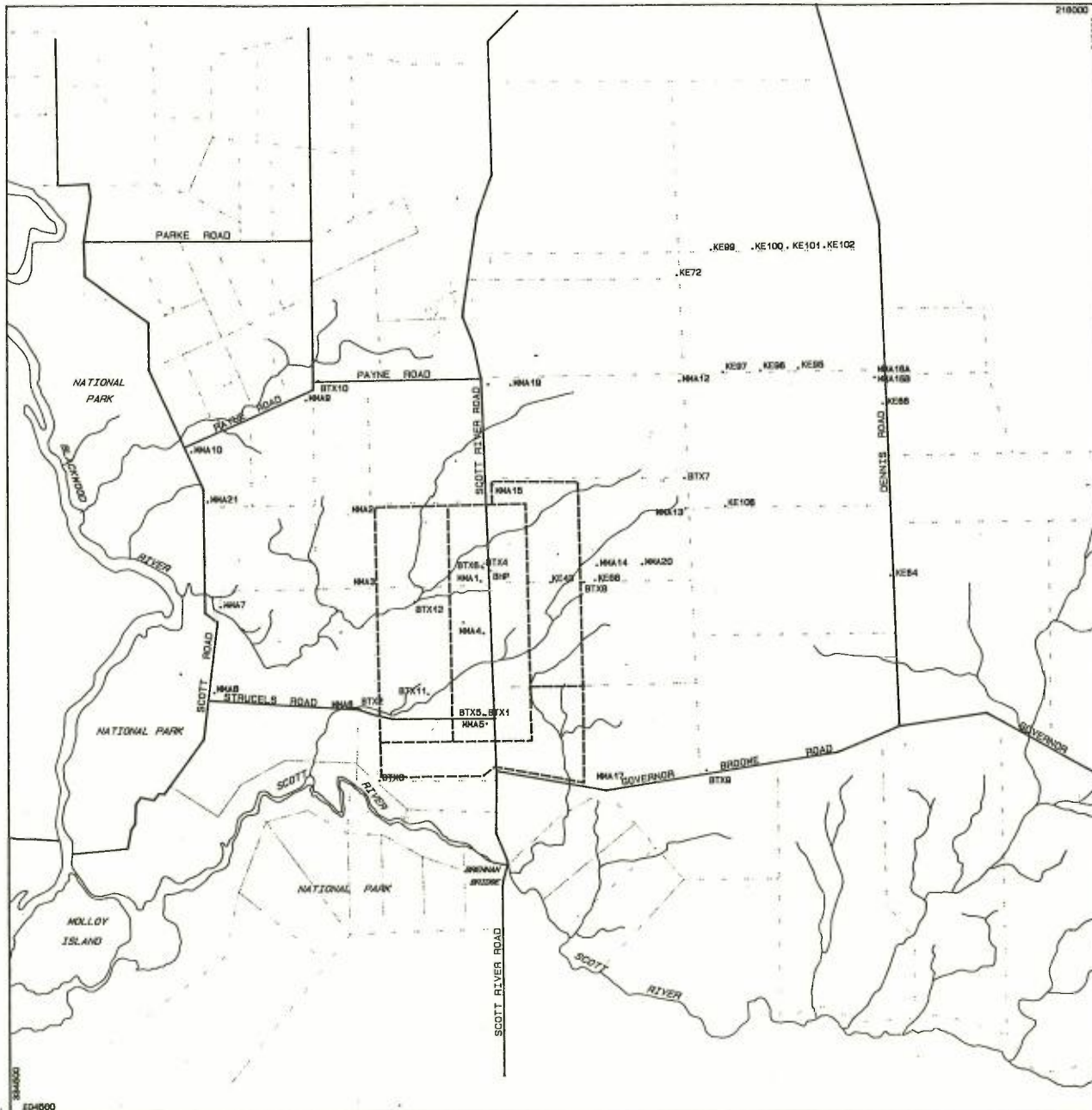
sunk into the deeper Lesueur aquifer where water yields and qualities are suitable for process purposes. The latter option is preferred.

- ° Regional impact of shallow heavy mineral mining is expected to be negligible providing dredge pond levels are maintained at the same level as measured groundwater levels.

Surface waters occurring within the mine site area present no special problems for drainage. The construction of diversion channels or the redirection of waters to the slimes pond or stilling reservoir provides a measure of staging.

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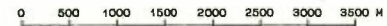
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BHP-UTAH MINERALS INTERNATIONAL
 BEENUP MINERAL SANDS PROJECT
 HYDROGEOLOGICAL STUDIES
 ON BEHALF OF
 LEWIS ENVIRONMENTAL CONSULTANTS

- LEGEND:
 - - - - - PORTION BOUNDARIES
 - - - - - PERIMETER OF PROPOSED MINING AREA (DREDGE BLOCKS)
 • MA19 EXPLORATION BORE SITE

NOTES:
 GEOGRAPHIC DATA DIGITIZED FROM 1:50000 PUBLISHED TOPD. SHEETS



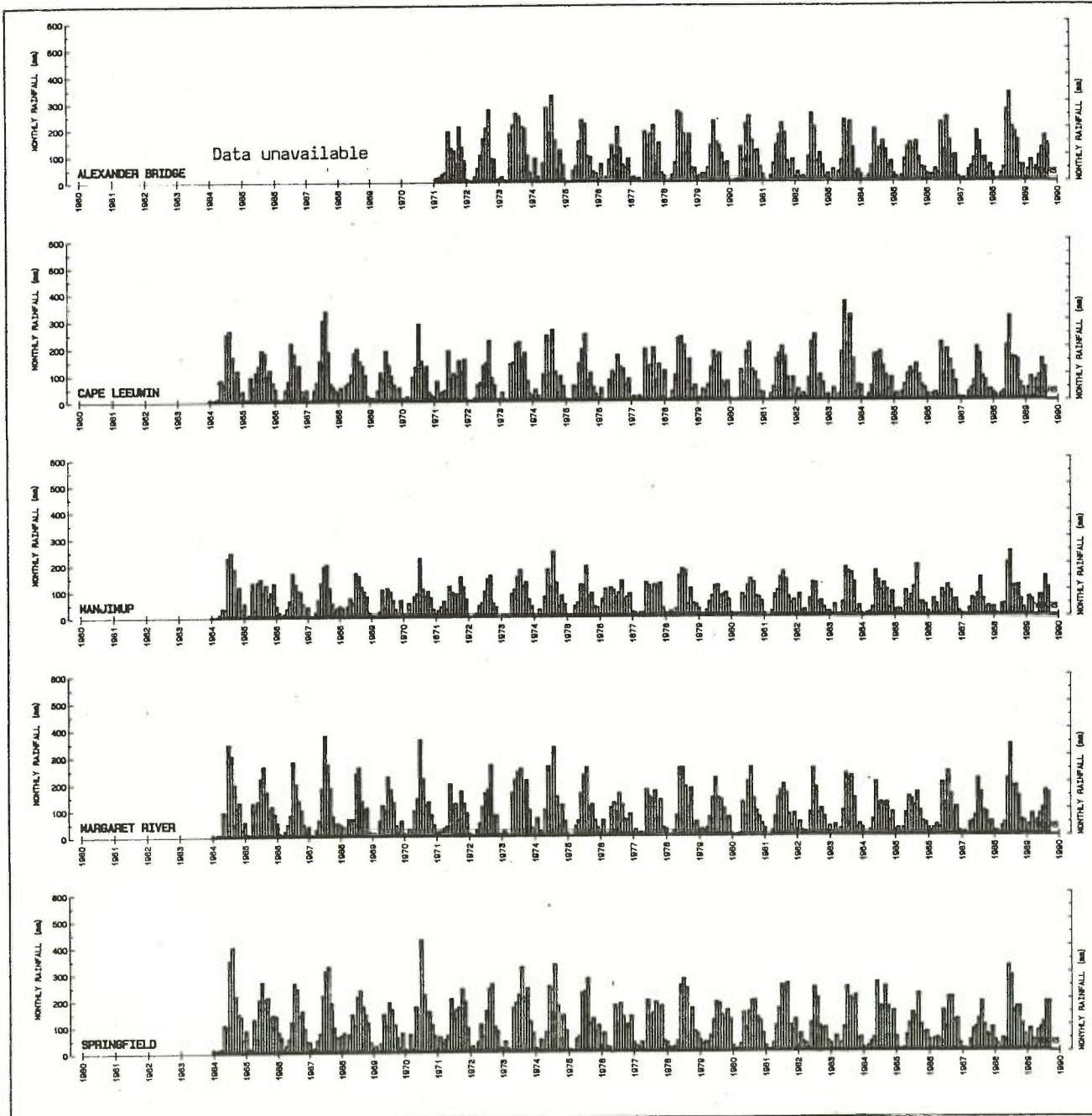
DRAWN SCALE 1:50000

GENERAL LOCALITY PLAN

FIGURE IV-1

BHP-UTAH MINERALS INTERNATIONAL
 BEENUP MINERAL SANDS PROJECT
 HYDROGEOLOGICAL STUDIES
 ON BEHALF OF
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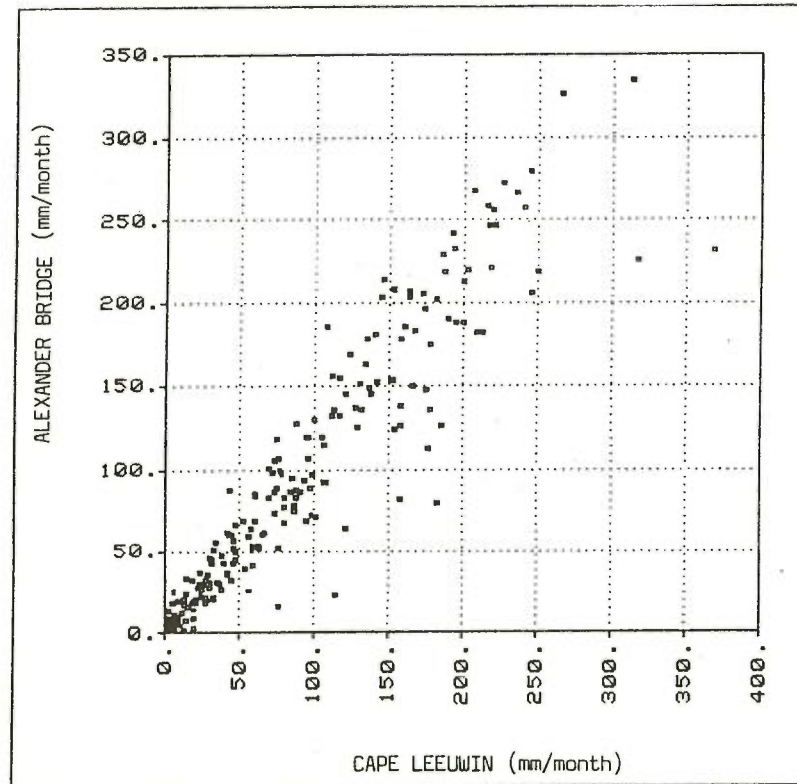
NOTES:
 DATA OBTAINED FROM DEPT. OF METEOROLOGY NATIONAL RECORDS



HISTORICAL MONTHLY RAINFALL
 OVER THE AUGUSTA REGION
 FOR THE LAST 25 YEARS

FIGURE IV-2

RAINFALL CORRELATION - CAPE LEEUWIN & ALEXANDER BRIDGE



SCATTER PLOT & STATISTICS

STATISTICS:

X1 MEAN	8.611E+01
X1 VARIANCE	5.498E+03
X1 ST.DEV.	7.415E+01
X2 MEAN	8.981E+01
X2 VARIANCE	6.138E+03
X2 ST.DEV.	7.835E+01
COVARIANCE	5.455E+03
CORRELATION R	9.389E-01

ALEXANDER BRIDGE
&
CAPE LEEUWIN

FIGURE IV-3

REGIONAL RAINFALL & EVAPORATION
(CAPE LEEUWIN)

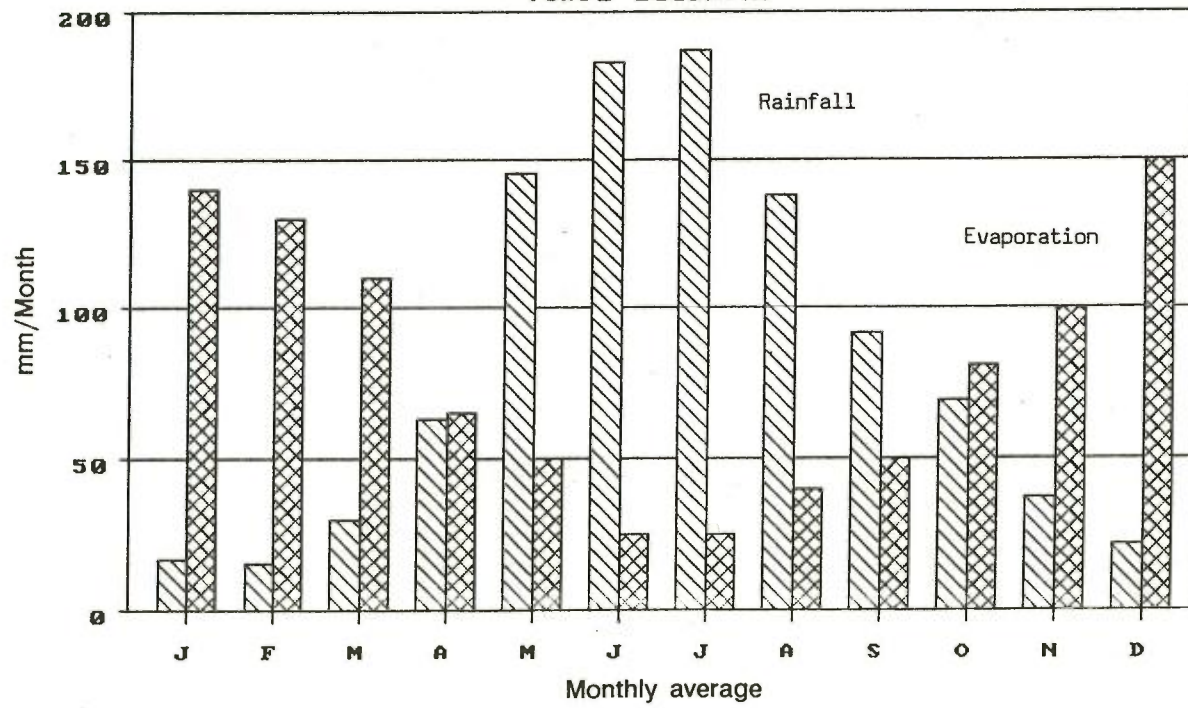


FIGURE IV-4

RAINFALL INTENSITY-FREQUENCY-DURATION PLOT FOR THE BEENUP AREA

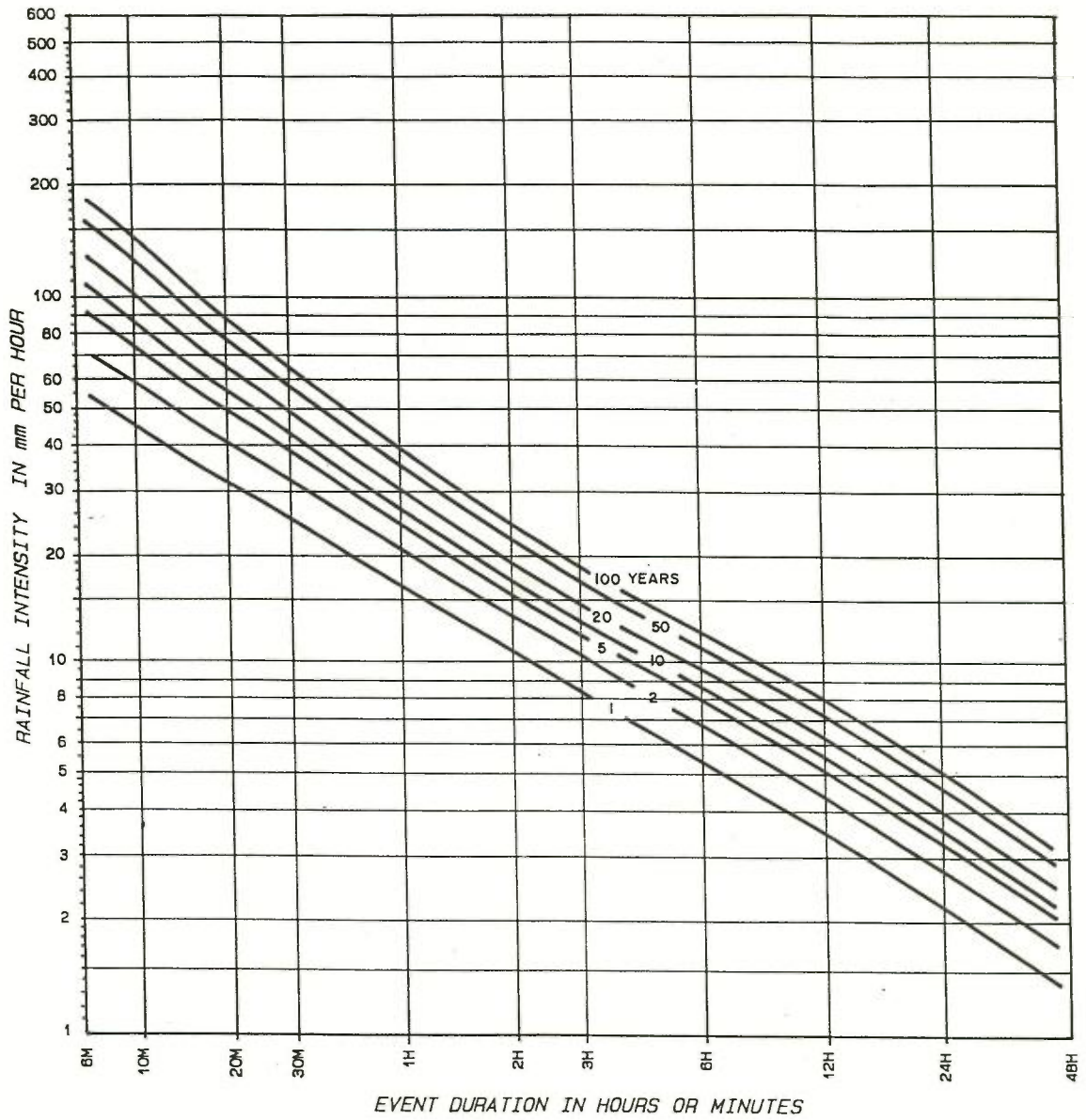


FIGURE IV-5

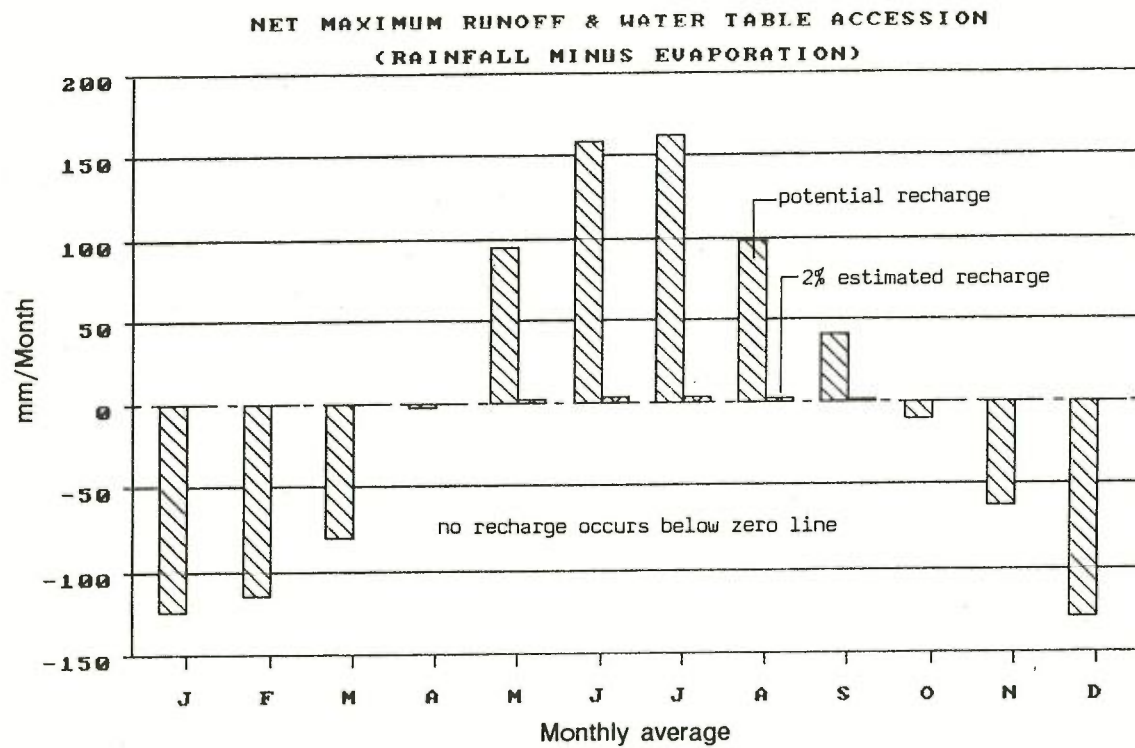


FIGURE IV-6

PIEZOMETER MONITORING DATA

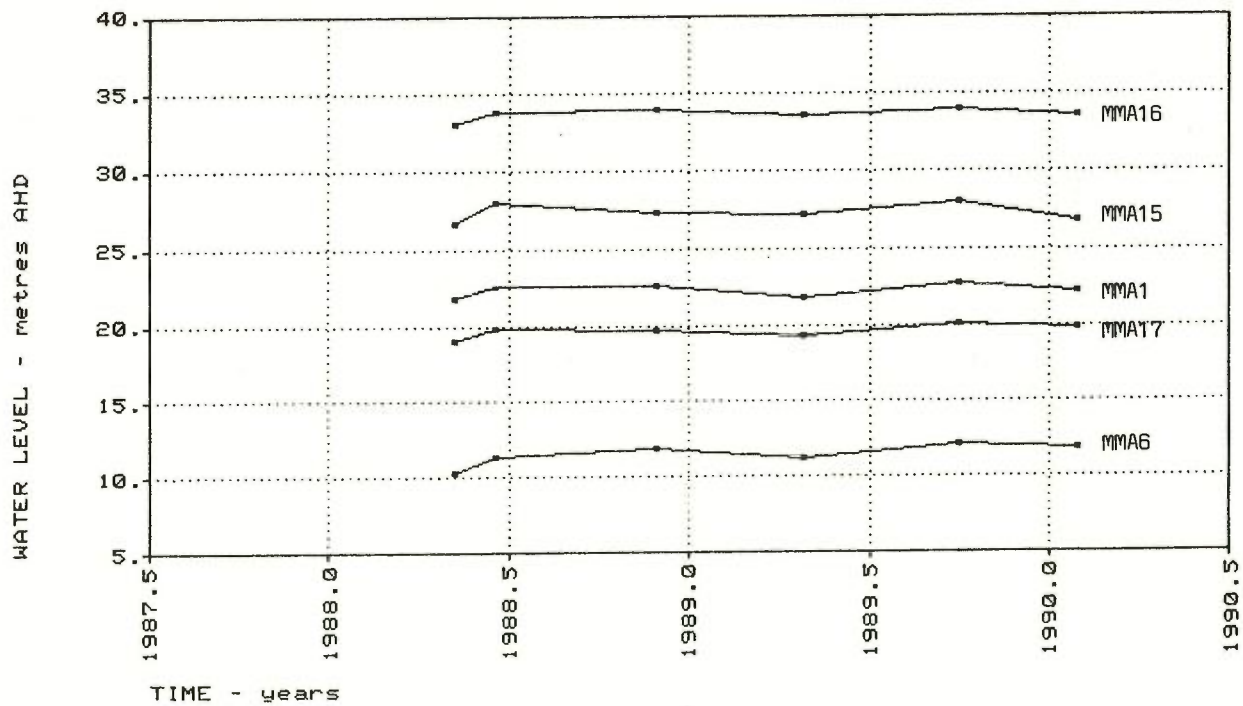
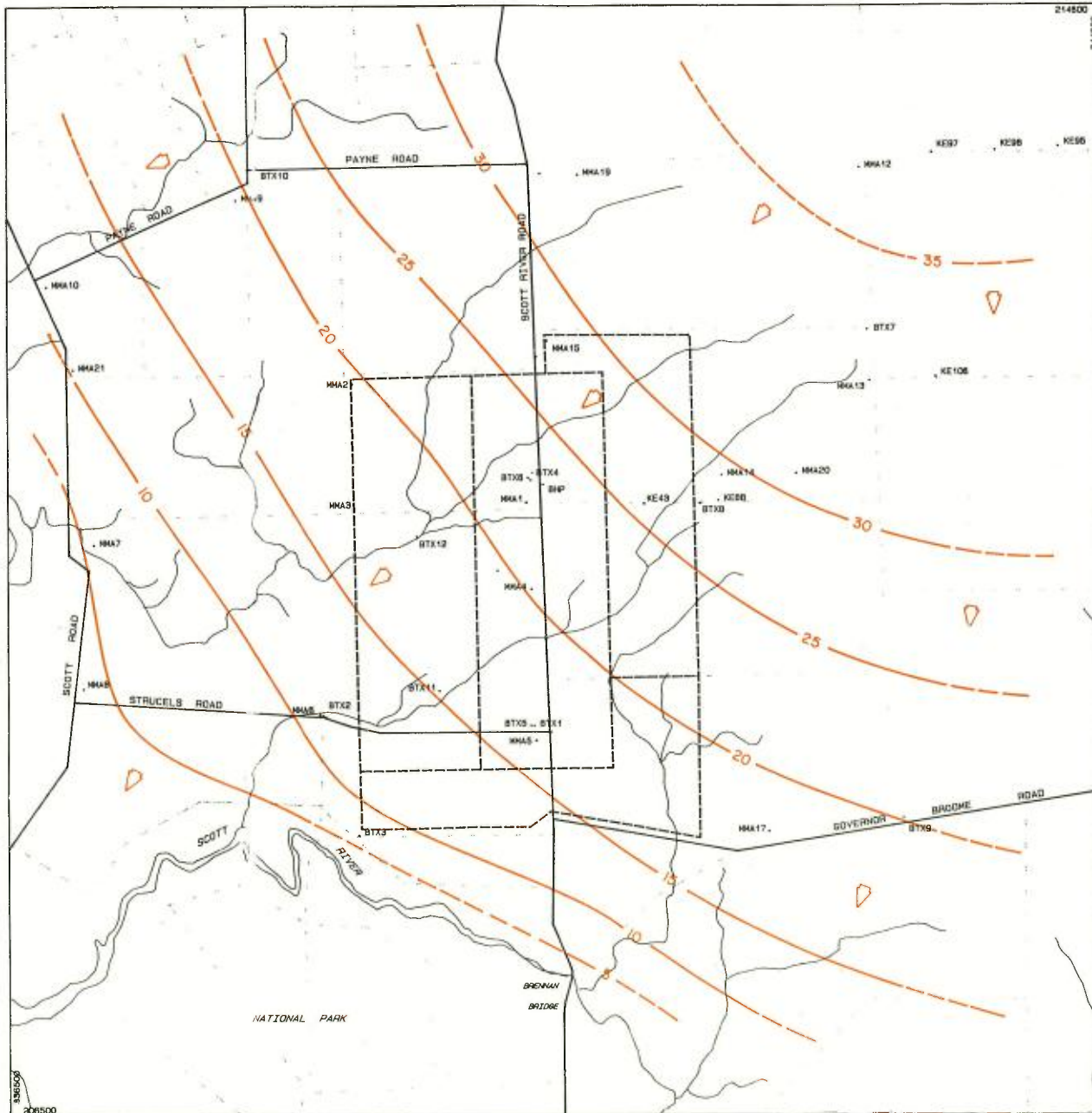


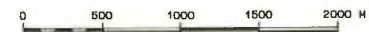
FIGURE IV-7



BHP-UTAH MINERALS INTERNATIONAL
 BEENUP MINERAL SANDS PROJECT
 HYDROGEOLOGICAL STUDIES
 ON BEHALF OF
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- LEGEND:
- - - PARTITION BOUNDARIES
 - PERIMETER OF PROPOSED MINING AREA (DREDGE BLOCKS)
 - WATER TABLE CONTOURS (metres AHD)
 - MHA EXPLORATION BORE SITE
 - △ GROUNDWATER FLOW DIRECTION

NOTES:
 IMPACT HAS BEEN DETERMINED BY SUBTRACTING WATER LEVELS
 CALCULATED FOR DREDGING FROM WATER LEVELS DETERMINED
 FOR PRISTINE CONDITIONS - STEADY STATE



DRAWN SCALE 1:30000

LOCAL WATER TABLE INTERPOLATED
 FROM BOREHOLE MEASUREMENTS

FIGURE IV-8

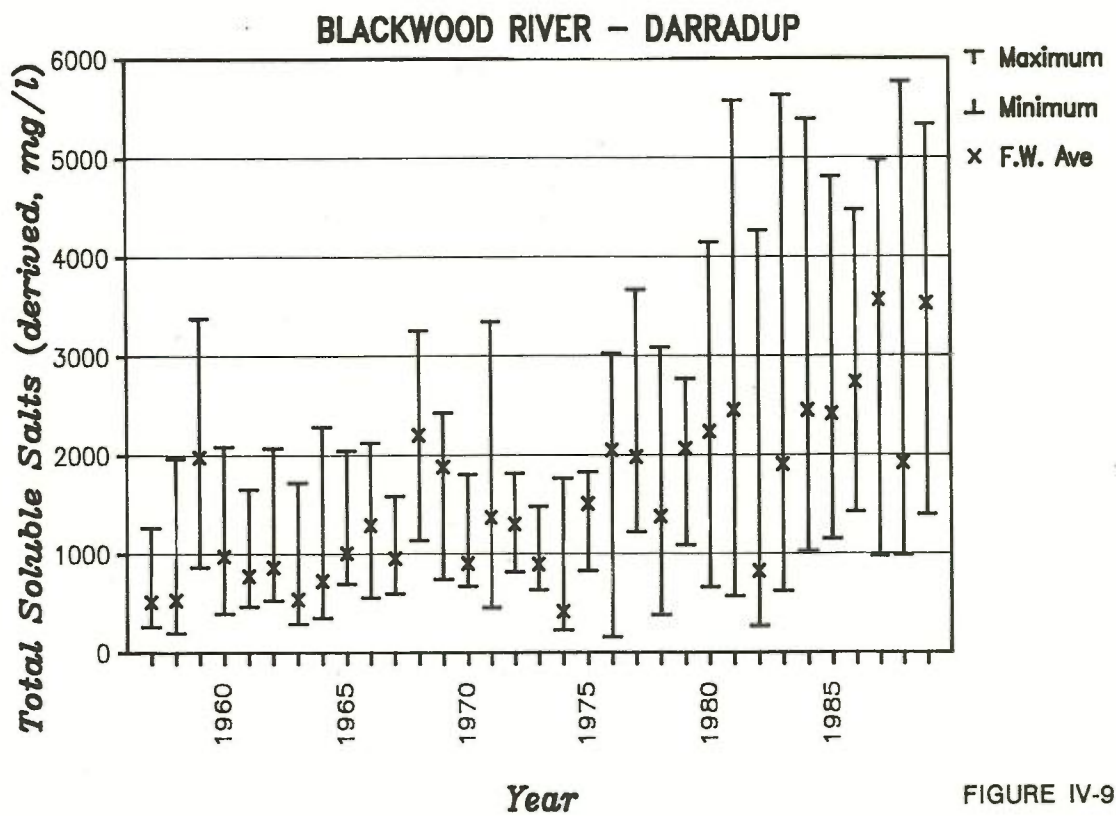
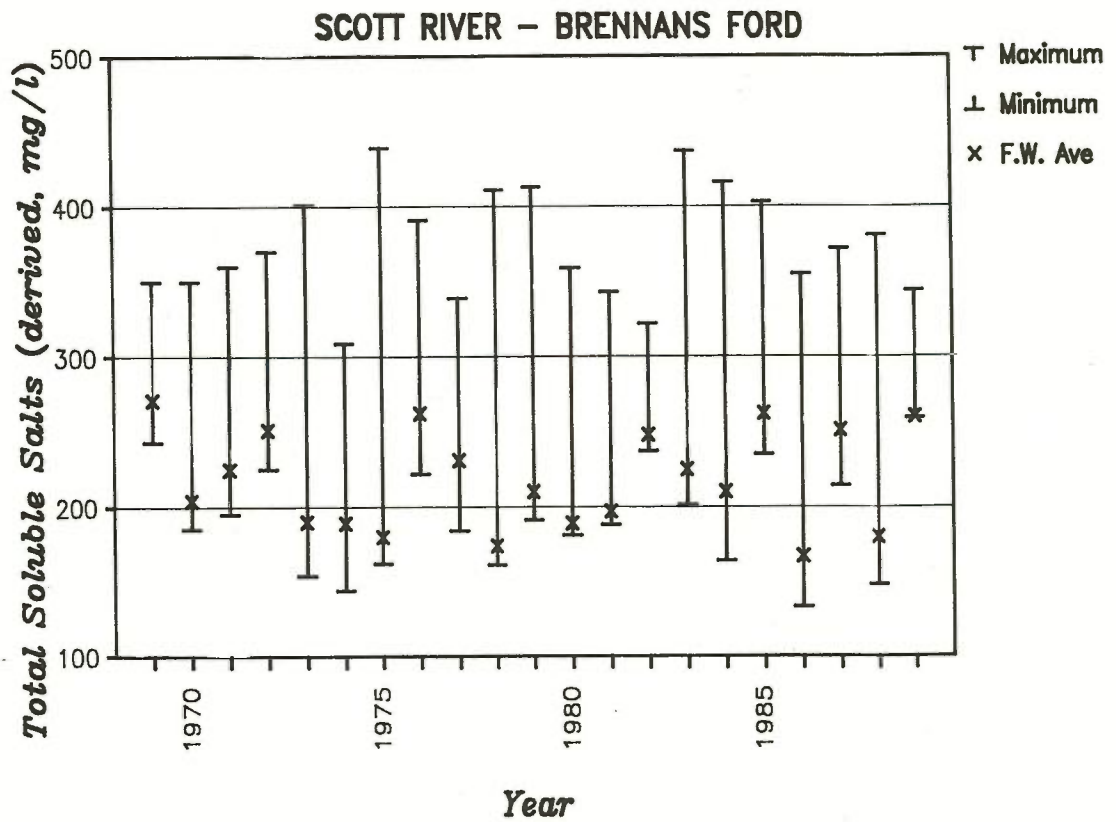
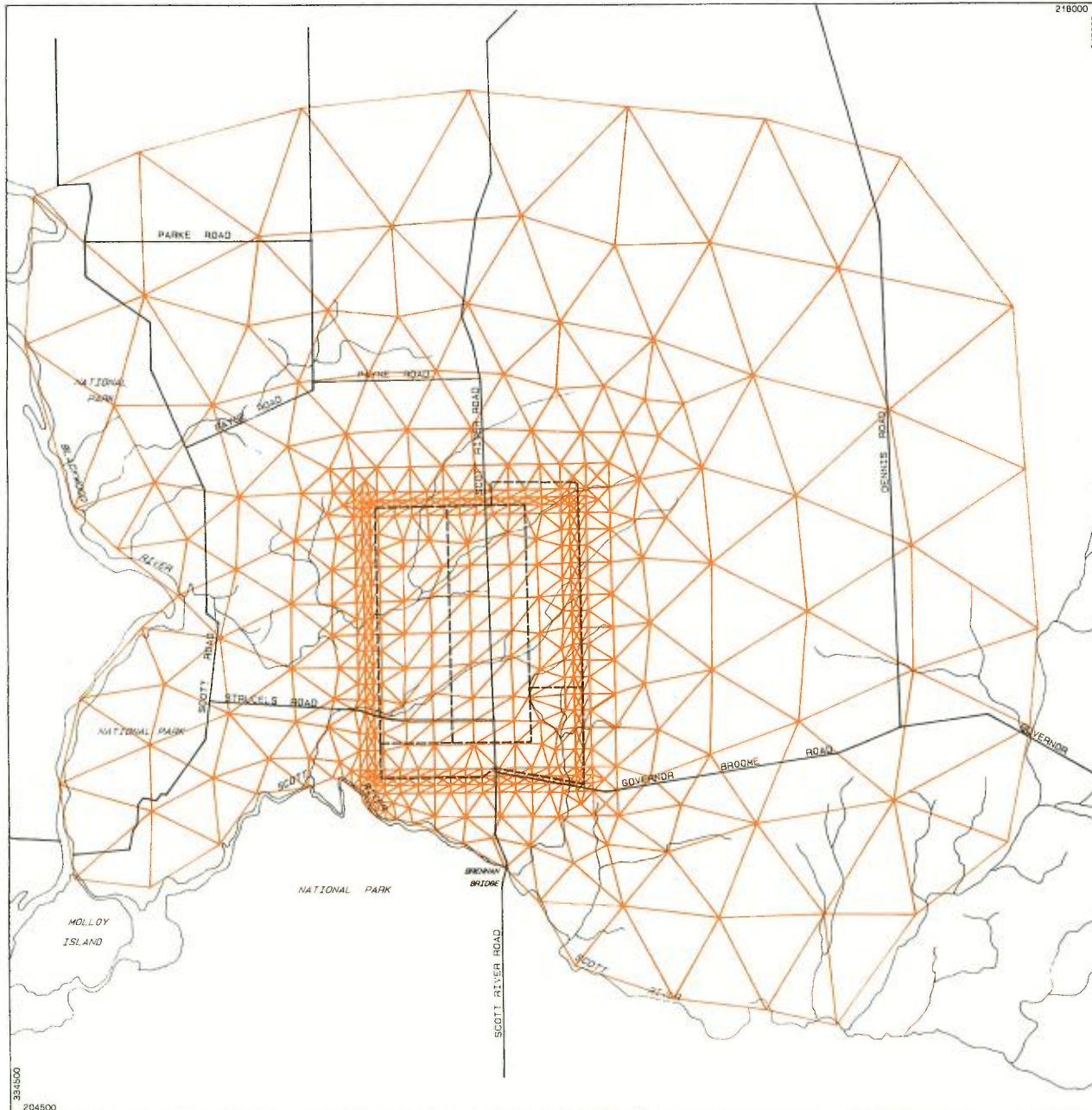


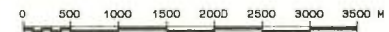
FIGURE IV-9



BHP-UTAH MINERALS INTERNATIONAL
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 ON BEHALF OF
 LEWIS ENVIRONMENTAL CONSULTANTS

LEGEND:
 — PERIMETER OF PROPOSED MINING AREA (DREDGE BLOCKS)

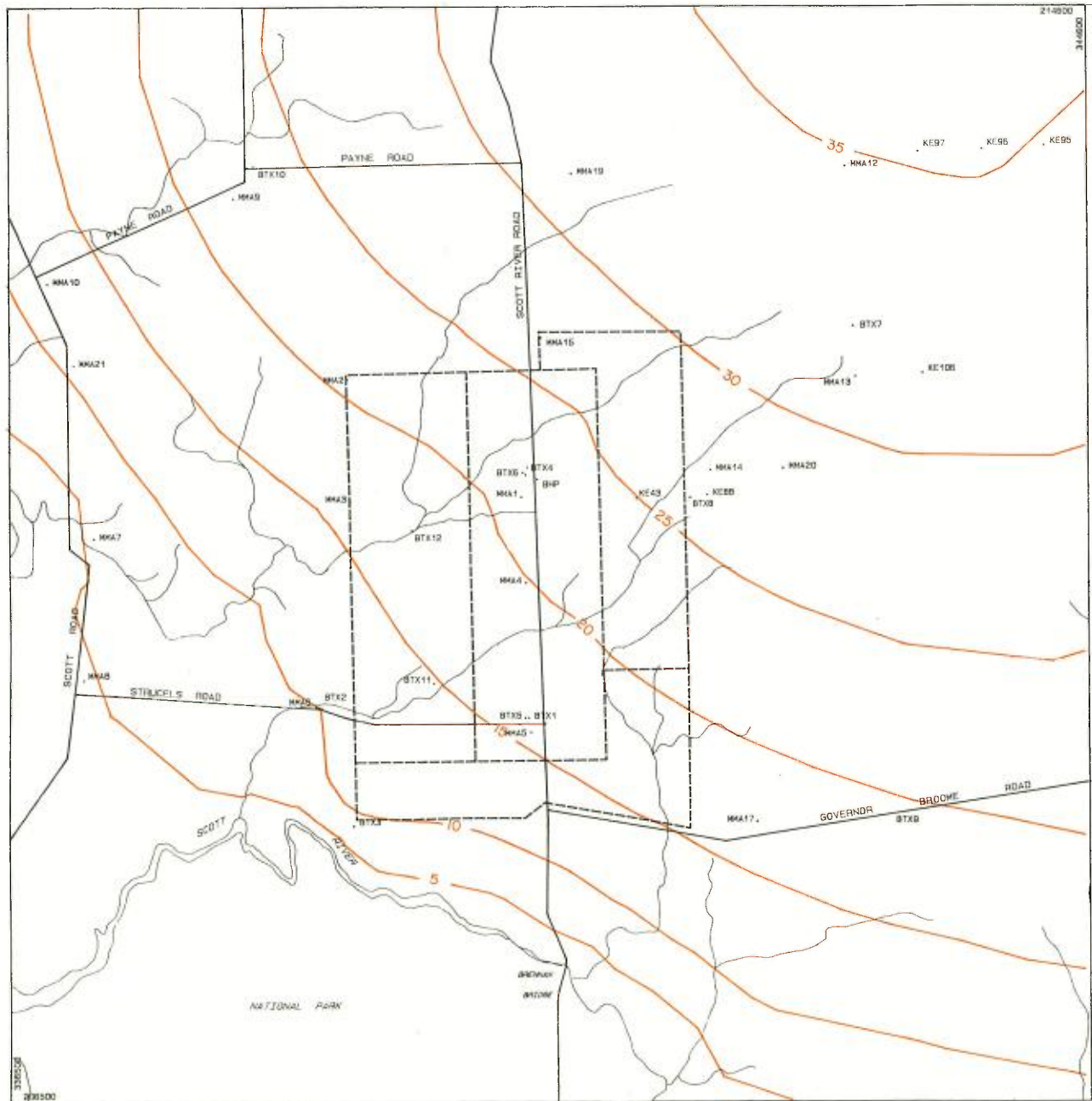
NOTES:
 GEOGRAPHIC DATA DIGITIZED FROM 1:50000 PUBLISHED TOPD. SHEETS



DRAWN SCALE 1:50000

COMPUTER NUMERICAL MODEL GRID

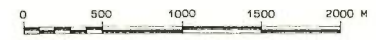
FIGURE IV-10



BHP-UTAH MINERALS INTERNATIONAL
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 HYDROGEOLOGICAL STUDIES
 ON BEHALF OF
 LEWIS ENVIRONMENTAL CONSULTANTS

- LEGEND:
- - - - - PORTION BOUNDARIES
 - PERIMETER OF PROPOSED MINING AREA (DREDGE BLOCKS)
 - MODEL WATER TABLE CONTOURS (metres AHD)
 - BTXB EXPLORATION BORE SITE

NOTES:

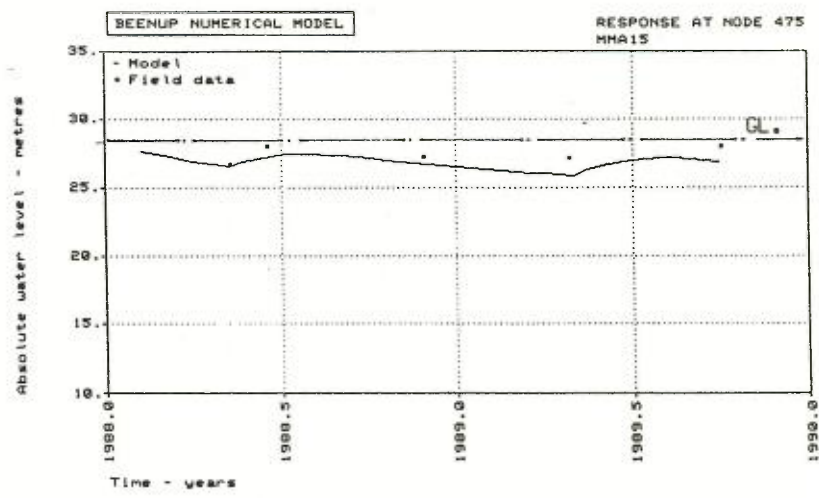
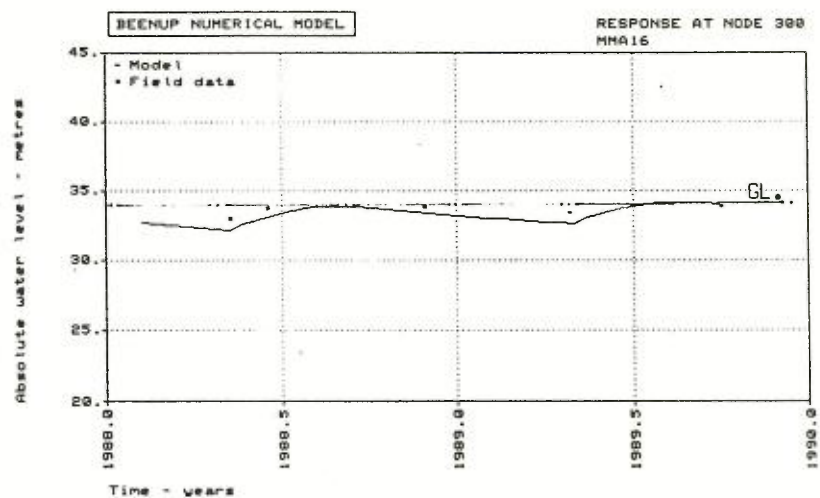
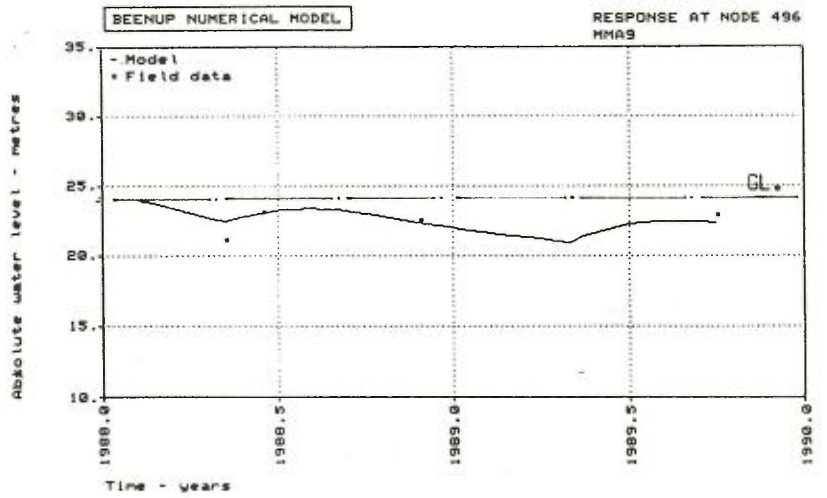


DRAWN SCALE 1:30000

LOCAL WATER TABLE GENERATED
 BY COMPUTER MODEL

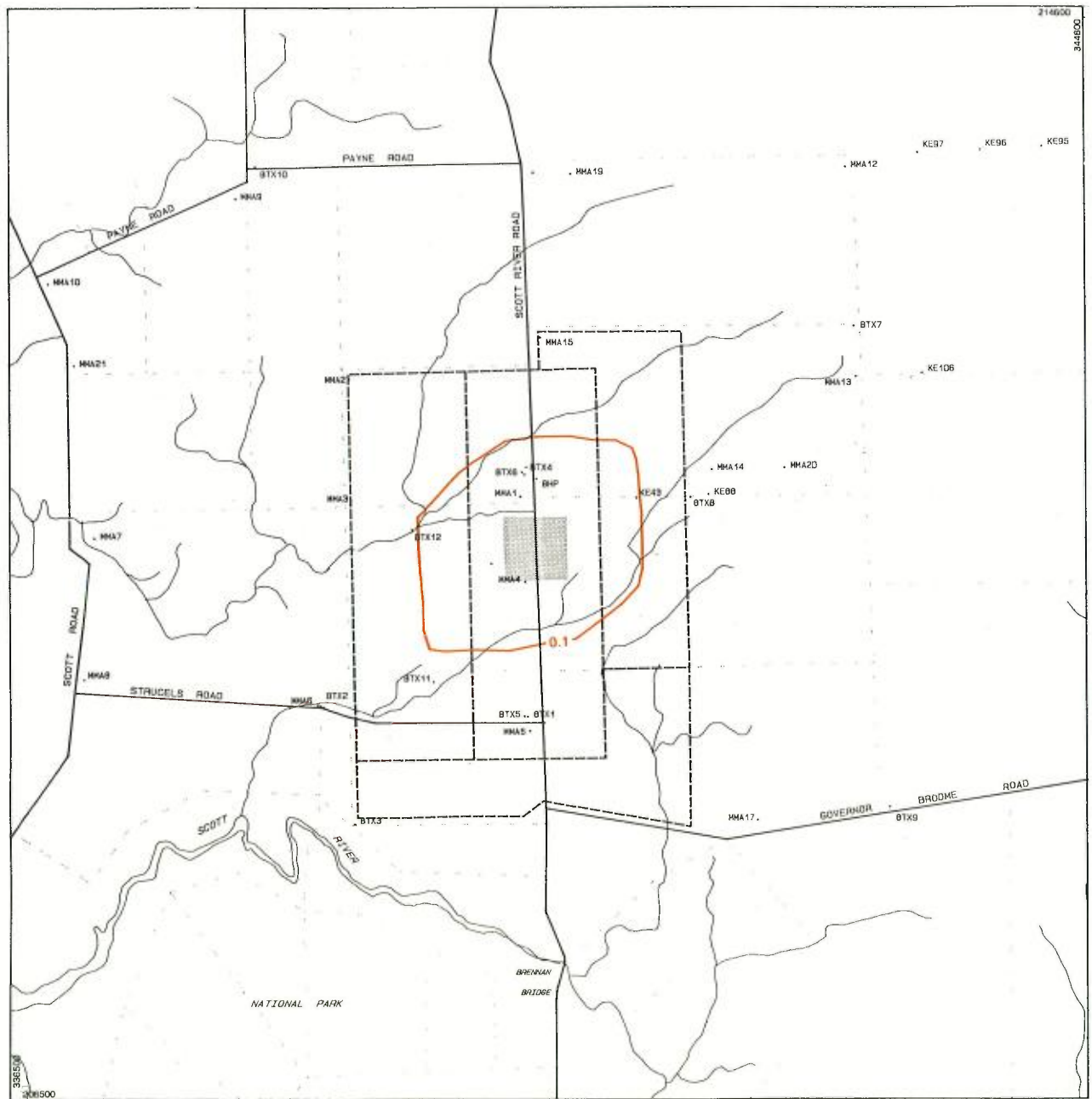
FIGURE IV-11

COMPUTER MODEL CALIBRATION - TYPICAL NODE RESPONSE



GL. = ground level

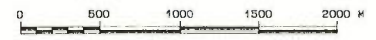
FIGURE IV-12



**BHP-UTAH MINERALS INTERNATIONAL
BEENUP MINERAL SANDS PROJECT
HYDROGEOLOGICAL STUDIES**
ON BEHALF OF
LEWIS ENVIRONMENTAL CONSULTANTS

- LEGEND:
- - - PARTITION BOUNDARIES
 - PERIMETER OF PROPOSED MINING AREA (DREDGE BLOCKS)
 - CONTOURING GIVEN AS HEAD DIFFERENCE IN METRES
 - BTX) EXPLORATION BORE SITE
 - ▨ POND LOCATION

NOTES:
IMPACT HAS BEEN DETERMINED BY SUBTRACTING WATER LEVELS
CALCULATED FOR DREDGING FROM WATER LEVELS DETERMINED
FOR PRISTINE CONDITIONS - STEADY STATE



DRAWN SCALE 1:30000

**EXTENT OF IMPACT OF
DREDGING OPERATIONS**

FIGURE IV-13

Appendix V

RADIATION LEVELS

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RADIATION LEVELS

by

Katee Enterprises
Consultant in the Physical Sciences

PART A: Absorbed Dose Rates in Air at Beenup

1.0 INTRODUCTION

It is common for heavy mineral deposits to contain monazite, a thorium bearing mineral which also contains a low concentration of uranium. Other heavy minerals extracted from mineral sands deposits also have an impurity content of thorium and uranium. The presence of these radioactive elements requires the radiological aspects of mining and processing of mineral sands to be addressed. The amount of monazite in the Beenup deposit is very low - less than 0.001% in the concentrated heavy mineral.

This report documents the results of a pre-operational radiation monitoring programme for the absorbed dose rates in air. The measurements provide baseline gamma radiation data which can be used for determining:

- ° The expected gamma background radiation exposure of the work force during mining operations.
- ° The gamma radiation levels to achieve during rehabilitation of the site.

The pre-operational radiation monitoring programme also involves measuring radionuclides in air and water at monthly intervals over 12 months. These results are to be the subject of subsequent reports.

2.0 LOCATION OF SITES

The location of the project is approximately at 340 000 mE and 6210 000 mN on the Australian Map Grid. This is shown in Figure V-1.

In particular, the proposed minesite covers Locations 4254, 4257, 4259 and parts of Locations 4260, 4261 and 4264 on the Boranup sheet, National Map Reference Sheets 1929-I and IV and Pt.1829-I, and the Augusta sheet, National Map Reference Sheets 1929-II and III.

the proposed processing plant site is on part of Locations 4268 and 4151 on the Boranup sheet, National Map Reference Sheets 1929-I and IV and Pt. 1829-I.

These locations are shown in Figures V-2 and V-3.

3.0 EXPERIMENTAL PROCEDURE

Gamma radiation levels were measured one metre above ground level using a Berthold LB1200 radiation meter. The meter had previously been calibrated against a caesium-137 standard by the Radiation Health Branch of the Health Department of Western Australia.

The mean reading over a one minute period was recorded. The surveys were undertaken over a 200 m x 200 m grid and a 50 m x 50 m grid over the minesite and plant site respectively. These two grids are shown in Figures V-2 and V-3 respectively. Measurements were undertaken when the land was being used for pastoral purposes, prior to removal of the topsoil. Additional readings were taken at locations in the general project area.

4.0 RESULTS

The experimental data from the gamma surveys over the minesite and plant site are shown in Tables V-1 and V-2 respectively. The calculated absorbed dose rates in air for the two surveys are shown in Tables V-3 and V-4 and on Figures V-2 and V-3. The values range from 0.05 - 0.12 micrograys per hour.

The absorbed dose rates in air measured at locations in the general project area are shown in Table V-5.

The mean absorbed dose rates in air are shown in Table V-6. The values are 0.082 ± 0.018 micrograys per hour and 0.076 ± 0.015 micrograys per hour at the minesite and plant site respectively. The error is quoted as one standard deviation from the mean.

5.0 CONCLUSIONS

The absorbed dose rates in air have been measured over the proposed location of a mineral sands project at Beenup, 15 km north-east of the Augusta townsite.

The values over both the proposed minesite and the proposed plant site have ranged from 0.05-0.12 micrograys per hour with a mean of 0.08 ± 0.02 micrograys per hour. The error is quoted as one deviation from the mean. The size of the range can be accounted for by the statistical fluctuations of the readings. This is

more likely rather than an actual variation of the absorbed dose rates in air across the project area.

Measured values at locations in the general project area give a mean value of 0.08 micrograys per hour. The absorbed dose rates in air reported in Environmental Review and Management Programmes for Cooljarloo (1987), Pinjarra (1988) and Jangardup (1989) are 0.08, 0.15 and 0.16 micrograys per hour respectively. Consequently the measured values at the proposed heavy minerals project at Beenup are low environmental baseline values and indicate no discernible variations over the orebody.

TABLE V-1

Experimental data from gamma survey at Beenup minesite
(values in microroentgens per hour)

North	Easting																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1									9	8	12	10	10	8			
2	12	11	15	9	15	16	9	9	9	6	10	8	9	10			
3	9	7	14	14	8	10	10	11	10	7	11	8	8	12			
4	7	13	12	13	10	9	8	13	11	12	8	9	10	8			
5	12	8	7	14	13	10	10	10	9	8	8	8	9	10			
6	10	10	11	13	13	12	7	7	9	11	8	10	8	10			
7	10	9	12	14	12	12	12	9	8	9	8	12	8	10			
8	7	9	11	9	12	10	10	8	8	9	8	8	7	10			
9	12	14	12	14	11	9	8	9	7	7	9	9	10	9			
10	12	7	9	8	9	9	8	9	8	8	6	8	7	9			
11	9	8	8	8	8	9	10	8	9	7	6	7	7	8			
12	8	9	8	12	10	9	7	10	8	11	7	7	7	8			
13	7	8	10	8	9	10	10	9	7	7	7	7	8	8			
14	11	9	9	12	13	8	10	9	6	8	8	8	9	10	9	10	10
15	9	8	11	8	7	9	8	-	8	7	9	10	9	7	8	8	10
16	-	10	7	6	8	10	7	9	8	10	7	8	9	8	7	8	9
17	-	8	9	7	9	11	11	7	8	8	8	7	9	9	7	8	7
18	-	9	9	9	12	10	10	7	8	9	10	7	8	9	9	8	7
19	-	13	11	12	12	9	11	8	8	7	9	8	9	13	10	10	7

TABLE V-2

Experimental data from gamma survey at Beenup plant site
(values in microentgens per hour)

North	Easting											
	1	2	3	4	5	6	7	8	9	10	11	12
1					7	9	8	8	7	7	8	8
2					7	8	8	10	7	6	8	7
3					8	10	9	10	9	7	9	9
4					8	8	8	9	9	9	8	7
5					7	8	10	12	10	11	10	8
6					6	8	9	8	7	7	8	8
7					10	8	14	9	7	10	13	10
8	10	8	7	8	9	8	12	11	11	11	10	8
9	7	10	10	9	11	8	13	14				
10	9	9	10	9	9	9	8	8				
11	8	8	9	10	8	7	7	8				
12	7	8	7	7	10	8	7	8				
13	9	8	8	8	7	9	9	8				
14	7	7	6	7	7	8	9	11				
15	10	7	7	8	7	8	10	9				

TABLE V-3

Absorbed dose rates in air at Beenup minesite
(values in micrograys per hour x 100)

North	Easting											
	1	2	3	4	5	6	7	8	9	10	11	1
1									8	7	11	
2	11	10	13	8	13	14	8	8	8	5	9	
3	8	6	12	12	7	9	9	10	9	6	10	
4	6	12	11	12	9	8	7	12	10	11	7	
5	11	7	6	12	12	9	9	9	8	7	7	
6	9	9	10	12	12	11	6	6	8	10	7	
7	9	8	11	12	11	11	11	8	7	8	7	1
8	6	8	10	8	11	9	9	7	7	8	7	
9	11	12	11	12	10	8	7	8	6	6	8	
10	11	6	8	7	8	8	7	8	7	7	5	
11	8	7	7	7	7	8	9	7	8	6	5	
12	7	8	7	11	9	8	8	9	7	10	6	
13	6	7	9	7	8	9	9	8	6	6	6	
14	10	8	8	11	12	7	9	8	5	7	7	
15	8	7	10	7	6	8	7	-	7	6	8	
16	-	9	6	5	7	9	6	8	7	9	6	
17	-	7	8	6	8	10	10	6	7	7	7	
18	-	8	8	8	11	9	9	6	7	8	9	
19	-	12	10	11	11	8	10	7	7	8	8	

TABLE V-4

Absorbed dose rates in air at Beenup plant site
(values in micrograys per hour x 100)

North	Easting											
	1	2	3	4	5	6	7	8	9	10	11	12
1					6	8	7	7	6	6	7	7
2					6	7	7	9	6	5	7	6
3					7	9	8	9	8	6	8	8
4					7	7	7	8	8	8	7	6
5					6	7	9	11	9	10	9	7
6					5	7	8	7	6	6	7	7
7					9	7	12	8	6	9	12	9
8	9	7	6	7	8	7	11	10	10	10	9	7
9	6	9	9	8	10	7	12	12				
10	8	8	9	8	8	8	7	7				
11	7	7	8	9	7	6	6	7				
12	6	7	6	6	9	7	6	7				
13	8	7	7	7	6	8	8	7				
14	6	6	5	6	6	7	8	10				
15	9	6	6	7	6	7	9	8				

TABLE V-5

Absorbed dose rates in air at locations in the
general project area

Location	Absorbed dose rate in air micrograys per hour
Augusta townsite - Bill Hillier Park	0.08
Karridale townsite - grounds of Catholic Church	0.17
Junction of Brockman Highway and Courtney Road	0.09
Junction of Brockman Highway and Scott River Road	0.09
Payne Road, west end	0.09
Junction of Payne Road and Scott River Road	0.08
Strucels Road - entrance of I Strucel's farm	0.09
Scott River Road, at right angle bend, 2.5 km south of Scott River	0.07
Mean *	0.084

* excluding the Karridale townsite reading

TABLE V-6

Summary of absorbed dose rates in air at Beenup

Location	No. of data	Absorbed dose rate in air $\mu\text{Gy h}^{-1}$		
		Mean	Standard deviation	range
Minesite	271	0.082	0.018	0.05-0.14
Plant site	124	0.076	0.015	0.05-0.12
General	7	0.084	0.008	0.070-0.09

PART B: Monitoring of airborne Radiation at Beenup

1.0 ACTIVITIES

1.1 JANUARY, 1990

An air sampling monitor was set up near a shearing shed on the proposed mining area at Beenup. The air sampler was fitted with a pre-weighed glass microfibre filter. It was run for a 74 hour period commencing on 15 January, 1990 at a nominal 100 litres per minute. The gross alpha activity and the total dust on the filter were subsequently measured.

1.2 FEBRUARY, 1990

Visits were made to Beenup on 16 and 20 February, 1990.

On the first visit the air sampling monitor was set up near the shearing shed. The air sampler was fitted with a pre-weighed glass microfibre filter and run for approximately 100 hours at a nominal 100 litres per minute. In addition, gamma radiation levels were measured at various locations in the general project area.

On the second visit the air sampling monitor was switched off, the filter removed and the equipment brought back to Perth. The gross alpha activity and the total dust on the filter were subsequently measured.

This monitoring activity will be carried out on a monthly basis.

2.0 RESULTS AND DISCUSSION

The data from the radionuclides in air and total dust measurements are presented in Table V-7.

The gross alpha activity of radionuclides in air during the monitoring period at the proposed minesite at Beenup was 0.055 ± 0.053 millibecquerels per cubic metre for January, 1990 and 0.030 ± 0.021 millibecquerels per cubic metre for February, 1990. The quoted error is based upon counting statistics at the 95% confidence level. The measured value is typical of environmental levels throughout the State. The contribution of the radionuclides in air to the baseline annual effective dose equivalent is negligible.

The total dust loading of the sampled air in January, 1990 was 330 micrograms per cubic metre. This value is high for an environmental level but can be attributed to the shearing activity taking place in the vicinity during the monitoring period.

TABLE V-7

Data for radionuclides in air

Filter no.	BHP 01	BHP 02
Collection period	15-18/1/90	16-20/2/90
Hourmeter start	220.31	294.66
Hourmeter finish	294.66	387.98
Collection time	74.35 h	93.32 h
Flow rate	77.5 l/min	90 l/min
Activity standard	5370 Bq	5377 Bq
Counts from standard (1 min)	134099	135137
Counts from sample (50 min)	39	17
Counts from background (50 min)	23	4
Initial weight of filter	145947 ug	137990 ug
Final weight of filter	259960 ug	143470 ug
Weight of dust collected	114013 ug	5480 ug
Total dust level	330 ug m ⁻³	11 ug m ⁻³
Gross alpha activity	0.055 ± 0.053 mBq m ⁻³	0.030 ± 0.021 mBq m ⁻³
Effective dose equivalent		
Non-designated employee	0.0028 ± 0.0027 mSv y ⁻¹	0.0015 ± 0.0011 mSv y ⁻¹
Member of the public	0.012 ± 0.012 mSv y ⁻¹	0.0066 ± 0.0046 mSv y ⁻¹

The quoted error is based upon counting statistics at the 95% confidence level. A 1 um AMAD uranium ore dust is assumed.

The total dust loading of the sampled air in February, 1990 was 11 micrograms per cubic metre. This value is towards the bottom of the range of environmental levels throughout the State.

REFERENCES

- Cooljarloo Mineral Sands Project. Environmental Review and Management Programme. Maunsell & Partners Pty. Ltd. November, 1987
- Proposed Rare Earths Processing Plant, Pinjarra, Western Australia. Environmental Review and Management Programme. Dames & Moore, February, 1988.
- Jangardup Heavy Minerals Mine. Environmental Review and Management Programme. W.G. Martinick & Associates Pty. Ltd., June 1989

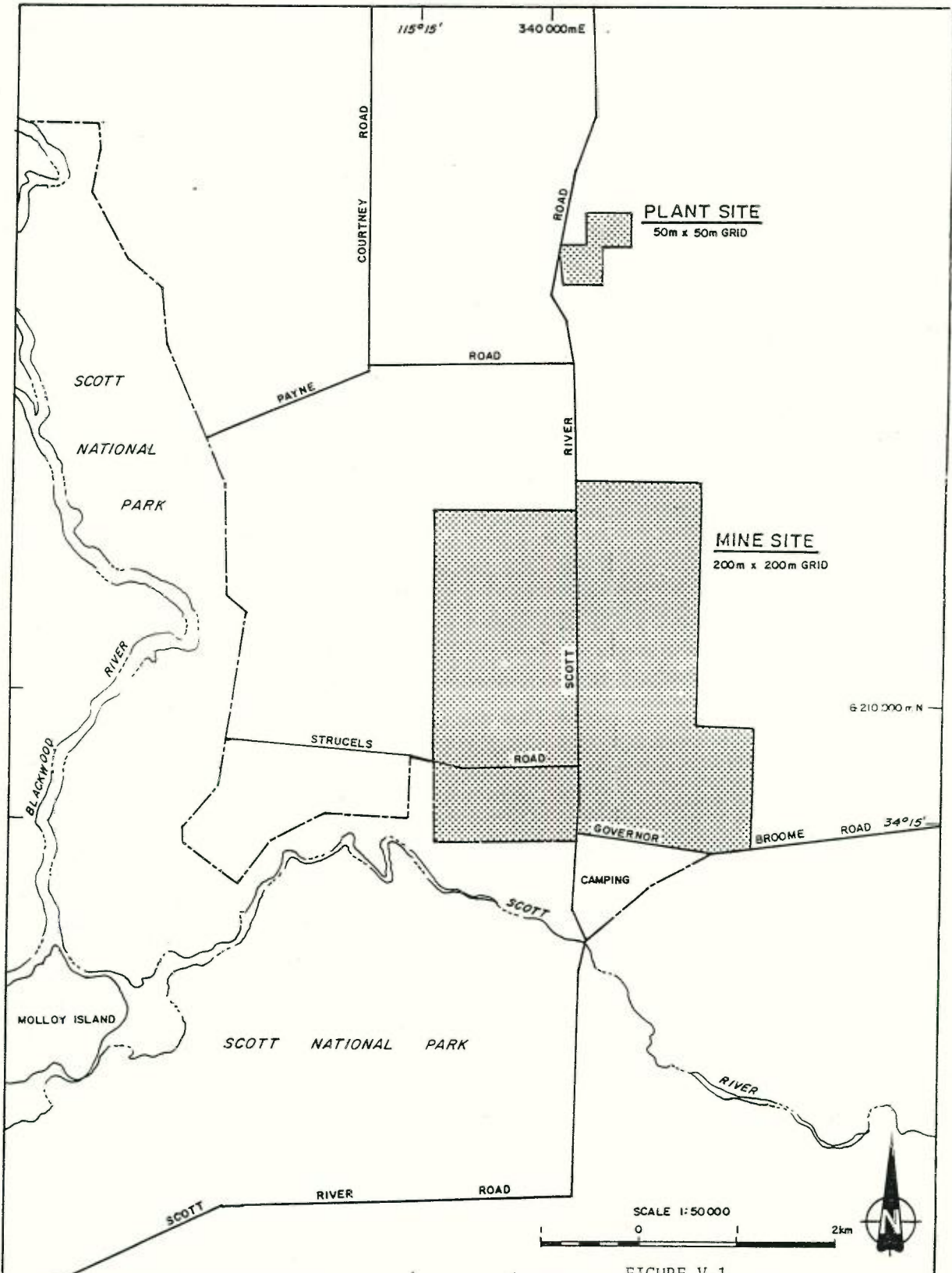


FIGURE V-1

WORK BY	
PREPARED	E. SMYTH
DRAWN	PANTING
CENTRE	PERTH



BHP - UTAH MINERALS INTERNATIONAL
 ASIA PACIFIC DIVISION - EXPLORATION
BEENUP
LOCATION OF PLANT AND MINE SITES

DATE	31.1.90
REVISED	
PROJECT NUMBER	NC 5
PLAN No	A4- 5093

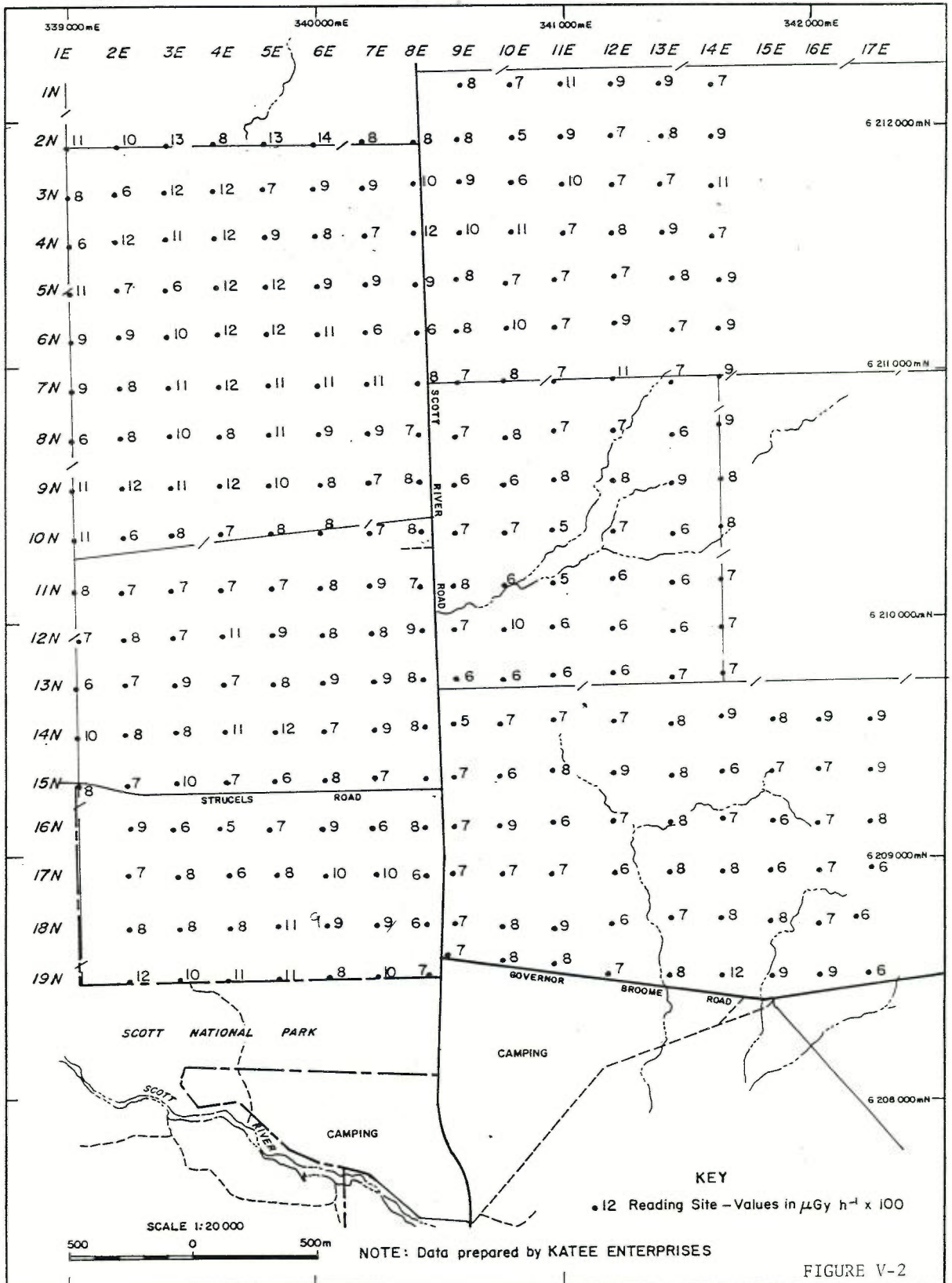

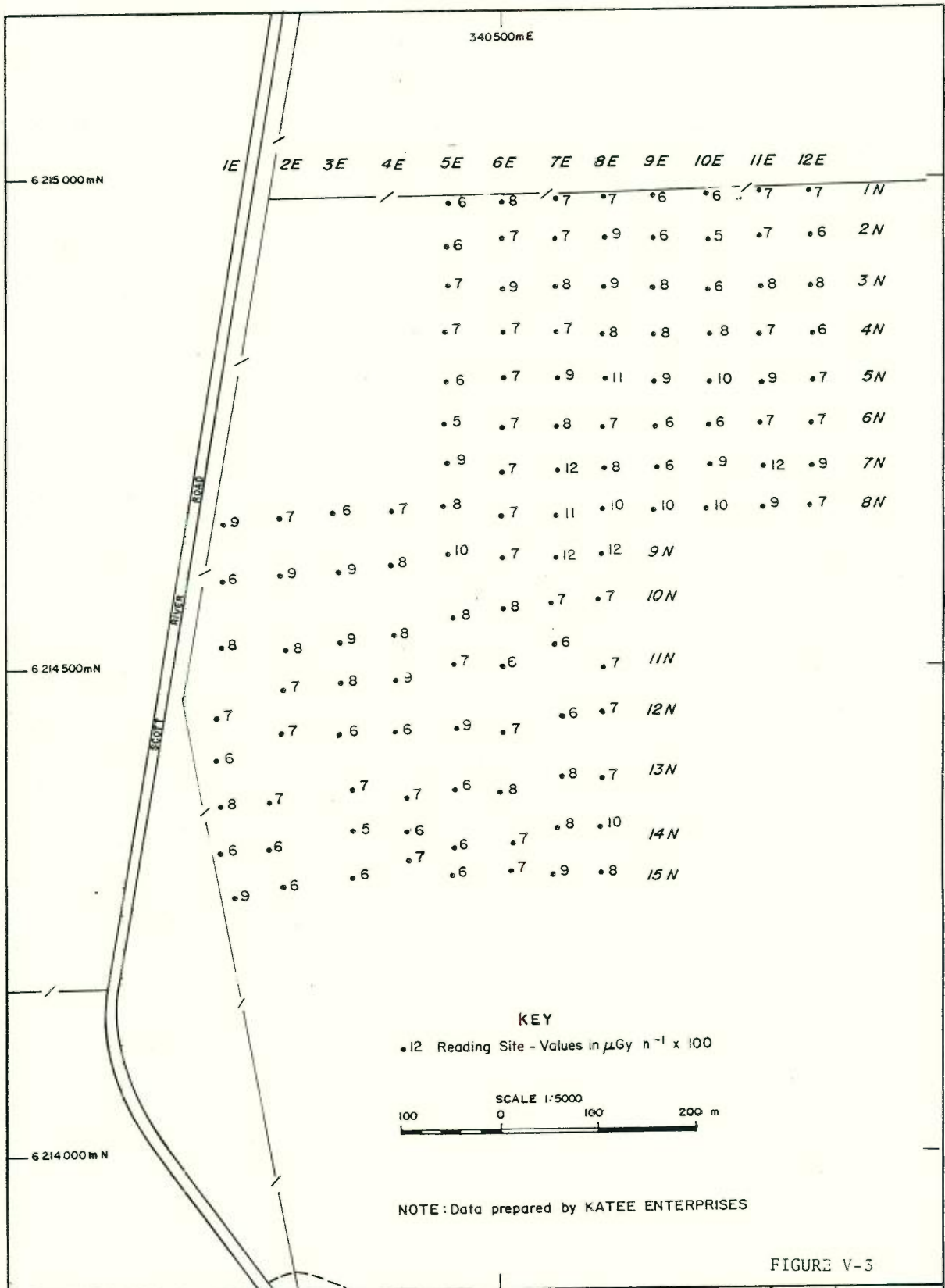


FIGURE V-2

WORK BY		 BHP - UTAH MINERALS INTERNATIONAL ASIA PACIFIC DIVISION - EXPLORATION BEENUP MINE SITE ABSORBED DOSE RATES IN AIR	DATE	30.1.90
PREPARED	E. SMYTH		REVISED	
DRAWN	PANTING		PROJECT NUMBER	NC 5
CENTRE	PERTH		PLAN No.	A4-5094




KEY
 •12 Reading Site - Values in $\mu\text{Gy h}^{-1} \times 100$

SCALE 1:5000
 100 0 100 200 m

NOTE: Data prepared by KATEE ENTERPRISES

FIGURE V-3

WORK BY		 BHP - UTAH MINERALS INTERNATIONAL ASIA PACIFIC DIVISION - EXPLORATION BEENUP PLANT SITE ABSORBED DOSE RATES IN AIR	DATE	30.1.90
PREPARED	E. SMYTH		REVISED	
DRAWN	PANTING		PROJECT NUMBER	NC 5
CENTRE	PERTH		PLAN No.	A4-5095

Appendix VI

AMBIENT AND PREDICTED SOUND LEVELS

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AMBIENT AND PREDICTED SOUND LEVELS

by

Tibor Vass, acoustic consultant
Curtin Consultancy

1.0 **ESTABLISHMENT OF EXISTING SOUND LEVELS AT RESIDENCES NEAR THE PROPOSED MINING AREA AND DRY MILL**

1.1 **PURPOSE OF THE INVESTIGATION**

To establish mean airborne Sound Pressure Levels (SPL) and Sound Levels (SL) of the existing sound environment at 17 locations at the proposed Beenup mining site as shown in Annex A.

1.2 **UNITS EMPLOYED**

1.2.1 **Sound Pressure Level - SPL**

SPL's are expressed in decibels (dB) re 2×10^{-5} N/m² in 1/1 octave bands in frequencies shown in paragraph 1.7.3 and according to the following Australian Standards:

AS Z33 Preferred Frequencies and Band Centres for Acoustical Measurements.

AS Z1047 Expression of the Physical and Subjective Magnitudes of Sound and Noise.

1.2.2 **Hertz - Hz**

Frequency, cycles per second, being the rate of repetition of the cycles as a periodic quantity.

1.2.3 **Sound Level - dB(A)**

'A' weighted value of the SPL as determined by a Sound Level Meter (SLM) satisfying : AS 1259-1982.

1.2.4 Statistical SL - L_{eq}

The equivalent continuous equal energy SL (L_{eq}) is that constant noise level, which over the same period of time expends the same amount of energy as the fluctuating level.

1.2.5 Exceedance levels/Statistical levels - L_n

Fluctuating airborne sound indicated in dB or dB(A) may be a mean level averaged over a period of time, which can be however expressed more precisely in statistical form as L_n , which indicates how frequently a particular SL is exceeded e.g. L_{10} 40 dB(A) means that 40 dB(A) was exceeded for 10% of the measuring time.

1.3 INSTRUMENTATION

1.3.1 Recording

- ° Precision Sound Level Meter, B & K Type 2215, Serial No. 615668.
- ° Precision Integrating Sound Level Meter, B & K Type 2230, Serial No. 1116291.
- ° Nagra IV SJ tape recorder, Serial No. 11085 with adaptor QSJP, Serial No. 590.
- ° 12.5 mm condenser microphone, B & K type 4165, Serial No. 600222 together with microphone preamplifier, B & K type 2619, Serial No. 327215.
Note: Both Precision Sound Level Meter and 12.5 mm condenser microphone do satisfy AS 1259 -'82.
- ° Noise Level Analyser, B & K type 4426 with Alpha-numeric Printer, B & K type 2312, Serial No. 630598 and 699515.
- ° Pistonphone, B & K type 4220, Serial No. 252068, to establish reference levels for tape recording/analysis and to calibrate the Sound Level Meters.
- ° Tripod, B & K type UA 0049.
- ° Windscreen, B & K type UA 0207.
- ° Zeal, Whirling Psychrometer to establish dry and wet bulb temperature.

- ° Electronic Anemometer, Airflow Development Ltd., Serial No. 20735.
- ° Measuring tape and all necessary connectors.

1.3.2 **Analysis**

- ° Tape recorder, see above.
- ° Digital Frequency Analyser, B & K type 2131, Serial No. 629099.
Note: This Digital Frequency Analyser satisfies AS Z41, 1/1 and 1/3 octave band pass filters intended for the analysis of sound and vibration.
- ° Computer, Digital Pdp11/03, with Data System Design Floppy Disk, type DSD/440, Serial No.44-606 with visual display unit and Adler hard copier.
- ° All necessary connectors.

1.4 **DATE AND TIME OF RECORDINGS**

Recordings were made at locations shown in Annex A on the following dates:

- (i) 28th December, 1989 between 12 noon and 7.00 pm
- (ii) 29th December, 1989 between 7.00 am and 3.00 pm

The recorded data were analysed in the Architectural Science Acoustics Laboratory, Department of Architecture, Curtin University.

1.5 **CLIMATIC CONDITIONS**

1.5.1 **Temperature and relative humidity**

- ° The ambient dry bulb temperature during the noise recording period ranged from 17°C to 24°C with a mean level of 20.9°C.
- ° The relative humidity during the noise recording period ranged from 44% to 68% with a mean level of 54%.

1.5.2 **Wind conditions**

- ° The weather on both days during the noise recordings was fine.

- ° The wind speed during the noise recordings ranged from calm, 0 m/sec to 4.5 m/sec. No noise level recordings were made when wind gusts exceeded 5.0 m/sec.
- ° The wind direction on both days varied from south to south west/south east.

1.6 TRAFFIC DENSITY

1.6.1 Scott River Road

During the noise recording the traffic flow was very low, estimated 5 to 15 vehicles/hour.

1.6.2 Brockman Highway

During the noise recording the traffic flow was estimated to be between 50 and 70 vehicles/hour.

1.7 METHOD OF TESTING

1.7.1 Recording

All noise recordings were performed with the microphone at approximately 1.2 m from the ground and a minimum of 4.0 m from vertical reflecting surfaces eg. walls etc. For microphone locations see Annex A.

At locations indicated in Annex A, a recording of 20 minutes minimum was made at each site, using the SLM's, Noise Level Analyser, and on Tape recorder on linear mode, all referred to in Section 1.3.1.

1.7.2 Analysis

1/1 octave band SPL's were obtained from tape recorded linear signals of 1 to 5 minutes duration together with visual SLM recordings. Statistical SL's were obtained from printed displays of the Noise Level Analyser at 1 to 5 minute intervals. All dB figures are rounded off to the nearest dB.

1.7.3 Test frequencies

All SPL recordings were made in the following 1/1 octave band centre frequencies : 31.5, 63, 125, 250, 500, 1k, 2k, 4k and 8k.

VI-5

1.8 DATA

TABLE VI-1

Date, time, wind and temperature

Test location	Date	Time	Wind,m/s	Temp.°C	RH%
1a	28/12	5.50 pm	3.5	18	59
1b	29/12	9.00 am	1.5	20	63
2a	28/12	5.00 pm	3.5	19	57
2b	29/12	8.25 am	1.5	20	59
3a	28/12	4.10 pm	3	20	55
3b	29/12	8.05 am	1.5	20	55
4a	28/12	3.30 pm	3	20	59
4b	29/12	2.45 pm	4.5	23	48
5 a & b	29/12	9.35 am	2	24	44
6	29/12	9.57 am	2	23	45
7	29/12	10.20 am	2.5	23	48
8	29/12	10.43 am	2.5	22	50
9	29/12	11.07 am	2.8	22	50
10a	28/12	2.30 pm	3	20	54
10b	29/12	11.30 am	3	22	51
11	29/12	11.55 am	3.5	22	51
12	29/12	12.20 om	3.5-4	21	53
13	29/12	12.45 pm	3.5-4	22	50
14	29/12	1.08 pm	3.5-4	23	48
15 a & b	29/12	1.30 pm	3.5-4.5	23	48
16a	28/12	2.00 pm	3.5	20	55
16b	29/12	2.00 pm	3.5-4.5	23	49
17-1	28/12	6.15 pm	2	17.5	65
17-2	28/12	6.40 pm	1	17	67
17a-d	29/12	2.30 pm	3.4-4.5	23	49
17-3	28/12	7.30 pm	1	17	66

Note: See Annex A for test location

1.9 RESULTS

TABLE VI-2
dB(A) Sound levels

Test location	dB(A)			Remarks
	L ₁₀	L ₉₀	L _{eq}	
1a	41	37	39	
1b	41	34	40	
2a	40	33	38	
2b	52	37	47	Dogs barking
3	42	37	40	
4a	42	37	40	
4b	53	40	49	Aircraft overhead
5a & b	38	27	35	
6	39	27	36	
7	38	27	37	
8	48	37	46	60/70 vehicles/hr
9	47	36	45	50/60 vehicles/hr
10	49	38	46	70/80 vehicles/hr
11	44	39	42	Wind up to 3.5 m/s
12	45	41	44	Wind up to 4.0 m/s
13	43	35	41	Wind up to 4.0 m/s
14	44	34	40	Wind up to 4.0 m/s
15a & b	45	38	41	Wind up to 4.5 m/s
16a	42	37	39	Wind up to 3.5 m/s
16b	45	35	43	Wind up to 4.5 m/s
17-1	40	36	37	Wind up to 2.0 m/s
17-2	38	31	35	Calm
17a to d	45	37	42	Wind up to 4.5 m/s
17-3	30	22	27	Calm
Mean levels-				
7 am-7 pm	42	34	39	
Standard deviation	2.5	4.2	2.6	

Test locations 2b, 4b and 17-3 are not included in the mean

Note: See Annex A for test location

TABLE VI-3

Typical 1/1 Octave Band SPL's

1/1 octave	L ₁₀	L ₉₀
31.5	44	38
63	42	37
125	36	30
250	36	29
500	36	29
1k	36	29
2k	35	28
4k	33	22
8k	30	21

Note: See Annex B

2.0 ESTABLISHMENT OF ACCEPTABLE SOUND LEVELS AT THE BEENUP RESIDENCES, ACCORDING TO CURRENT W.A. NOISE REGULATIONS

2.1 PURPOSE OF THE INVESTIGATION

To establish acceptable SL's generated by mining activities, at the existing residences near the proposed Beenup mining site. The acceptable levels are based on the *Environmental Protection Act*, 1986 section 123 and *Noise Abatement (Neighbourhood Annoyance) Regulations*, 1979 and amendments.

2.2 ACCEPTABLE OUTDOOR NOISE LEVELS

2.2.1 Neighbourhood category : 'A-1'

- ° Use of premises at place of reception : RESIDENTIAL
- ° Description of neighbourhood in which place of reception is situated : ONLY OR PREDOMINANTLY COUNTRY, WITH NEGLIGIBLE TRANSPORTATION.

° Acceptable outdoor noise levels:

- (a) Monday to Friday 7am to 7pm : 40 dB(A)
- (b) Monday to Friday 7pm to 10 pm
weekends and public holidays,
7am to 10 pm : 35 dB(A)
- (c) Always 10 pm to 7 am : 30 dB(A)

2.2.2 Neighbourhood category : 'A-2'

Once approval for mining activity at the Beenup site is given, then the neighbourhood category would likely change to Category 'A-2', when the acceptable levels would become:

- (a) 45 dB(A)
- (b) 40 dB(A)
- (c) 35 dB(A)

2.3 METHODS OF ESTABLISHING EXISTING SOUND LEVELS AT RESIDENCES - BEENUP

Refer to Regulations indicated in Section 2.1.

2.3.1 To measure existing background noise

Regulation 13-(1) ..."the background noise shall be measured in the absence of the noise alleged to be offending ... used as the assigned outdoor neighbourhood noise level, and where this measurement is less than the lowest values indicated in Table 1, the lowest value for the appropriate time period in Table 1 is used as the assigned level."

Regulation 13-(2) ... "The result of the measurement of background noise shall be ascertained by taking the average of the minimum pointer deflections on the sound level meter."

Note: The average of the minimum pointer deflections is the L_{90} .

If the calculated noise level as documented in Section 5.0 exceeds the assigned outdoor level indicated in Section 2.2, by no more than 5 dB(A), Regulation 10, no offence occurs.

3.0 ESTABLISHMENT OF TYPICAL SOUND LEVEL CONTOURS AROUND THE CAPEL DRY MILL OF WESTRALIAN SANDS LTD.

3.1 PURPOSE OF THE INVESTIGATION

To establish mean airborne SPL's and SL's of the existing dry mill operations of Westralian Sands, Capel (Figure VI-1), at locations shown in Annex C.

Based on the above measurements, calculate and draw SL contours for the far field around the plant as shown in Annex D. Due to the many obstructions, buildings etc. the drawing of the near field SL contours around the plant is not practical.

3.2 UNITS EMPLOYED

- SPL - See Section 1.2.1
- Hz - See Section 1.2.2
- dB(A) - See Section 1.2.3
- L_{eq} - See Section 1.2.4
- L_n - See Section 1.2.5
- $L_{w(A)}$ - 'A' weighted sound power level of the source.

3.3 INSTRUMENTATION

3.3.1 Recording

See Section 1.3.1.

3.3.2 Analysis

See Section 1.3.2.

3.4 DATE AND TIME OF RECORDINGS

Recordings at the Capel plant were performed at locations shown in Annex C on: 24th January, 1990, between 1.00 pm and 6.30 pm. The dry mill plant at Muchea was inspected on: 19th January, 1990, between 9.15 am and 11.30 am.

3.5 CLIMATIC CONDITIONS

3.5.1 Temperature and relative humidity

The ambient dry bulb temperature during the noise recording ranged from 25°C to 28°C with a mean level of 26.5°C.

The relative humidity during the noise recording ranged from 49% to 54% with a mean level of 51.5%.

3.5.2 **Wind condition**

The weather during noise recording was fine. The wind speed during noise recording ranged from 2 m/s to 3 m/s. The wind direction varied from south to south west.

3.6 NOISE TYPES AND NOISE CHARACTER

3.6.1 **Plant noise**

Noise generated at various parts of the plant is mainly Broad Band, steady state with no noticeable Tonal Component. See Annex E.

3.6.2 **Service vehicle noise**

Front End Loader. Noise generated by the front end loader is mainly broad band with frequency/amplitude modulation.

Road Train, Volvo F10. Noise generated by the above vehicle is mainly broad band with frequency/amplitude modulation when accelerating/gear changing.

3.7 METHOD OF TESTING

3.7.1 **Recording**

All noise recordings were performed with the microphone at approximately 1.2 m from the ground and a minimum of 4.0 m from vertical reflecting surfaces eg. walls etc. For microphone locations see Annex C.

At each microphone location, due to the steady state character of the plant noise, a recording of 5 minutes was made using the SLM's, Noise Level Analyser and Tape Recorder in linear mode as indicated in Section 1.3.1.

Service vehicle noise was recorded on tape in linear mode at a distance indicated and for a representative period.

3.7.2 **Analysis**

1/1 and 1/3 octave band SPL's were obtained from tape recorded signals of 1 to 5 minutes duration together with visual SLM recordings. Statistical SL's were obtained from printed displays of the Noise Level Analyser at 1 to 5 minutes

intervals as well as from tape recorded signals fed into the Noise Level Analyser in the Architectural Science Acoustics Laboratory, Department of Architecture, Curtin University. Service vehicle noise was analysed in statistical units. All dB figures rounded off to nearest dB.

3.7.3 Test frequencies

All SPL recordings were made/analysed in the following 1/1 octave band centre frequencies : 31.5, 63, 125, 250, 500, 1k, 2k, 4k and 8k Hz. Most recordings were also analysed in 1/3 octave band centre frequencies from 31.5 to 8k Hz.

3.8 DATA : DATE, TIME, WIND AND TEMPERATURE

As indicated in Sections 3.4, 3.5.1 and 3.5.2.

3.9 RESULTS

TABLE VI-4

dB(A) sound levels

dB(A)				
Test location	L_{10}	L_{90}	L_{eq}	Remarks
1	75	74	74	Annex E-a
2	73	72	72	
3	69	68	68	
4	67	66	66	Annex E-b
5	75	74	74	
6	74	73	74	+ Construction noise
7	63	62	62	
8	75	74	74	
9	73	72	72	
10	66	65	65	
11	62	60	59	+ Traffic noise
12	60	60	60	
13a	54	52	52	
13b	59	55	57	+ Traffic noise
14	71	69	70	Annex E-c
15	64	61	62	+ Service vehicle noise
16a	80	71	77	Front end loader, 10 m, moving, Annex E-d
16b	89	84	87	Front end loader 5m
17a	65	64	64	
17b	61	60	60	
18	57	55	55	
19	60	59	59	Annex E-e
20	61	59	59	+ Service vehicle noise
21a	72	65	70	+ Fork lift @ 10 m Annex E-f
21b	72	71	72	+ Fork lift @ 8 m
22	66	64	64	+ Service vehicle noise

TABLE VI-4 (cont'd)

dB(A) sound levels

Test location	dB(A)			Remarks
	L_{10}	L_{90}	L_{eq}	
23	57	55	55	
24a	62	59	61	
24b	66	62	63	+ Tractor @ 10 m
25	71	69	69	
26	68	67	68	Annex E-g
27	63	62	62	
28	61	58	59	+ Traffic noise
29	54	53	52	
30a	58	57	57	
30b	62	56	59	+ Front end loader @ 10 m
31a	88	66	83	Volvo F10 @ 5 m stationary Annex E-h
31b	92	77	86	Volvo F10 @ 4 m moving
32	52	49	51	Mound in distance
33a	50	48	48	
33b	51	49	49	
34	47	45	46	Behind 3 m mound
35	48	47	47	Edge of road
36	53	51	51	Calculated
37	63	62	62	Calculated
38	62	60	60	Calculated
39	62	61	60	Calculated
40	53	52	52	Calculated

Note: See Annex C for locations

3.9.1 Result details

The overall noise generated by the dry mill is broad band and most of the time a steady state noise as indicated by the similarity of the L_{10} , L_{90} and L_{eq} levels. The geometric noise centre of the dry mill plant at Capel was found to be located near recording No.1.

4.0 ESTABLISHMENT OF TYPICAL SOUND LEVEL CONTOURS AROUND THE CATABY DREDGE OPERATIONS OF THE COOLJARLOO JOINT VENTURE

4.1 PURPOSE OF THE INVESTIGATION

To establish mean airborne SPL's and SL's of the existing dredge operations of the Cooljarloo Joint Venture's Cataby plant (Figure VI-1) at locations shown in Annex F.

Based on the above measurements, calculate and draw SL contours for near and far field around the plant at locations indicated in Annex G and Annex H.

4.2 UNITS EMPLOYED

- SPL - See Section 1.2.1
- Hz - See Section 1.2.2
- dB(A) - See Section 1.2.3
- L_{eq} - See Section 1.2.4
- L_n - See Section 1.2.5
- $L_{w(A)}$ - 'A' weighted sound power level of the source.

4.3 INSTRUMENTATION

4.3.1 Recording

See Section 1.3.1.

4.3.2 Analysis

See Section 1.3.2.

4.4 DATE AND TIME OF RECORDINGS

Recordings were made at locations shown in Annex F on the following dates:

- 19th January 1990, between 1.00 pm and 6.00 pm
- 20th January 1990, between 7.30 am and 12.30 pm

4.5 CLIMATIC CONDITIONS

4.5.1 Temperature and relative humidity

The ambient dry bulb temperature during the noise recording ranged from 26°C to 28°C with a mean level of 27°C.

The relative humidity during the noise recording ranged from 40% to 48% with a mean level of 44%.

4.5.2 Wind condition

The weather during noise recording was fine. The wind speed during noise recording ranged from 1.5 m/s to 4.5 m/s, (mean 3 m/s). The wind direction varied from south to south west.

4.6 NOISE TYPES AND NOISE CHARACTER

4.6.1 Dredge

Type: Ellicott Wheel Dragon Bucket Wheel dredge and 1600 tonne floating wet concentrator.

Noise generated by the dredge at the near field (between 50 and 150 m) was mainly broad band with just noticeable tonal component on the west side, @ 500 Hz 1/3 octave band, on the north side, @ 630 Hz 1/3 octave band and on the east side, @ 1.25k Hz 1/3 octave band.

The tonal components were not noticeable in the far field.

4.6.2 Excavator

Type: Liebherr 994.

Noise generated by the excavator in the near field was mainly broad band with noticeable tonal component @ 630 and 800 Hz 1/3 octave bands.

4.6.3 Dump truck

Type: Komatsu R 85.

Noise generated by the dump truck (also referred to as haul-pack) was mainly broad band.

4.6.4 **Horn, Dump truck**

Noise generated by the horn of the dump truck on backing or indicating departure after completing the load by the excavator produced a very prominent tonal component in the near and far field @ 800 Hz 1/3 octave band.

4.6.5 **Bulldozer**

Type: Komatsu 4875.

Noise generated by the bulldozer was mainly broad band with frequency/amplitude modulation and with an audible chain noise at 160 Hz 1/3 octave band, see 4.9 Results.

4.6.6 **Grader/Scraper**

Type: Caterpillar Elevating Scraper 633.

Noise generated by the grader/scraper was mainly broad band with frequency/amplitude modulation.

4.6.7 **Front End Loader**

Type: CAT 986E.

Noise generated by the front end loader was mainly broad band with frequency/amplitude modulation.

4.6.8 **Road Transport**

Type: Volvo F12, Intercooler.

Noise generated by the stationary Volvo F12 was mainly broad band. Noise generated by the moving Volvo F12 was mainly broad band with frequency/amplitude modulation on gear changing and acceleration.

4.6.9 **Compressor/pump**

Noise generated by the compressor/pump was mainly broad band.

4.6.10 **Wet Concentrate discharge**

Noise generated by the wet concentrate discharge had a tonal component at 500 Hz and 630 Hz 1/3 octave band.

4.7 METHOD OF TESTING

4.7.1 Recording

All noise recordings were performed with the microphone at approximately 1.2 m from the ground and a minimum of 4.0 m from vertical reflecting surfaces eg. walls etc.

For microphone locations see Annex F. At each microphone location, when recording the dredge and compressor/pump noise due to the steady state character of the plant noise, a recording of maximum 5 minutes was made using the SLM's, Noise Level Analyser and Tape Recorder in linear mode as indicated in Section 1.3.1.

Service vehicle noises (excavator, dump truck, bulldozer, grader, road train, medium size truck and light utility) were recorded on tape in linear mode at a distance indicated and for a representative period.

4.7.2 Analysis

For the dredge and compressor/pump 1/1 and 1/3 octave band SPL's were obtained from tape recorded signals of 1 to 5 minutes duration together with visual SLM recordings. Statistical SL's were obtained from printed displays of the Noise Level Analyser at 1 to 5 minutes intervals as well as from tape recorded signals fed into the Noise Level Analyser in the Architectural Science Acoustics Laboratory, Department of Architecture, Curtin University.

Service vehicle noise was analysed in statistical units.

All dB figures were rounded off to the nearest dB.

4.7.3 Test frequencies

All SPL recordings were made/analysed in the following 1/1 octave band centre frequencies: 31.5, 63, 125, 250, 500, 1k, 2k, 4k and 8k Hz. Most recordings were also analysed in 1/3 octave band centre frequencies from 31.5 to 8k Hz.

4.8 DATA : DATE, TIME, WIND AND TEMPERATURE

As indicated in 4.4, 4.5.1, and 4.5.2 above.

4.9 RESULTS

TABLE VI-5

dB(A) sound levels
(For calculations of SL see Section 5.0)

dB(A)				
Test location	L_{10}	L_{90}	L_{eq}	Remarks
1a	71	70	70	Annex I-a
1b	53	49	51	
1c	49	45	47	
1d	46	42	45	
2a	65	64	64	Annex I-b
2b	53	49	50	
2c	51	48	49	Calculated
3a	65	62	63	Annex I-c
3b	54	51	52	
3c	53	48	50	
3d	50	46	48	
3e	49	44	46	
3f	48	44	47	Annex I-d
3g	47	43	46	
3h	46	43	45	Calculated
4a	65	62	63	Annex I-e
4b	56	53	54	
4c	54	51	53	
4d	53	48	50	
4e	50	45	49	
4f	49	45	47	
4g	48	39	45	Calculated

TABLE VI-5 (cont'd)

dB(A) sound levels

Test location	dB(A)			Remarks
	L ₁₀	L ₉₀	L _{eq}	
4h	47	41	45	
5a	63	61	61	
5b	53	49	51	
5c	48	47	48	Calculated
5d	47	40	45	
6a	61	58	60	
6b	52	47	49	Annex I-f
6c	48	44	47	
6d	47	44	46	
7a	57	50	55	Annex I-g
7b	53	48	50	
7c	49	45	48	
7d	47	42	45	Calculated
8a	54	48	51	
8b	51	46	48	
8c	49	45	47	
8d	46	42	45	Calculated
9a	51	46	48	
9b	48	40	45	
9c	47	40	44	
9d	45	39	43	
10a	48	39	45	
10b	46	43	44	Calculated
10c	45	38	44	
10d	44	39	42	
11a	53	52	52	
11b	53	51	52	
11c	50	45	49	
11d	49	45	47	
12a	50	47	48	
12b	48	40	45	
12c	46	42	44	
12d	45	39	43	Calculated
13a	49	47	48	

TABLE VI-5 (cont'd)

dB(A) sound levels

Test location	dB(A)			Remarks
	L ₁₀	L ₉₀	L _{eq}	
13b	48	41	46	
13c	48	40	46	Calculated
13d	46	43	44	
14a	48	45	47	
14b	46	44	45	
14c	45	43	44	
14d	44	39	42	Calculated
15a	47	44	45	
15b	46	43	44	
15c	45	40	43	Calculated
15d	45	38	44	
16a	45	39	44	
16b	44	37	41	
17a	44	35	40	Annex I-h
17b	44	38	41	
17c	43	35	40	
17d	43	36	40	
18a	78	76	77	Volvo F12-Stationary 5 m - Annex I-j
18b	83	73	73	Volvo F12 - Moving - 7m.
18c	76	70	72	Front end loader 10m
19a	74	68	70	Medium size truck 5 m.
19b	67	60	62	Light utility 5 m.
20a	85	80	83	Excavator 20 m Annex I-k
20b	88	84	84	Bulldozer-moving 10 m. Annex I-l
20c	85	84	84	Compressor/pump 6m. Annex I-m
21	83	79	81	Haul pack, loading 30 m.
22	88	81	86	Haul pack, moving 10 m. Annex I-n

TABLE VI-5 (cont'd)

dB(A) sound levels

Test location	dB(A)			Remarks
	L ₁₀	L ₉₀	L _{eq}	
23	76	69	72	Loading cycle
24	84	82	83	Grader, moving 30m
25	91	86	88	Horn, haul pack 10 m. Annex I-o
26	52	48	50	
27a	50	47	48	
27b	50	47	48	
27c	48	45	47	Calculated
28	49	44	47	Calculated
29a	55	50	53	
29b	53	48	50	
29c	50	46	48	Calculated
30	39	36	37	2 km from plant.

Note: See Annex F for test locations

4.9.1 1/1 and 1/3 octave band SPL curves

For 1/1 and 1/3 octave band SPL curves of various noise sources see Annex I.

5.0 ESTABLISHMENT OF THE SOUND LEVELS CALCULATED TO REACH THE BEENUP RESIDENCES FROM THE PROPOSED MINING AND MILLING OPERATIONS AND COMPARED TO CRITERIA IN SECTION 2.0

5.1 PURPOSE OF THE INVESTIGATION

To predict at the proposed Beenup mining site, the mean airborne day-time, 7.00 am 7.00 pm, 7 days per week, SL's generated by a dry mill plant and associated equipment, sited as indicated in Annex J, and a dredge plant and associated equipment, sited as indicated in Annex K.

Noise generated by a dry mill plant is modelled on the Capel survey, see Section 3.0. It should be noted that the Capel plant was built a number of years ago and

it can be assumed that a new modern plant would generate less noise.

The new Muchea dry mill plant was inspected, but unfortunately at the time of compiling this report it had not been commissioned.

Noise generated by a dredge plant is modelled on the Cataby survey, see Section 4.0.

Based on predictions indicated in Section 5.0 and compare those SL's to acceptable SL's identified in Section 2.0. Comment on results.

5.2 UNITS EMPLOYED

See Sections 1.2.1 to 1.2.5 and Section 4.2.

5.2.1 Near field SL's

Points which lie close to the source in relation to its dimensions. Also, near field relating to a noise source: that part of the field radiating sound in free-field conditions when the sound pressure and the particle velocity are not in phase. Most of the near field SL's in this report have been obtained by *in situ* measurements.

5.2.2 Far field SL's

Part of the field of a source radiating sound in free-field conditions, where the sound pressure and the particle velocity are substantially in phase or in which the particle velocity is inversely proportional to the distance from the source when the noise source eg. dry mill plant, dredge plant, is considered to be a point source. Most of the far field SL's shown in Section 3.0 and Section 4.0 have been obtained by calculation.

5.2.3 Geometric centre of sound source

The location of the geometric centre of sound source eg. dry mill plant, dredge plant and combined operation of heavy earth moving equipment, has been arrived at by establishing the intersection of SL's of individual noise sources, obtained from near field noise measurements. Each geometric centre is a fixed point, relating to a plant, combined operation and is expressed in Sound Power Level $L_{w(A)}$

Such vehicle noise as light truck, utility whose noise level is at least 10 dB below that of the principal noise source levels were not considered to influence the total SL's.

5.3 METHOD OF 'SL' PREDICTIONS AT BEENUP

5.3.1 Near field 'A' weighted SPL - $L_{p(A)}$

The near field 'A' weighted SPL of non-directional noise sources eg. excavator, bulldozer, dry mill plant etc. has been established by *in situ* measurements as described in Section 3.0 and Section 4.0 of this report.

5.3.2 'A' weighted Sound Power Level of source - $L_{w(A)}$

The $L_{w(A)}$ of individual non-directional noise sources eg. excavator, bulldozer, etc. or a complete plant eg. dry mill, dredge was derived from the following equation:

$$L_{w(A)} = L_{p(A)} + 20 \log R + 8$$

where

$L_{w(A)}$ = 'A' weighted sound power level of a particular source in dB ref. 10^{-12} W

$L_{p(A)}$ = 'A' weighted SPL of particular non-directional noise source at a distance 'R' from the source in dB(A)

R = Distance from source, m.

5.3.3 $L_{w(A)}$ of noise sources, Capel (Cap.) and Cataby (Cat.)

Utility - Cap. and Cat.	88
Truck, medium size - Cap. and Cat.	95
Tractor - Cap.	98
Fork lift - Cap.	100
Loading cycle of sand - Cat.	106
Front end loader - Cap. and Cat.	
-mean	108
Compressor/pump - Cat.	109
Road train - Cap. and Cat. - mean	113
Dredge - Cat.	113
Grader - Cat.	114
Bulldozer - Cat.	116
Dump truck - Cat.	119
Excavator - Cat.	119

Note: The recording of the various items listed above was not performed under fully controlled conditions eg. it was not possible when recording the noise of an individual item to stop all operations of the other items and record the noise level of each item separately. However the SL of each item was recorded close enough to minimise the influence of noise levels of other items.

5.3.4 $L_{w(A)}$ of the geometric centre of plants

Dry mill, Capel	114
Dredge, Cataby,	113
Combined operation	114
Cataby total	117

5.3.5 The far field $L_{p(A)}$

The far field $L_{p(A)}$ was arrived at by taking the following steps:

- ° Calculation, using equation indicated in 5.3.2. This expression includes attenuation of a non-directional point source for distance from the source.
- ° Additional attenuation has to be allowed for sound propagation over soft ground. For a mean propagation height of 1.5 m it is 4 dB(A).

No allowance has been made for the effect of wind and temperature gradient. The nearest houses south of the dredge are No.2 and No.3. As the prevailing wind is from S/SW, hence there would be additional attenuation at those houses for a great part of the year.

At large distances from a source, additional attenuation would occur due to molecular absorption in the air. The absorption coefficient can be expressed in dB/m, which is dependent on frequency, temperature, humidity and barometric pressure. Translated into dB(A), a uniform 2 dB(A) reduction was applied at distances greater than 1.5 km. See Annex O for detailed calculations.

5.4 PREDICTED 'SL' AT THE BEENUP MINING SITE

5.4.1 Dry mill SL contours

The far field SL contours have been prepared from data contained in Section 3.0 and calculated as described in Section 5.3. The contours are centred on the geometric centre of the dry mill. See Annex J.

5.4.2 Dredge plant SL contours

The far field contours have been prepared from data contained in Section 4.0 and calculated as described in Section 5.3. The contours are centred on the geometric noise centre of the dredge plant operation. See Annex K.

TABLE VI-6

dB(A) SL details at various distances

Distance km	Dry mill dB(A)	Dredge (Mon.-Fri. 7am-7pm) dB(A)	Dredge (night & w/end) dB(A)
1	40	43	39
2	34	39	33
3	30	33	29
4	28	31	27
5	26	29	25
6	24	27	23
7	23	26	22
8	22	25	21

5.4.4 Combined SL's at residences near Beenup mining area

The geometric noise centre of the dry mill is fixed.

The geometric noise centre of the dredge plant is assumed to vary according to the mining operations.

The following conditions have been assumed for the dredge operation:

- ° Central, most southern location : X-1, see Annex L-a
- ° Central, middle location: X-2, See Annex L-b
- ° Central, most northern location : X-3, See Annex L-c
- ° South-western location : X-4, See Annex L-d
- ° North-eastern location : X-5, See Annex L-e.

5.4.5 Method of calculating SL's at residences

To arrive at a predicted mining activity noise level at any of the residences at Beenup, the following steps were taken:

- ° Calculate the SL originating from the dredge plant, then add:
- ° The calculated SL from the dry mill operation, then add:

° The existing background noise of the residence (L_{90}).

Road transport noise, being an intermittent noise, should be examined separately. (Table 3, Regulations and Section 2.1). Resident SL's, except No. 8 and 9, would not be affected by road transport noise. See Annex M for detailed calculations.

A noise barrier should be provided at locations indicated for residences No.8 and No.9. See Annex N for barrier design details.

According to the Australian Environmental Council : "A reappraisal of motor vehicle control in Australia", 1985, the F12 noise levels are acceptable levels.

5.5 RESULTS

TABLE VI-7

Noise levels at residences

Note: The first SL: Monday 7am to 7pm

SL in bracket : Weekends/public holidays 7am to 10 pm

Existing SL of all residences : 34 (22) dB(A) L₉₀

1 Dredge	2 Resi dence	3 Dist. Dredge km	4 SL dB(A)	5 Dist. Dry M. km	6 SL dB(A)	7 Total 4&6 dB(A)	8 Exist. L ₉₀	9 Total dB(A)
X-1	2 & 3	1.8	38 (34)	7	23 (21)	38 (34)	34 (22)	39 (34)
X-1	4	3	33 (29)	6	24 (22)	34 (30)	34 (22)	37 (31)
X-1	5a	4.5	30 (26)	4.5	27 (25)	32 (29)	34 (22)	36 (30)
X-1	15a & b	5	29 (25)	3.5	29 (27)	32 (29)	34 (22)	36 (30)
X-1	5b	6	27 (23)	6	24 (22)	29 (26)	34 (22)	35 (27)
X-1	14	6.5	27 (23)	2.5	32 (30)	33 (31)	34 (22)	37 (32)
X-1	6	6.5	27 (23)	3.5	29 (27)	31 (28)	34 (22)	36 (29)
X-1	13	6.5	27 (23)	2	34 (32)	35 (33)	34 (22)	38 (33)
X-1	12	7.5	25 (21)	3.5	29 (27)	30 (28)	34 (22)	35 (29)
X-1	11	8	25 (21)	3	30 (28)	31 (29)	34 (22)	36 (30)
X-1	1b	7.5	25 (21)	12	21 (19)	26 (23)	34 (22)	35 (26)
X-1	7	10	23 (19)	5.5	25 (23)	27 (24)	34 (22)	35 (26)
X-1	9,10 a&b	10	23 (19)	4.5	27 (25)	28 (26)	34 (22)	35 (27)
X-1	8	10.5	23 (19)	5	26 (24)	28 (25)	34 (22)	35 (27)
X-2	1b	8	25 (21)	12	21 (19)	26 (23)	34 (22)	35 (26)
X-2	4	3	33 (29)	6	24 (22)	34 (30)	34 (22)	37 (31)
X-2	2 & 3	3	33 (29)	7	23 (21)	33 (30)	34 (22)	37 (31)
X-2	5a	4	31 (27)	5	26 (24)	32 (29)	34 (22)	36 (30)
X-2	15 a&b	4	31 (27)	3	30 (28)	34 (31)	34 (22)	37 (32)
X-2	5b	6	27 (23)	6.5	24 (22)	29 (26)	34 (22)	35 (27)
X-2	14	5	29 (25)	2.5	32 (30)	34 (31)	34 (22)	37 (32)
X-2	6	6	27 (23)	3.5	29 (27)	31 (28)	34 (22)	36 (29)
X-2	13	5.5	28 (24)	1.5	36 (23)	37 (34)	34 (22)	39 (34)
X-2	12	6.5	27 (23)	3	30 (28)	32 (29)	34 (22)	36 (30)
X-2	11	7	26 (22)	3	30 (28)	31 (29)	34 (22)	36 (30)
X-2	9 & 10	8.5	25 (21)	4	28 (26)	30 (27)	34 (22)	35 (28)
X-2	8	9.5	23 (19)	5	26 (24)	28 (25)	34 (22)	35 (27)
X-2	7	8.5	25 (21)	5	26 (24)	29 (26)	34 (22)	35 (27)

TABLE VI-7 (cont'd)

Noise levels at residences

Note: The first SL: Monday 7am to 7pm
 SL in bracket : Weekends/public holidays 7am to 10 pm
 Existing SL of all residences : 34 (22) dB(A) L₉₀

1	2	3	4	5	6	7	8	9
Dredge	Resi dence	Dist. Dredge km	SL dB(A)	Dist. Dry M. km	SL dB(A)	Total 4&6 dB(A)	Exist. L ₉₀	Total dB(A)
X-3	1,2,3,4	-	Same or better than above					
X-3	5a	3.5	32 (28)	4.5	27 (25)	33 (30)	34 (22)	37 (31)
X-3	15 a&b	3	33 (29)	3.5	29 (27)	34 (31)	34 (22)	37 (32)
X-3	14	4	31 (27)	2.5	32 (30)	35 (32)	34 (22)	38 (32)
X-3	6	4.5	30 (26)	3.5	29 (27)	33 (30)	34 (22)	37 (31)
X-3	5b	5.5	28 (24)	6.5	24 (22)	29 (26)	34 (22)	35 (27)
X-3	13	4.5	30 (26)	1.5	36 (34)	37 (35)	34 (22)	39 (35)
X-3	12	5.5	28 (24)	3	30 (28)	32 (29)	34 (22)	36 (30)
X-3	11	6	27 (23)	3	30 (28)	32 (29)	34 (22)	36 (30)
X-3	10b	6	27 (23)	4	28 (26)	31 (28)	34 (22)	36 (29)
X-3	9 & 10a	6.5	27 (23)	4.5	27 (25)	30 (27)	34 (22)	35 (28)
X-3	8	8	25 (21)	5	26 (24)	29 (26)	34 (22)	35 (27)
X-4	- All residences north of the dredge same or better than above							
X-4	4	2	37 (33)	6	24 (22)	37 (33)	34 (22)	39 (33)
X-4	2	2.5	35 (31)	7	23 (21)	35 (31)	34 (22)	38 (32)
X-4	3	3	33 (29)	7.5	23 (21)	33 (30)	34 (22)	37 (31)
X-4	1b	7.5	26 (22)	12	21 (19)	27 (24)	34 (22)	35 (26)
X-5	- All residences NW of the dredge same or better than above							
X-5	12	6.5	27 (23)	3	30 (28)	32 (29)	34 (22)	36 (30)
X-5	5a	2.5	35 (31)	4.5	27 (25)	36 (32)	34 (22)	38 (32)
X-5	6	4.5	30 (26)	3.5	29 (27)	33 (30)	34 (22)	37 (31)
X-5	7	7	26 (22)	5	26 (24)	29 (26)	34 (22)	35 (27)

5.5.1 Details of results

Column 1 is the dredge location, based on the assumption that the dredge will shift its location from time to time within the minesite as indicated in Annex L.

Column 2 is a particular residence number.

Column 3 is the distance of various residences from a given dredge location.

Column 4 is the dredge SL (first figure) at a given residence Monday 7 am to Friday 7 pm. ($L_{w(A)}$ of plant : 117 dB(A)), figures in brackets weekend operation ($L_{w(A)}$ of plant : 113 dB(A)).

Column 5 is the distance of various residences from the dry mill.

Column 6 is the dry mill SL. First figure as in Column 4 ($L_{w(A)}$: 114 dB(A)), second figure as in Column 4 ($L_{w(A)}$: 112 dB(A)).

Column 7 is the total SL from columns 4 & 6.

Column 8 is the mean existing SL at residences. First figure as in Column 4, second figure, evening/night time levels, see Section 1.9.1, Test location 17-3.

Column 9 is the total SL, Columns 7 & 8.

5.6 DISCUSSION

5.6.1 Predicted SL at houses, Beenup, Monday-Friday 7 am to 7pm

During the above period the dredge plant consisting of the floating dredge plus service vehicles (excavator, bulldozer, grader, dump truck etc.) will operate at the same time as the dry mill. The total SL reaching the various residences are shown in Section 5.5 Results, column 9 first row of dB(A) levels.

All calculated SL's at the residences are less than the acceptable outdoor SL's of 40 dB(A) indicated in Section 2.2 for the above period.

Recommendation for the above period: NO REMEDIAL ACTION IS NEEDED.

5.6.2 Predicted SL at houses, weekends/holidays 7am-7pm

During the above period, both the dry mill and the dredge plant will be operating. The total SL reaching the residences are shown in Section 5.5 Results, column 9 first dB(A) figures. Most of the calculated SL's reaching the residences are between 35-39 dB(A). The acceptable outdoor SL for this period is 35 dB(A).

According to regulations, a 5 dB(A) excess is acceptable.

Recommendation for the above period : NO REMEDIAL ACTION IS NEEDED.

5.6.3 Predicted SL's at residences, always 7 pm-7am

During the above period, the dredge only (not the service vehicles) plus the dry mill (not the service vehicles) will be operating. The total SL reaching the various residences are shown in Section 5.5 Results, column 9 dB(A) figures in bracket. The acceptable outdoor SL for this period is 30 dB(A). Most of the calculated SL's are between 26 dB(A) and 30 dB(A). There is one case when the SL is 35 dB(A) and according to regulations an excess of 5 dB(A) is acceptable.

Recommendation for the above period: NO REMEDIAL ACTION IS NEEDED.

5.6.4 Predicted road transport noise at residences, Beenup

The principal Regulations dealing with traffic noise in WA are:

- (a) Road Traffic Act 1974-1982
- (b) Australian Design Rule No. 28 & 28a
- (c) Main Road Department Practice WA
- (d) Noise Abatement (Neighbourhood Annoyance) Regulations 1979.

(a) and (b) control by various means the permissible noise emission levels. Manufacturers and maintenance bodies have to satisfy these regulations.

(c) deals with transportation noise in terms of $L_{10-18 \text{ hr}}$ dB(A). The Main Roads Department uses design level of 68 dB(A) 1 m in front of a residence.

(d) refers to transportation noise in Table 1 of the Regulations, in terms of medium density, very dense etc. transportation, which in turn relates to assigned outdoor noise levels indicated in Table 1.

The route to be taken by road transport vehicles (Annex M), according to calculations will only affect residences No. 8 and No.9. The SL at these two residences would be 49 dB(A). The construction of a long earth embankment, minimum height 5 m, on the houses side of the road, would reduce the SL by 12 dB(A).

The following calculations are based on Table 3 of the Noise Abatement (Neighbourhood Annoyance) Regulations 1979, which makes provision for

amending an intermittent noise for its duration. In this case the road transport noise could exceed one minute at a house, which will reduce the noise level effectively by 10 dB(A) at a residence. See calculations in Annexes M and N. At the same time the noise level figure will be increased by 5 dB(A) due to its characteristics : frequency/amplitude modulation. See Table 4 of the above Regulation.

The calculations may be summarised as follows:

Calculated SL at residences No.8 and No. 9	49 dB(A)
Deduction for intermittent noise	10 dB(A)
Addition for special characteristics	5 dB(A)
Deduction for barrier	12 dB(A)
	<hr/>
Net SL	32 dB(A)

This net SL at these two residences is acceptable always.

5.6.5 Type of terrain at Beenup

The terrain around the minesite at Beenup is fairly flat. Noise levels from the plants will be attenuated by soft ground : 4 dB(A) irrespective of distance.

5.6.6 Noise generation pattern, dry mill

Based on the Capel Study, Section 3.0, most of the noise sources are enclosed by some sort of building fabric. Further attenuation may be provided by forming earth berms. If there is a pronounced directivity of any sound source, then the layout of the plant should ensure that the sound is directed towards the south : the dredge plant.

5.6.7 Noise generation pattern, dredge plant

The dredge plant has two major noise components:

- (a) the dredge
- (b) the service vehicles (excavator, bulldozer etc.)

Examining (a) at Cataby, the dredge sits below the natural ground level by its nature of operation. In addition a perimeter berm exists all round the dredge pond. SL measured at location 11 a is 18 dB(A) less than the SL measured at location 1 a, yet it is less than 100 m away.

Examining (b) at Cataby, at many locations there is a direct view of the excavation pit and the service vehicles. Consequently between locations 9 (a) and 9 (d), there is only a 6 dB(A) reduction over a distance of 600 m. A 5 to 10 high earth berm could reduce the noise levels at the above locations by 10 to 15 dB(A).

Note: A noise barrier, to be efficient, should be either near the noise source or the receiver and be as high and as long as practical to minimise diffraction over the top and the sides, especially at low frequencies.

5.6.8 Use of warning devices eg. horns

A horn sound, which is a very narrow frequency sound, can be heard at great distances and could be very annoying eg. at Beenup to residents. To assess the level of horn noise at a location, a penalty of 5 dB(A) for tonal component, see Section 2.0, "Regulations", is given. See also Annex I-o for 1/1 octave band frequency spectrum of a horn noise.

5.6.9 The pattern of service vehicle usage

Noise generated by service vehicles often depends on the manner of usage eg. excess revving of the engines would increase the noise generated by those vehicles.

Finally, good minesite management can make a lot of difference to the noise level generated by mining activity.

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BEENUP PROJECT

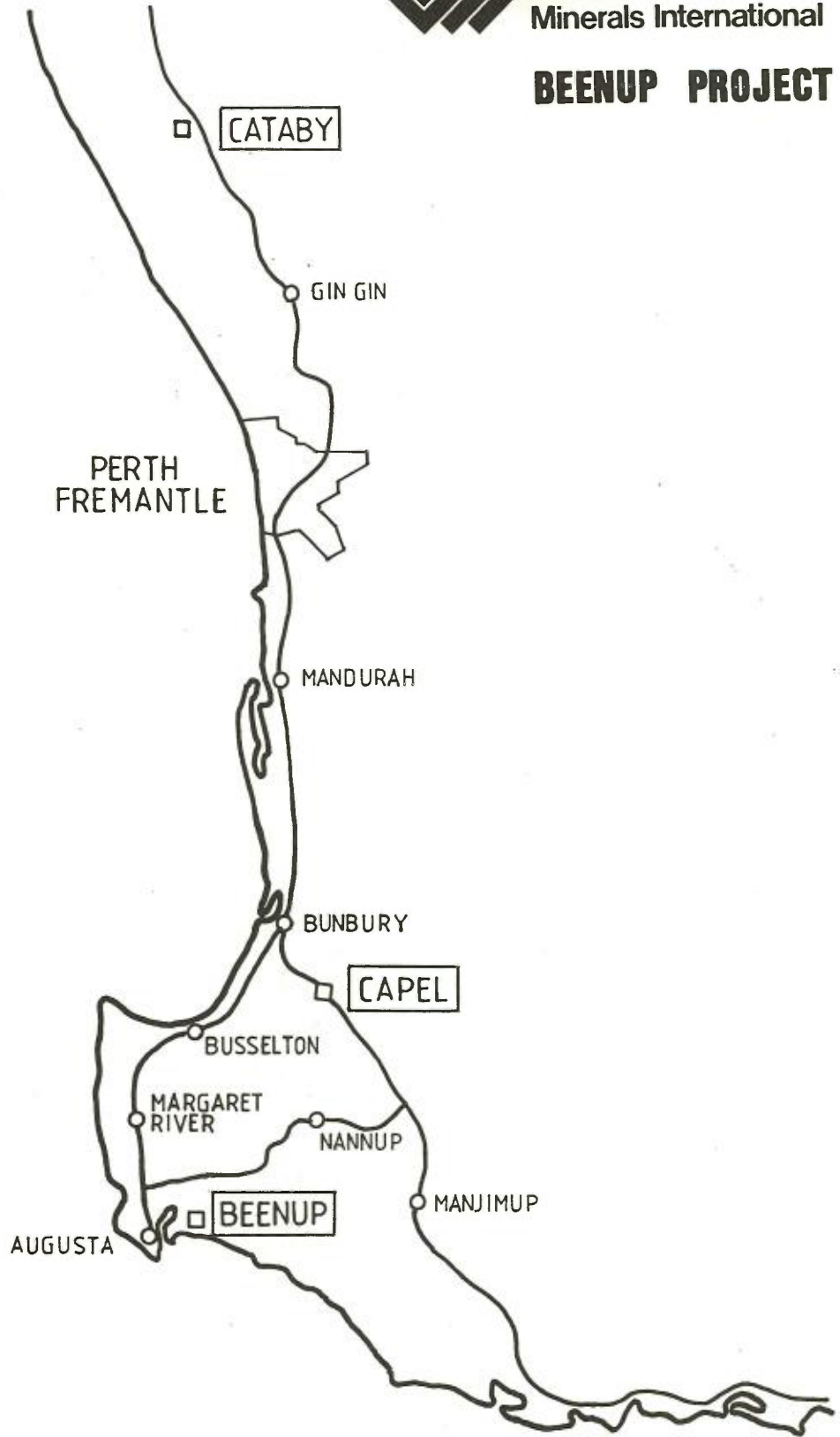


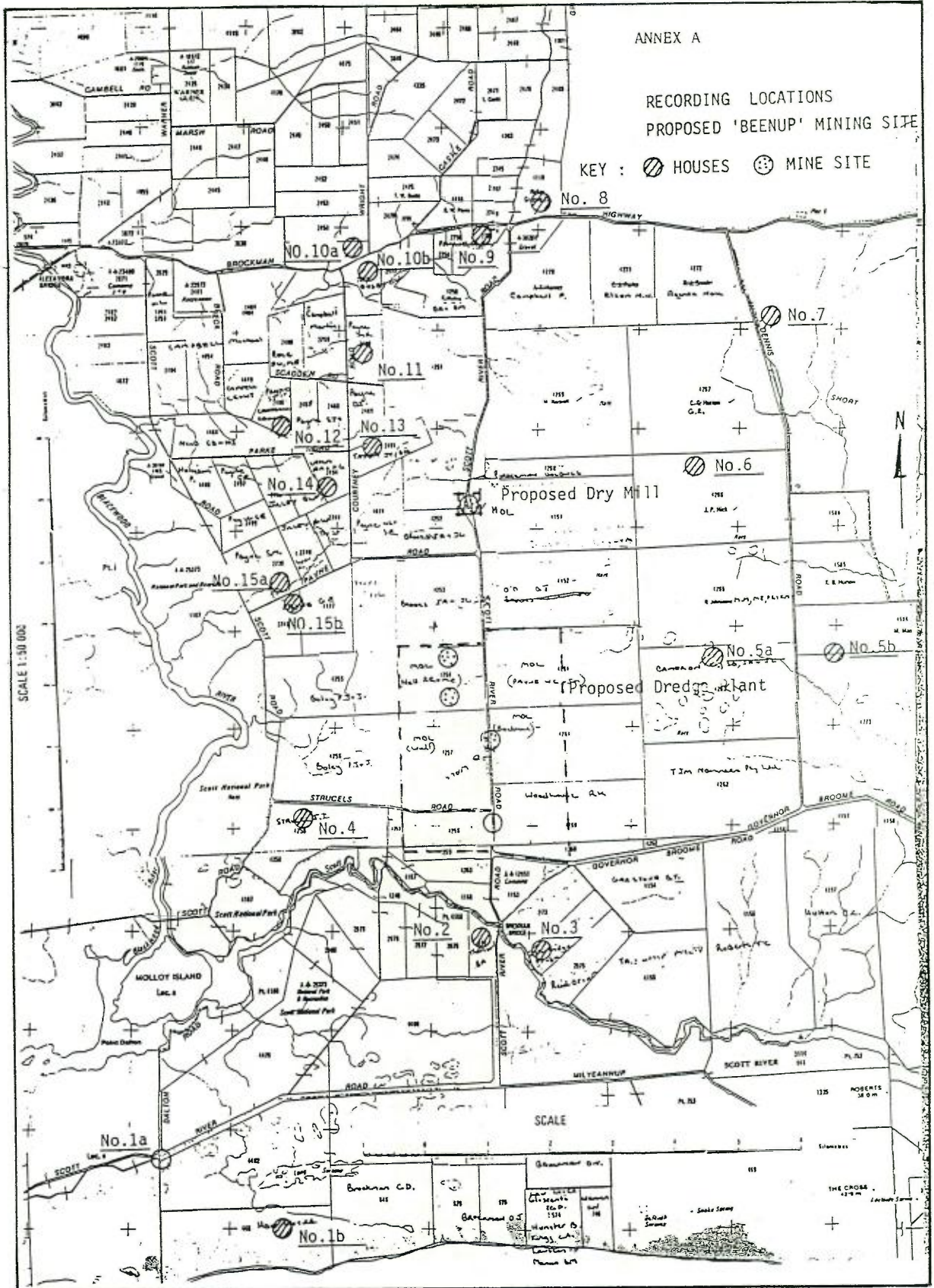


FIGURE VI-1
Location of Measurements of
Sound Levels

ANNEX A

RECORDING LOCATIONS
PROPOSED 'BEENUP' MINING SITE

KEY :  HOUSES  MINE SITE

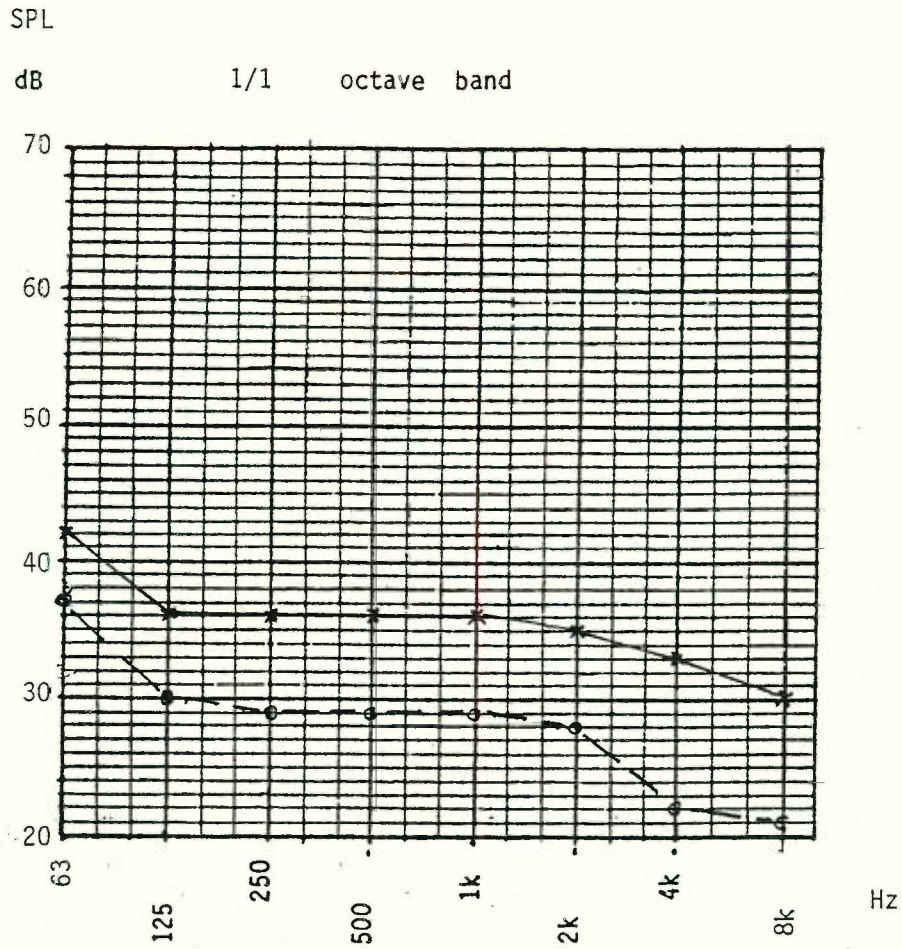


ANNEX B

TYPICAL 1/1 octave band SPL at residences

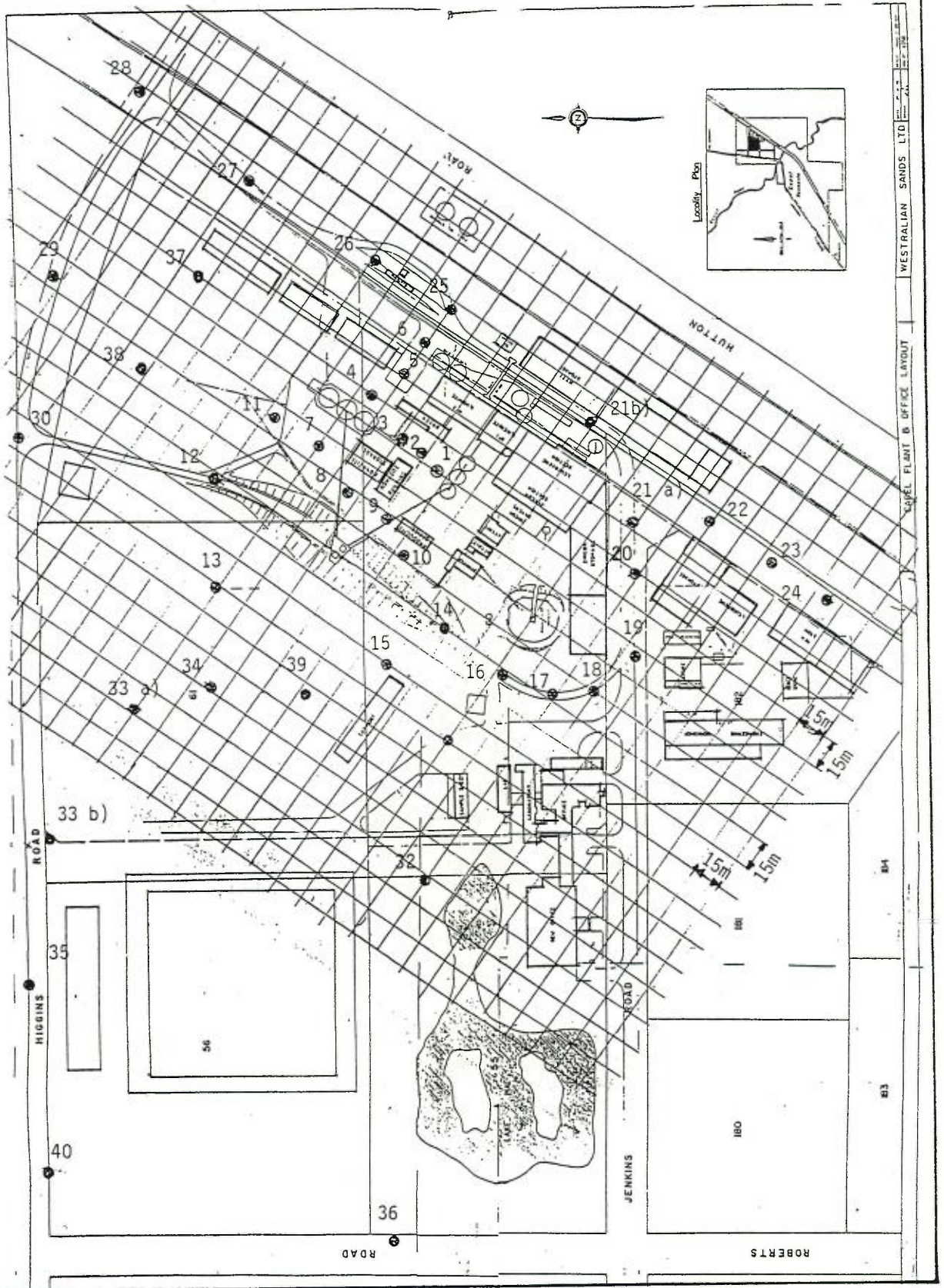
Top curve L₁₀

Bottom curve L₉₀

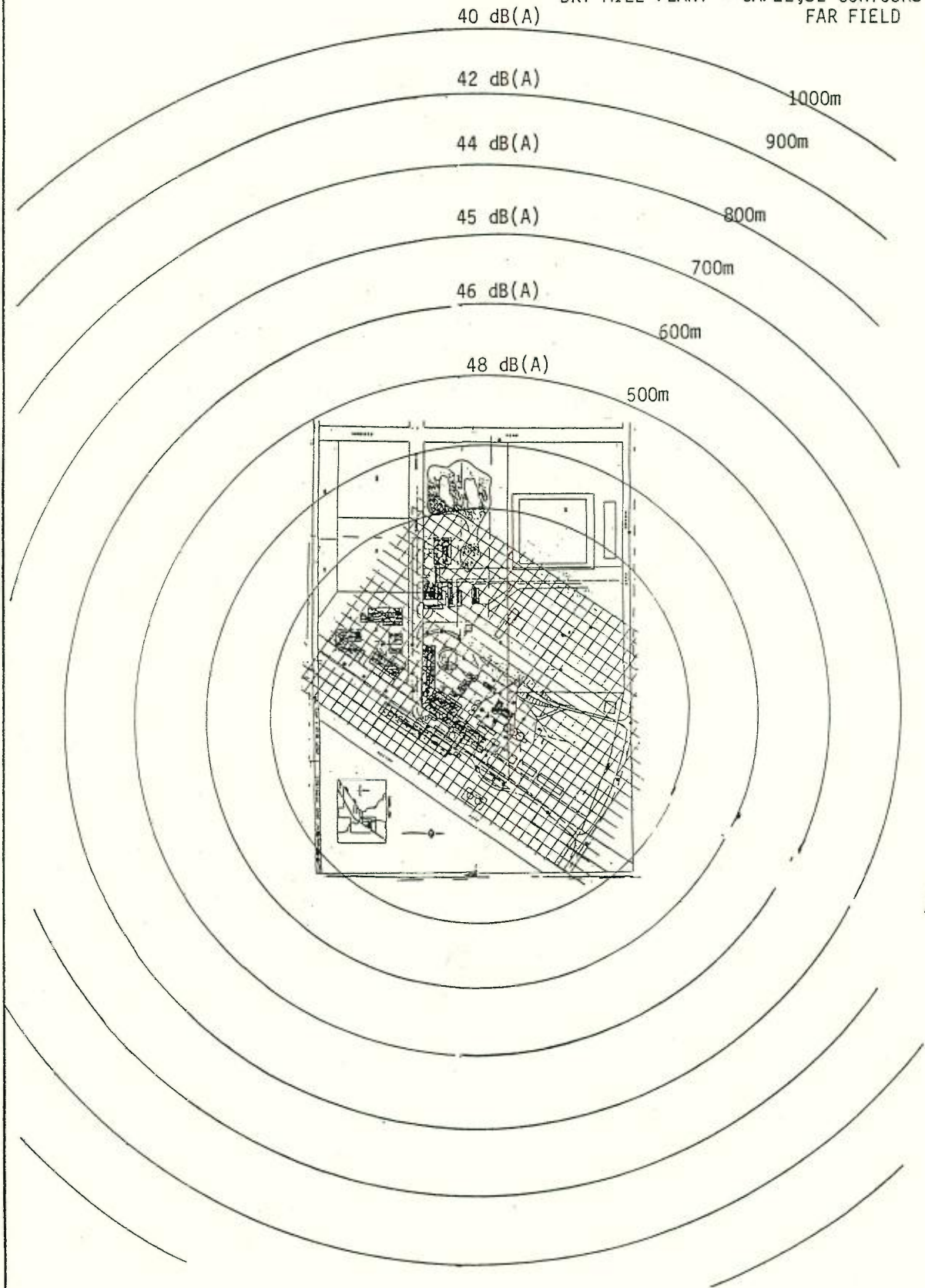


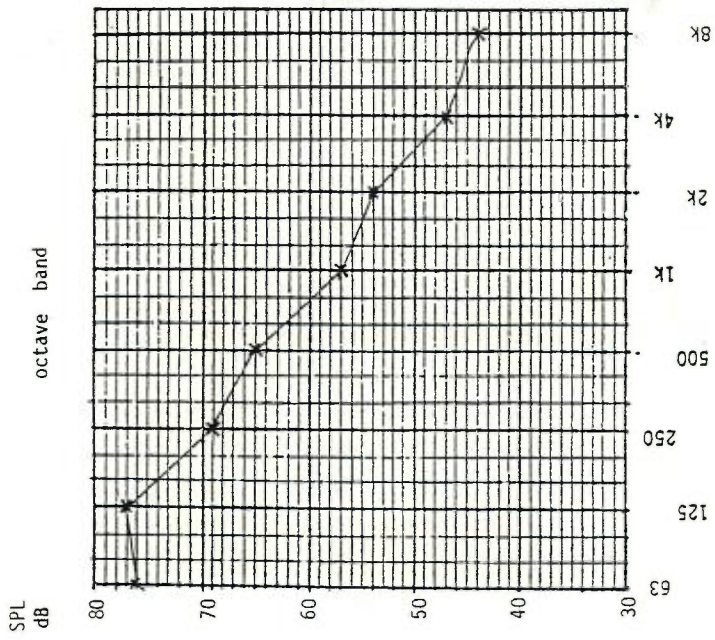
ANNEX C

RECORDING LOCATIONS AT CAPEL SITE
DRY MILL PLANT

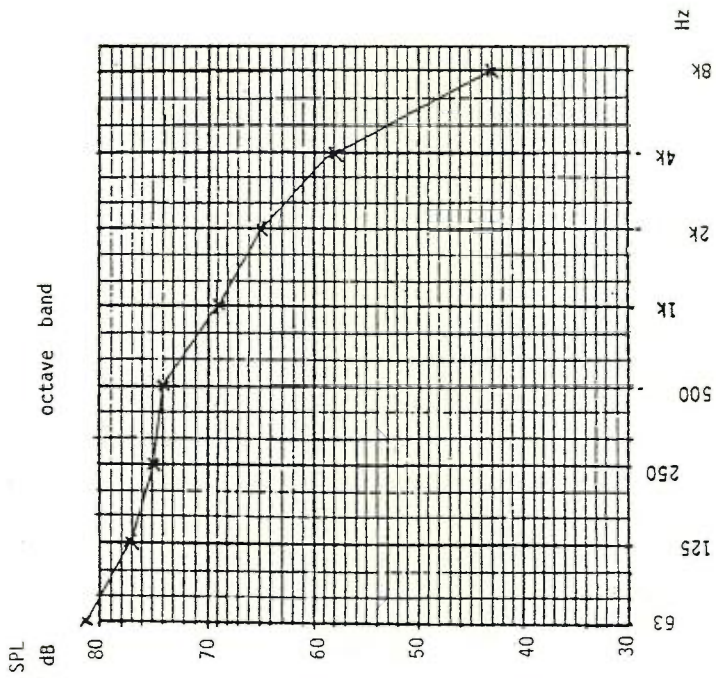


ANNEX D
DRY MILL PLANT - CAPEL, SL CONTOURS
FAR FIELD

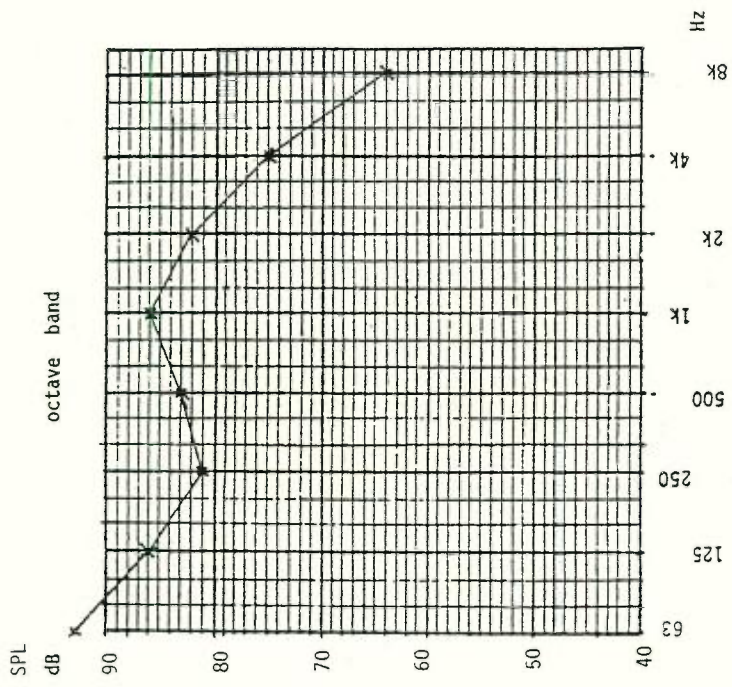




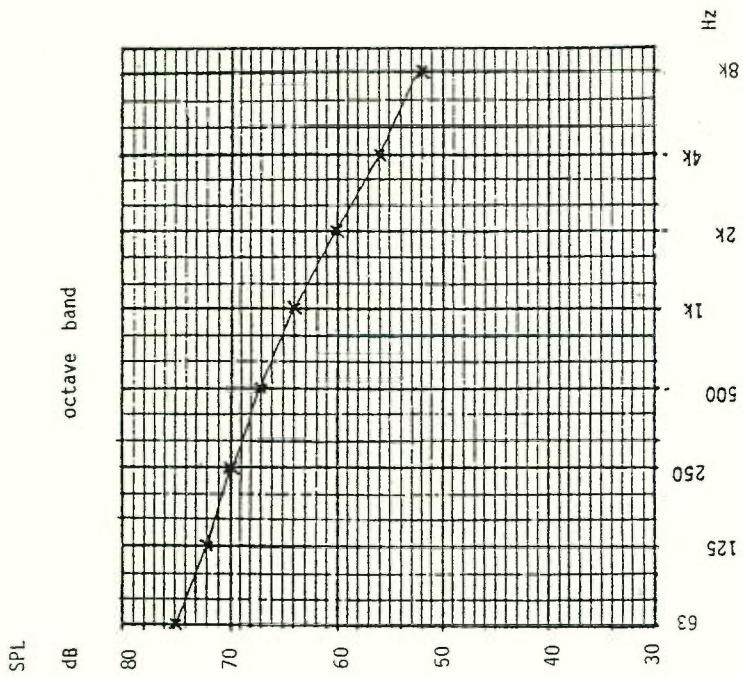
b) Recording location 4



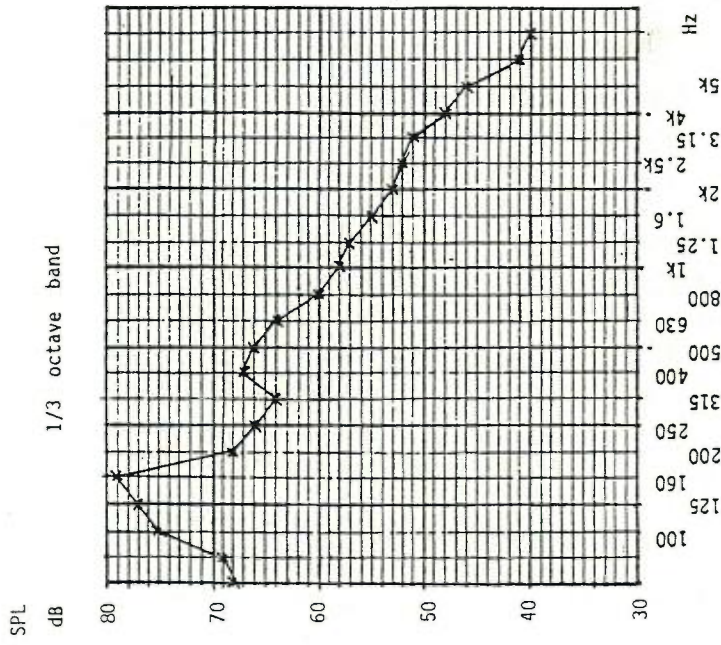
a) Recording location 1



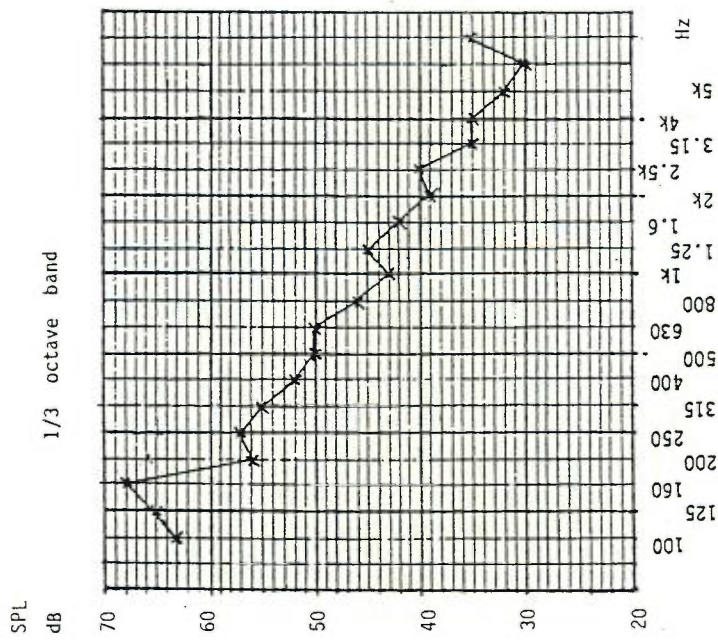
d) Recording location 16 b)



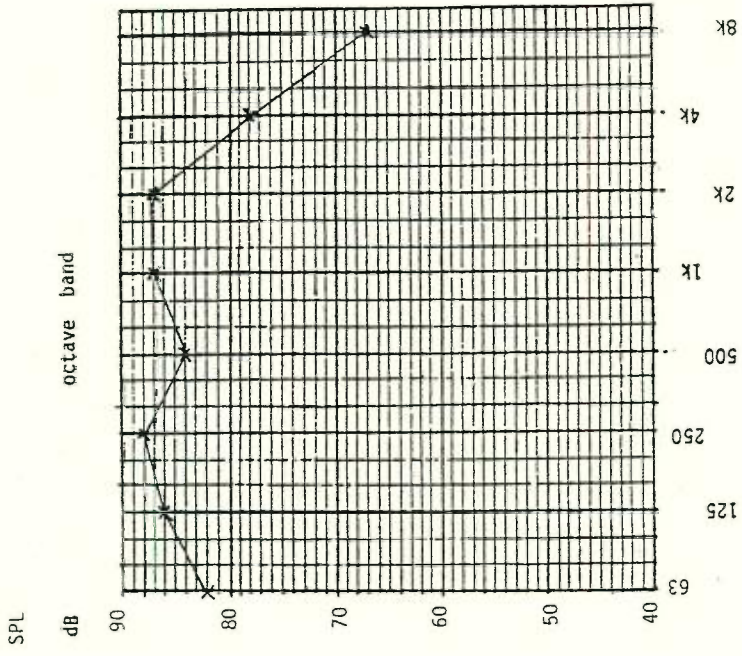
c) Recording location 14



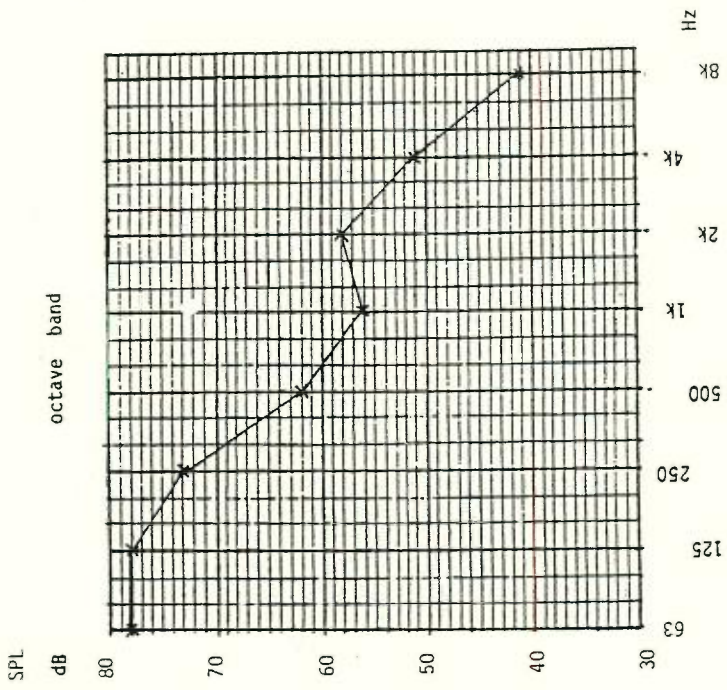
f) Recording location 21 b)



e) Recording location 19



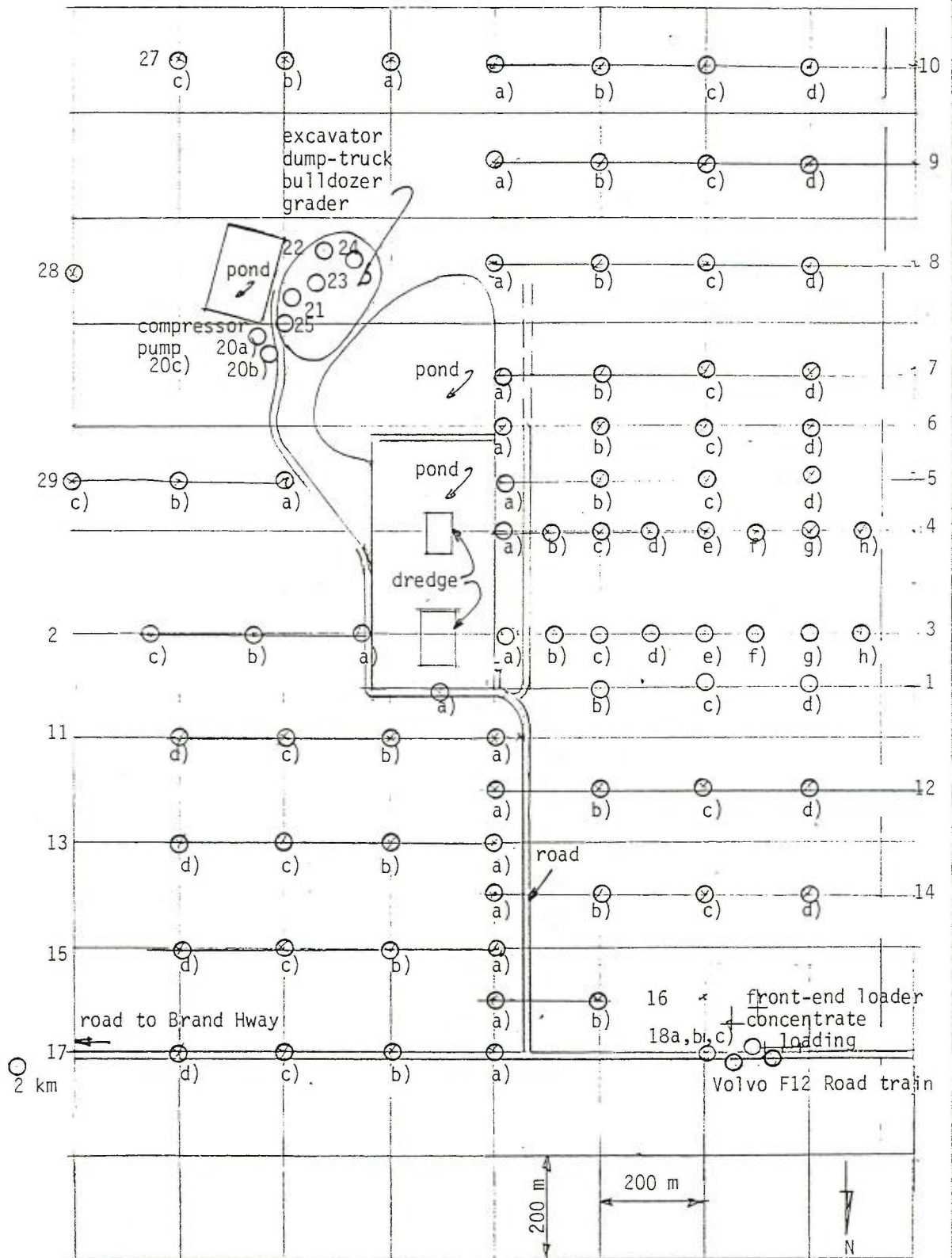
h) Recording Location 31 b)



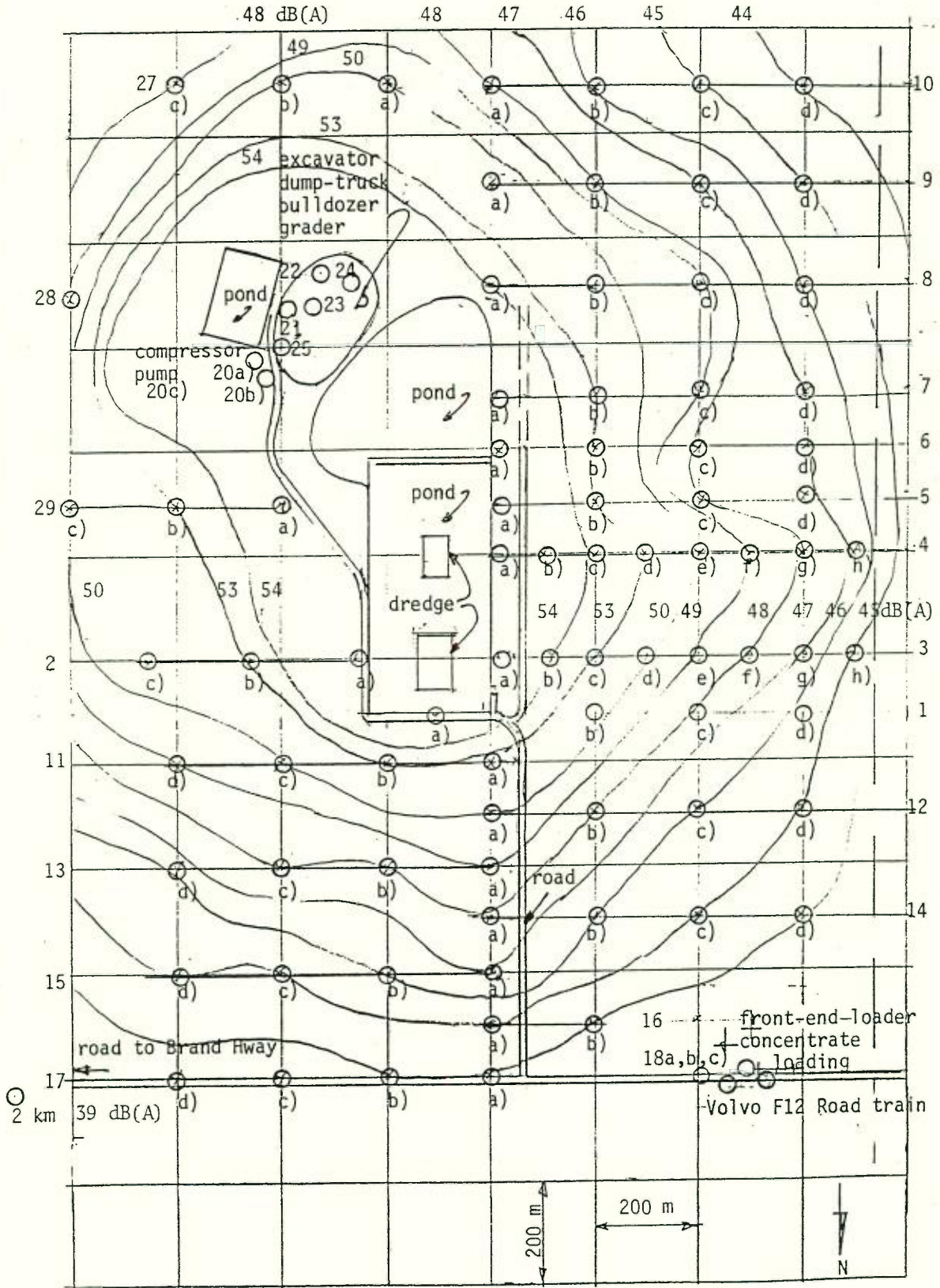
g) Recording Location 26

ANNEX F

RECORDING LOCATIONS AT CATABY MINING SITE

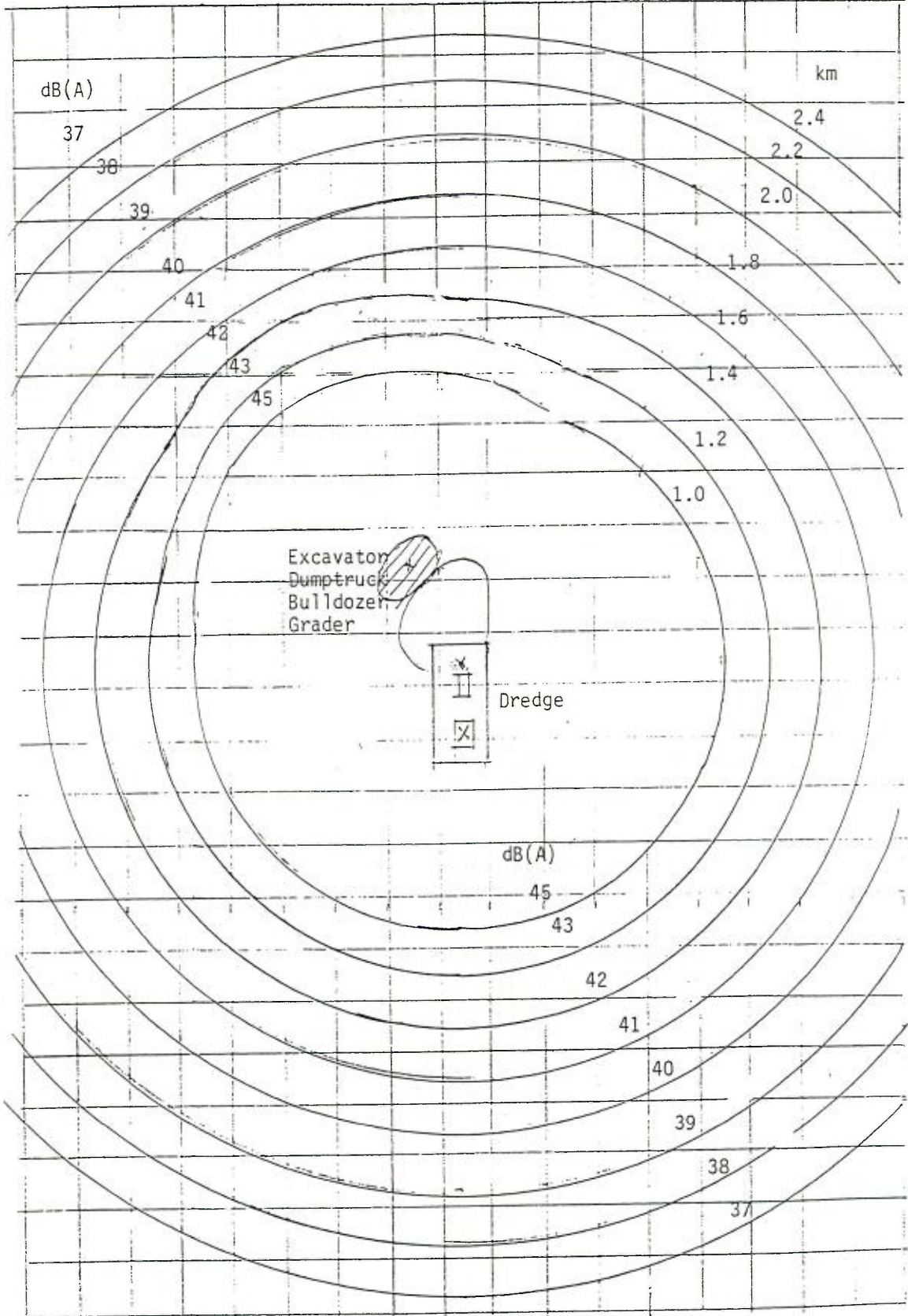


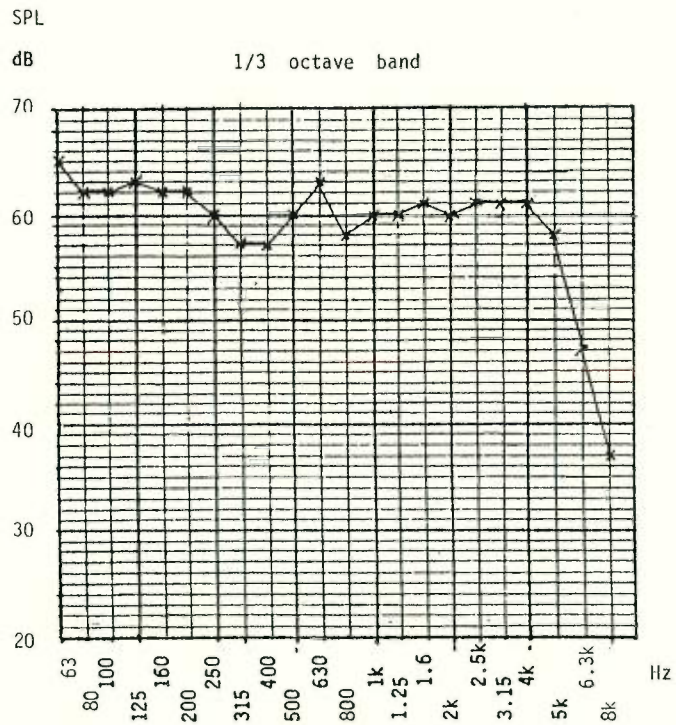
ANNEX G
 RECORDING SL CONTOURS- CATABY MINING SITE
 dB(A) - L₁₀ - NEAR FIELD CONTOURS



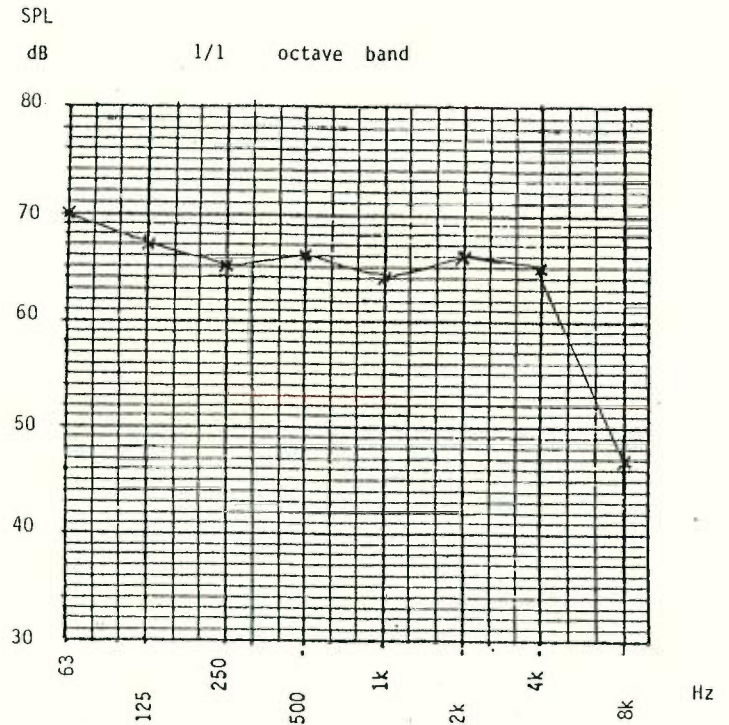
ANNEX H

SL CONTOURS : L₁₀ dB(A) - FAR FIELD CONTOURS

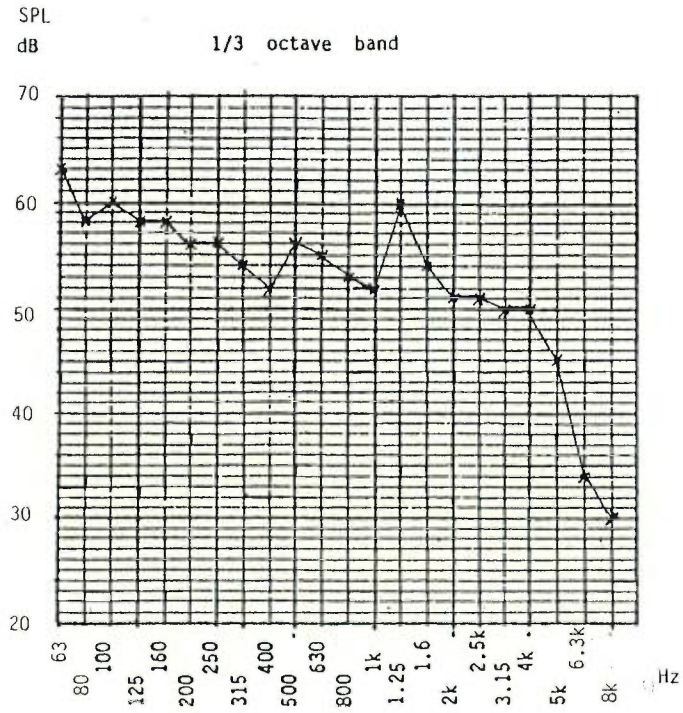




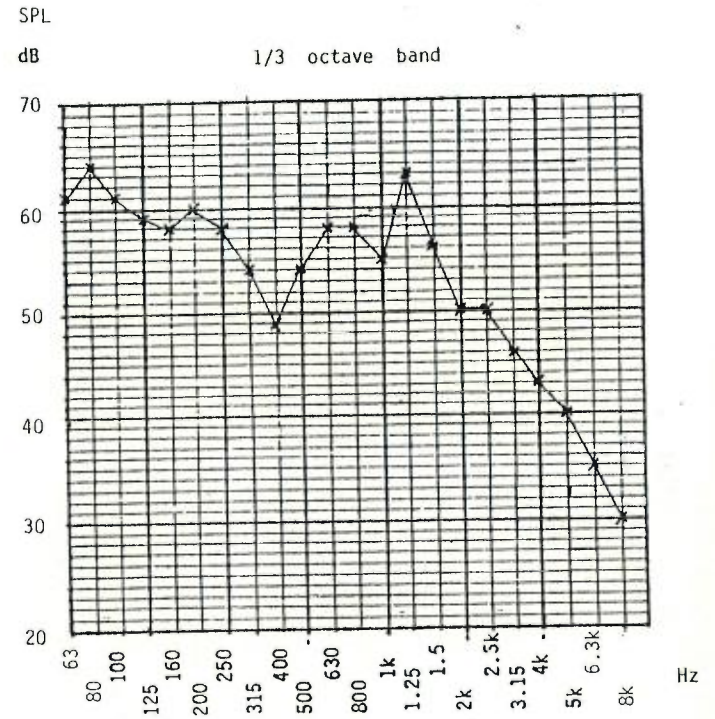
a) DREDGE - North side - 1/3 oct.
Recording location 1a)



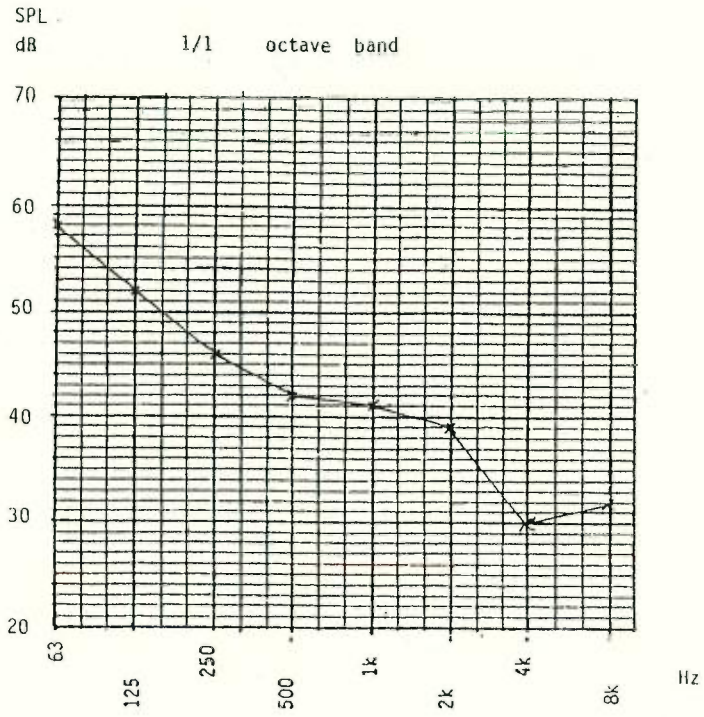
a) DREDGE - North side - 1/1 oct.
Recording location 1a)



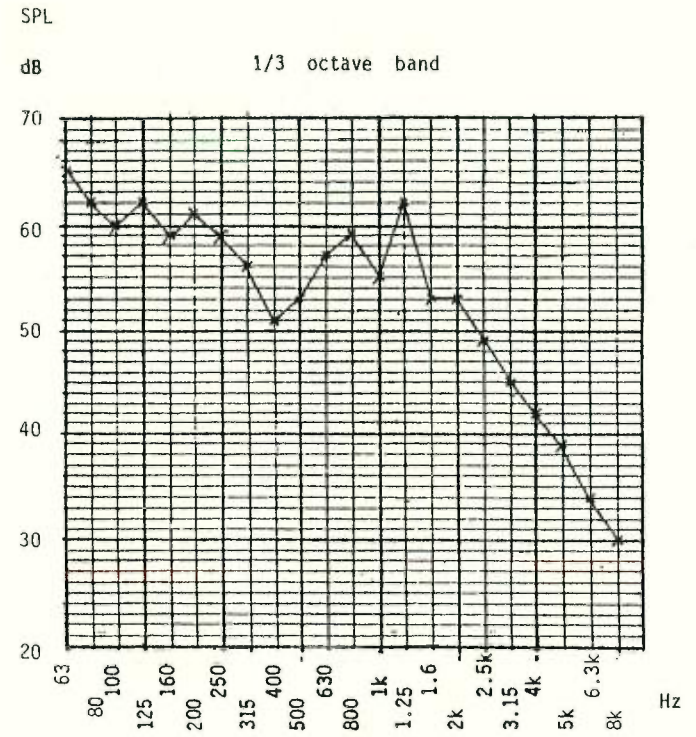
b) - DREDGE - East side
Recording location 2a)



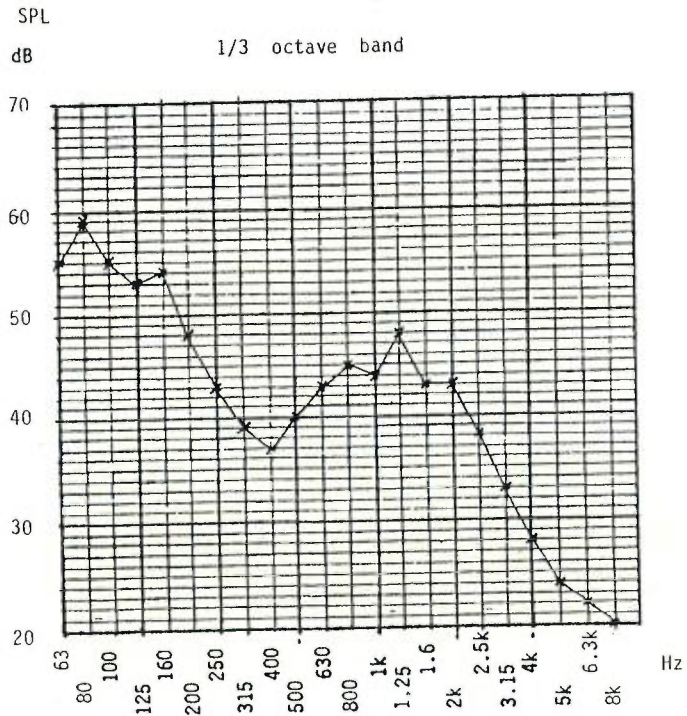
c) DREDGE - West side
Recording location 3a)



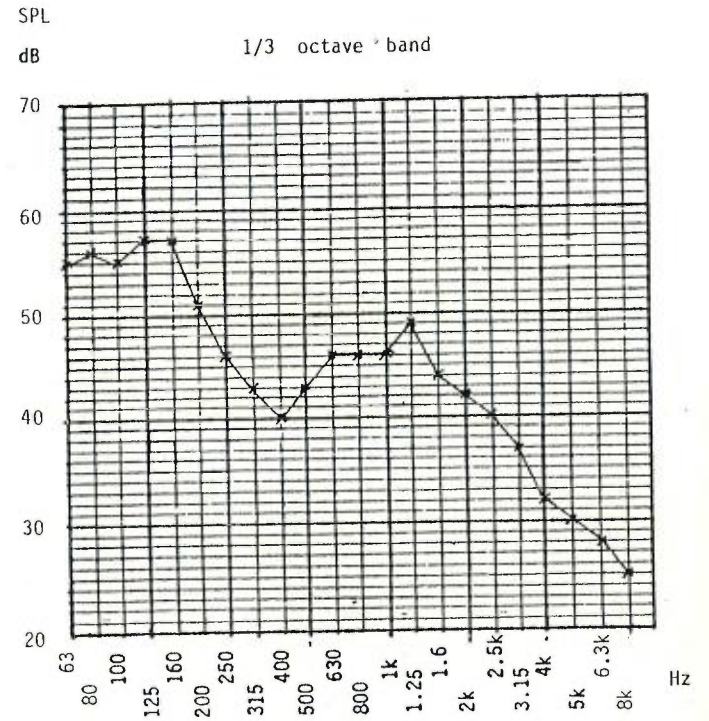
d) Recording location 3f)



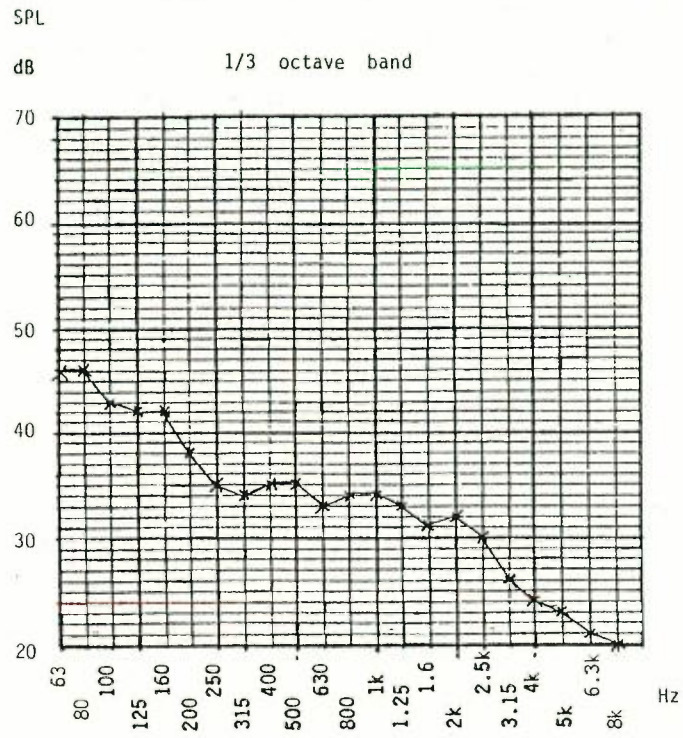
e) Recording location 4a)



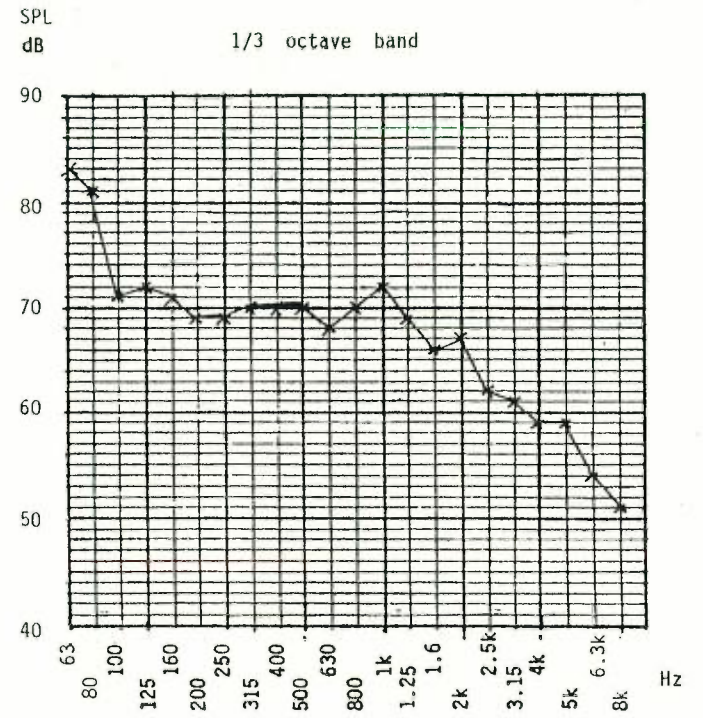
f) Recording location 6b)



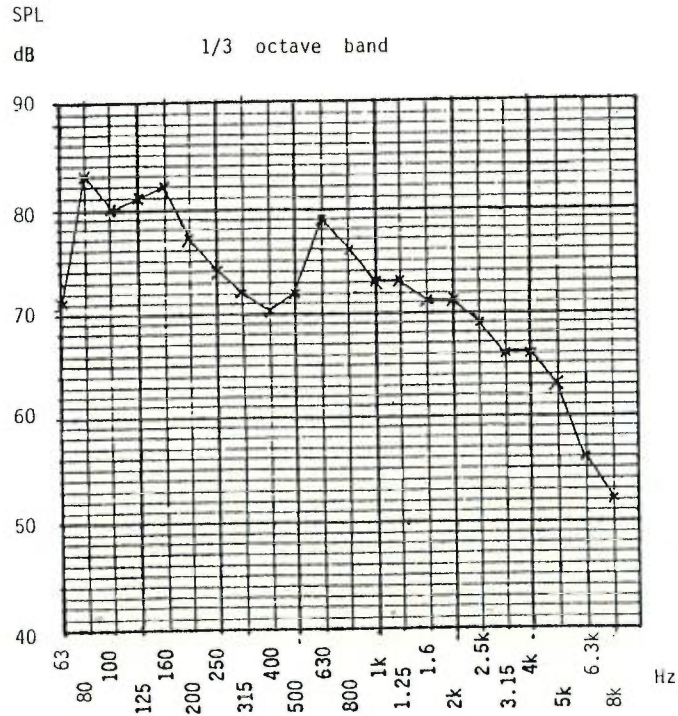
g) Recording location 7a)



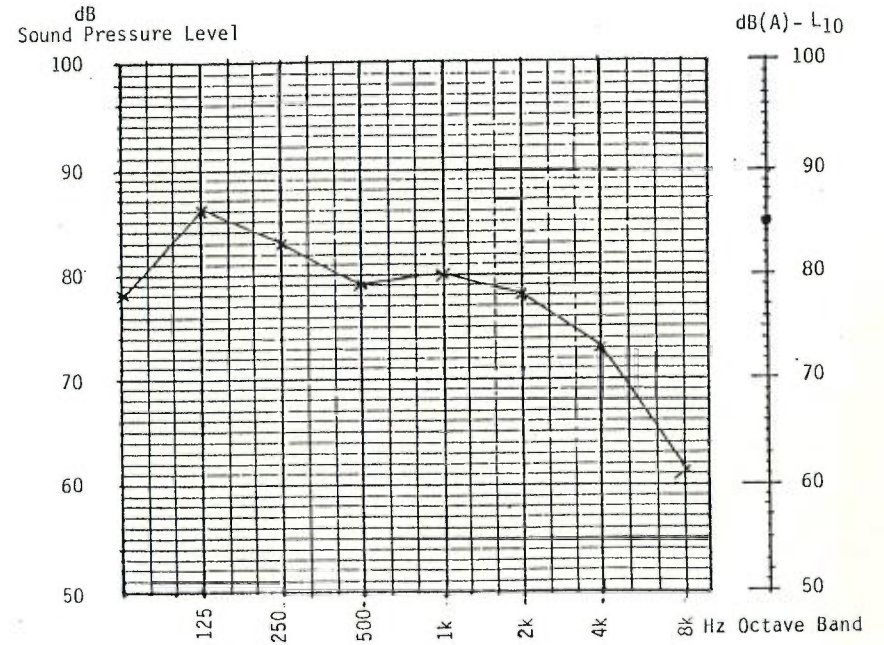
h) Recording location 17a)



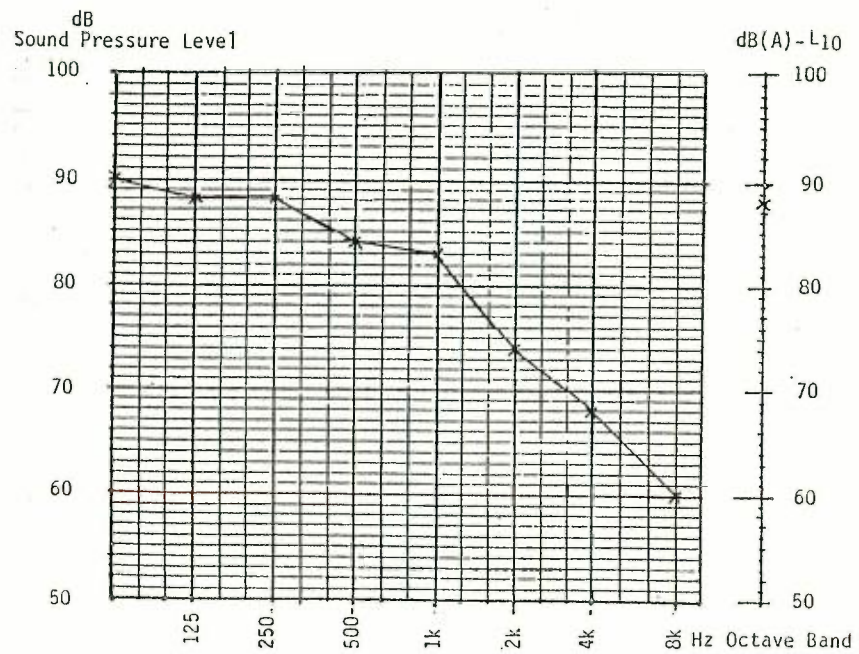
j) Recording location 18a)



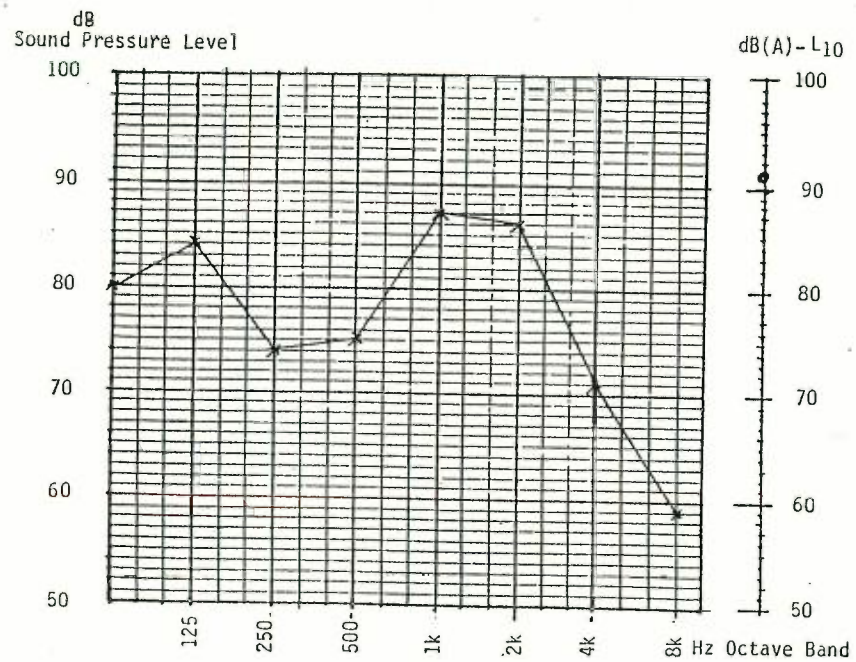
k) Recording location 20a)



m) Recording location 20c)





n) Recording location 22

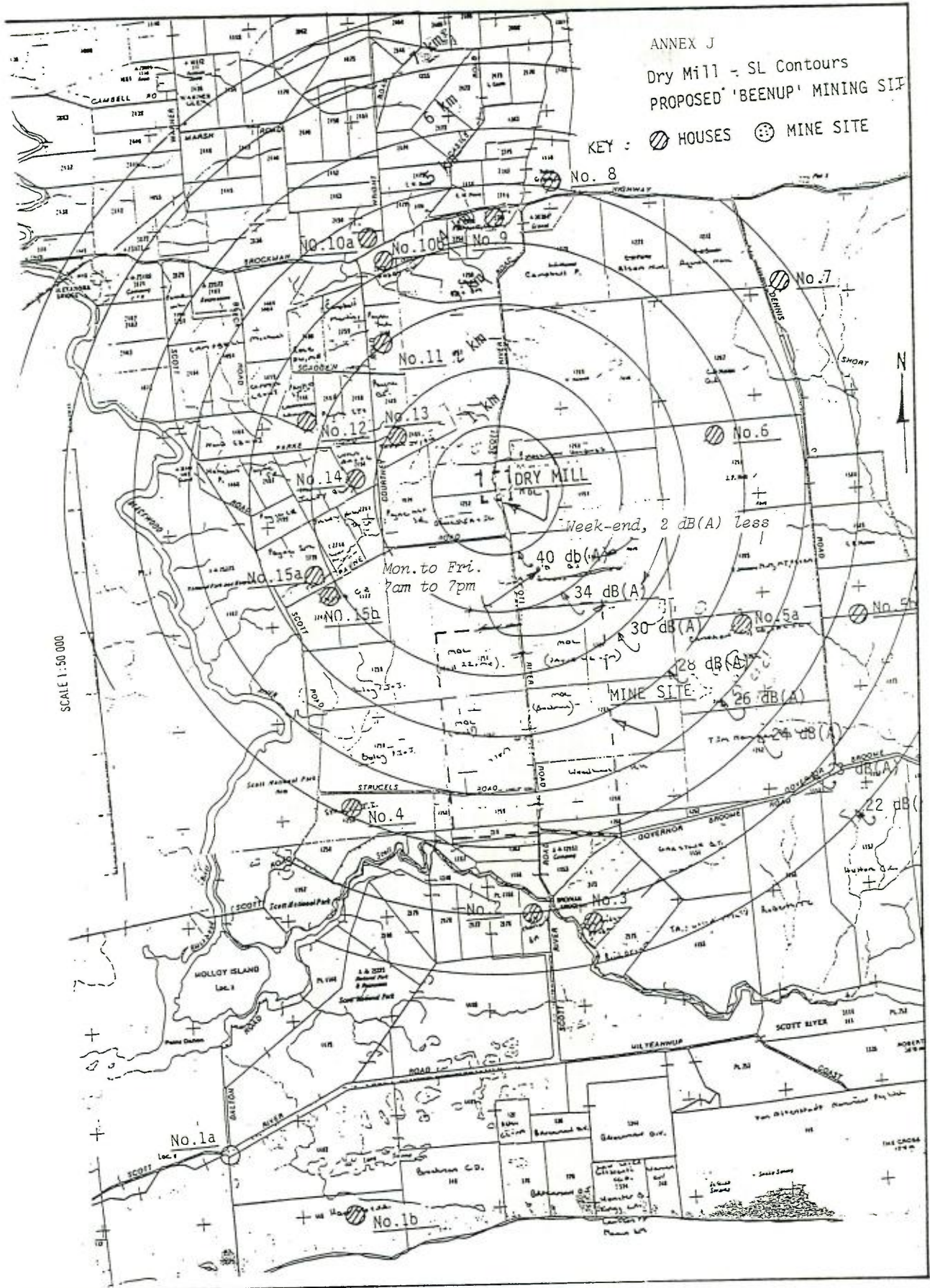


o) Recording location 25



ANNEX J

Dry Mill - SL Contours
PROPOSED 'BEENUP' MINING SITE

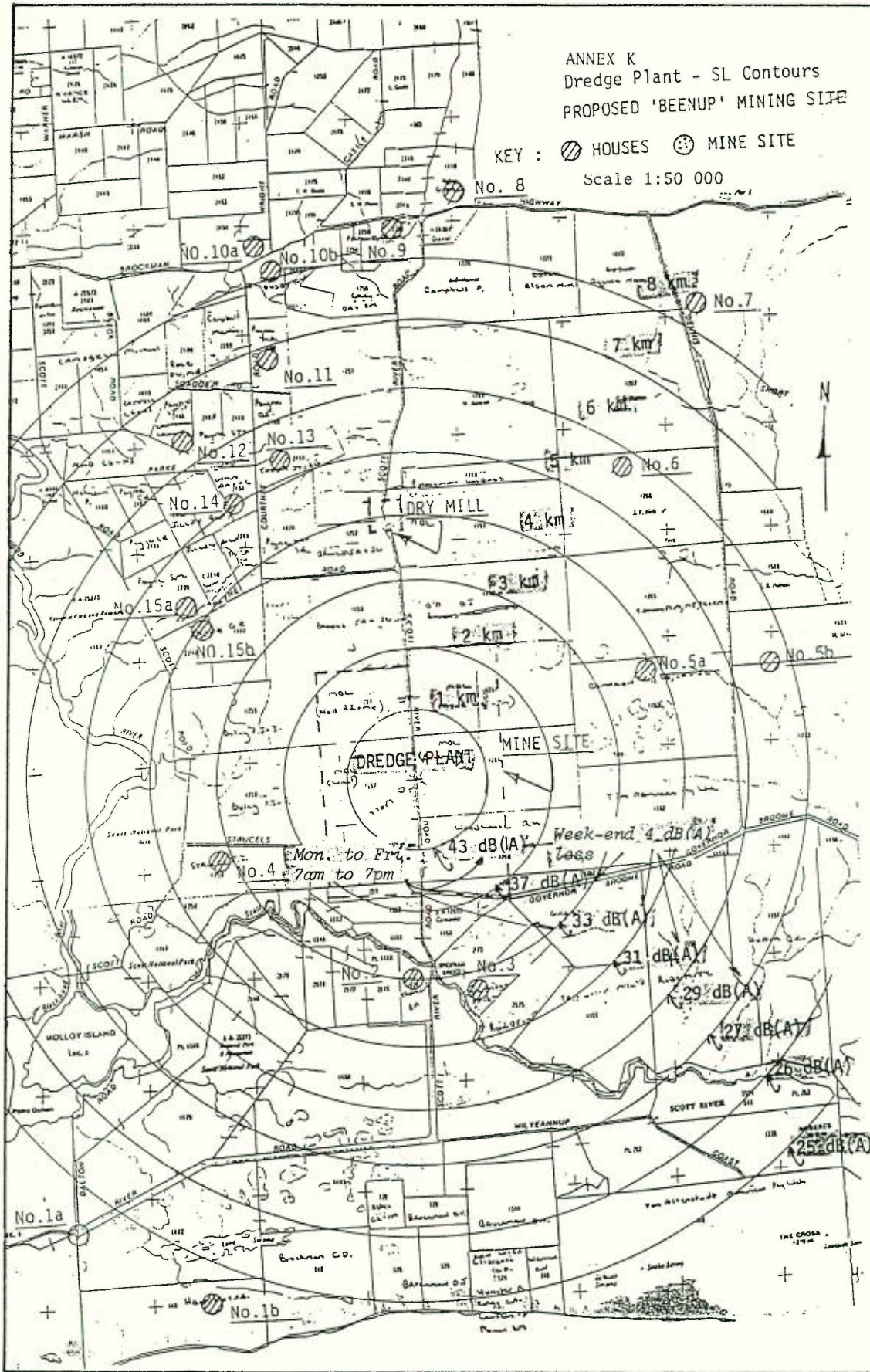
KEY :  HOUSES  MINE SITE





ANNEX K
Dredge Plant - SL Contours
PROPOSED 'BEENUP' MINING SITE

KEY :  HOUSES  MINE SITE

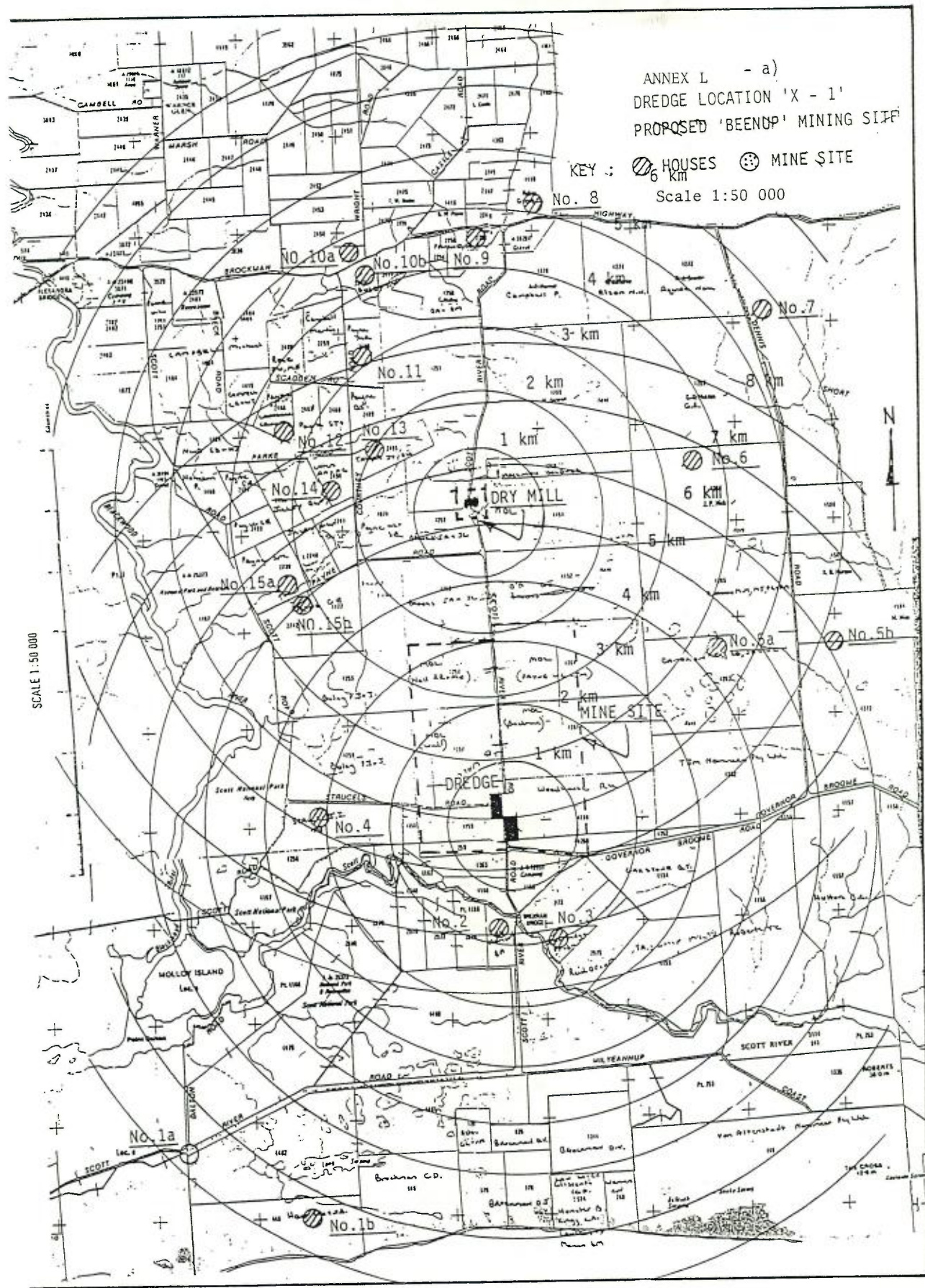
No. 8 Scale 1:50 000



ANNEX L - a)
 DREDGE LOCATION 'X - 1'
 PROPOSED 'BEENUP' MINING SITE



KEY :  HOUSES  MINE SITE

Scale 1:50 000

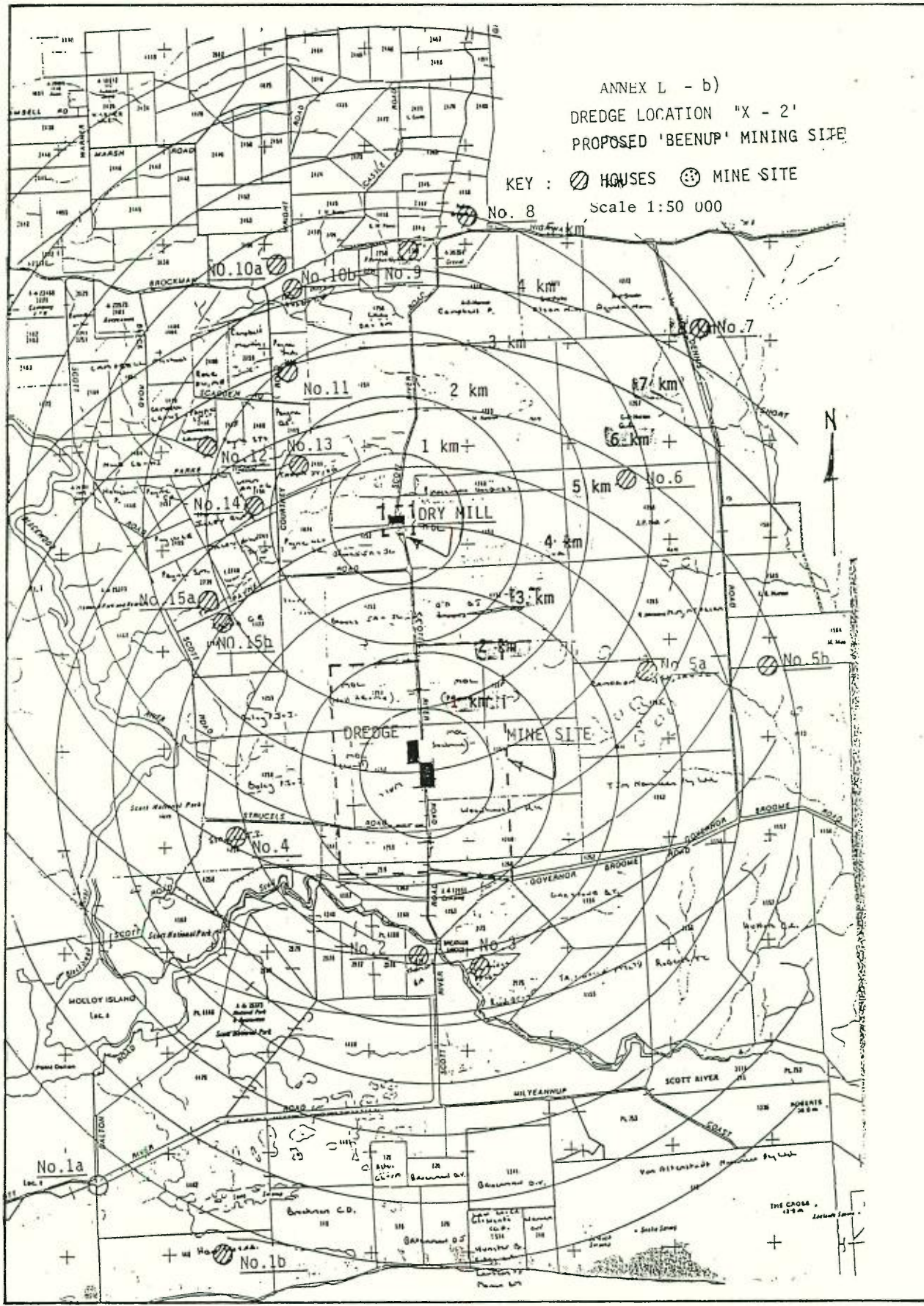


SCALE 1:50 000



ANNEX L - b)
DREDGE LOCATION "X - 2"
PROPOSED 'BEENUP' MINING SITE

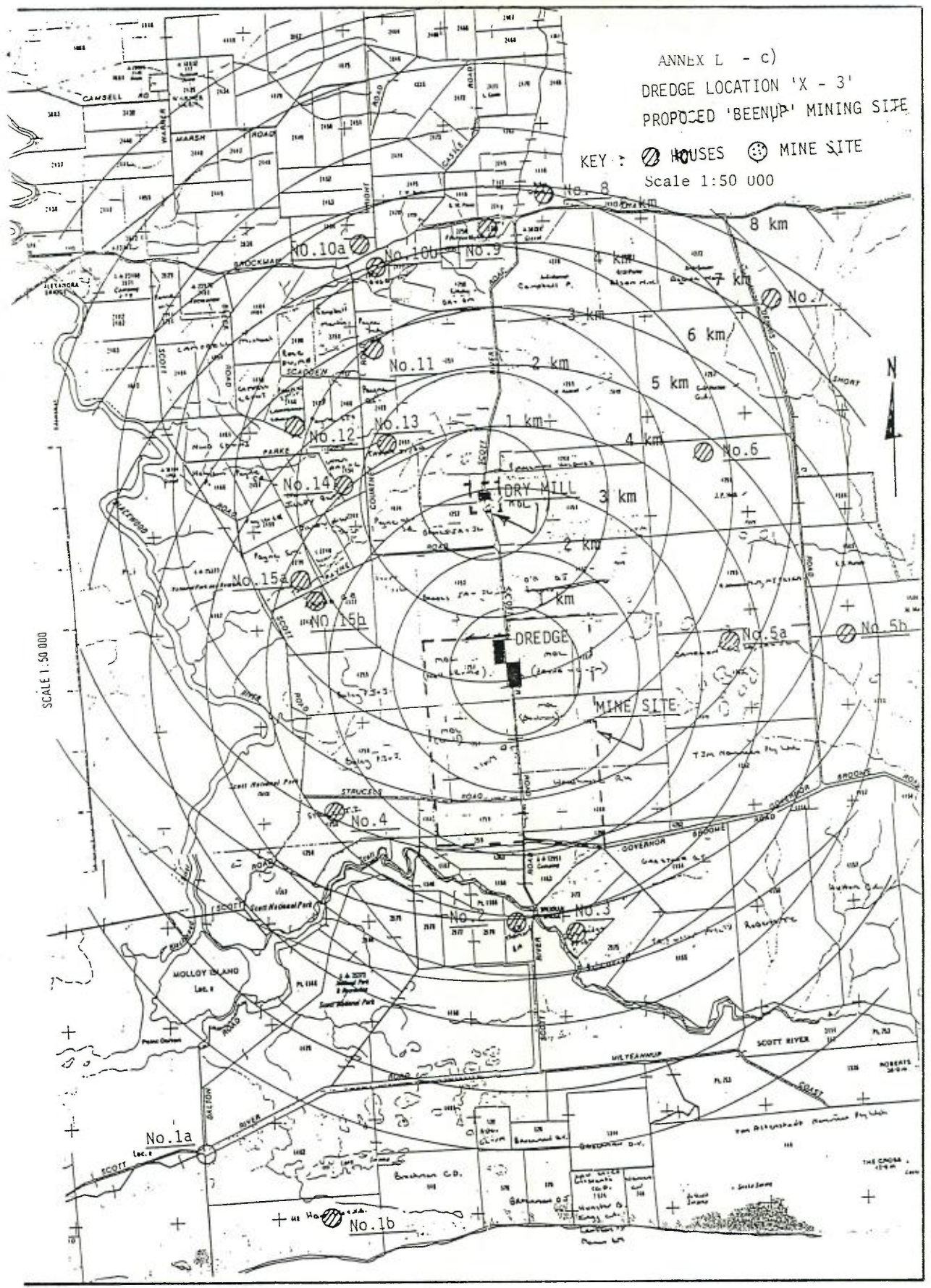
KEY :  HOUSES  MINE SITE

Scale 1:50 000





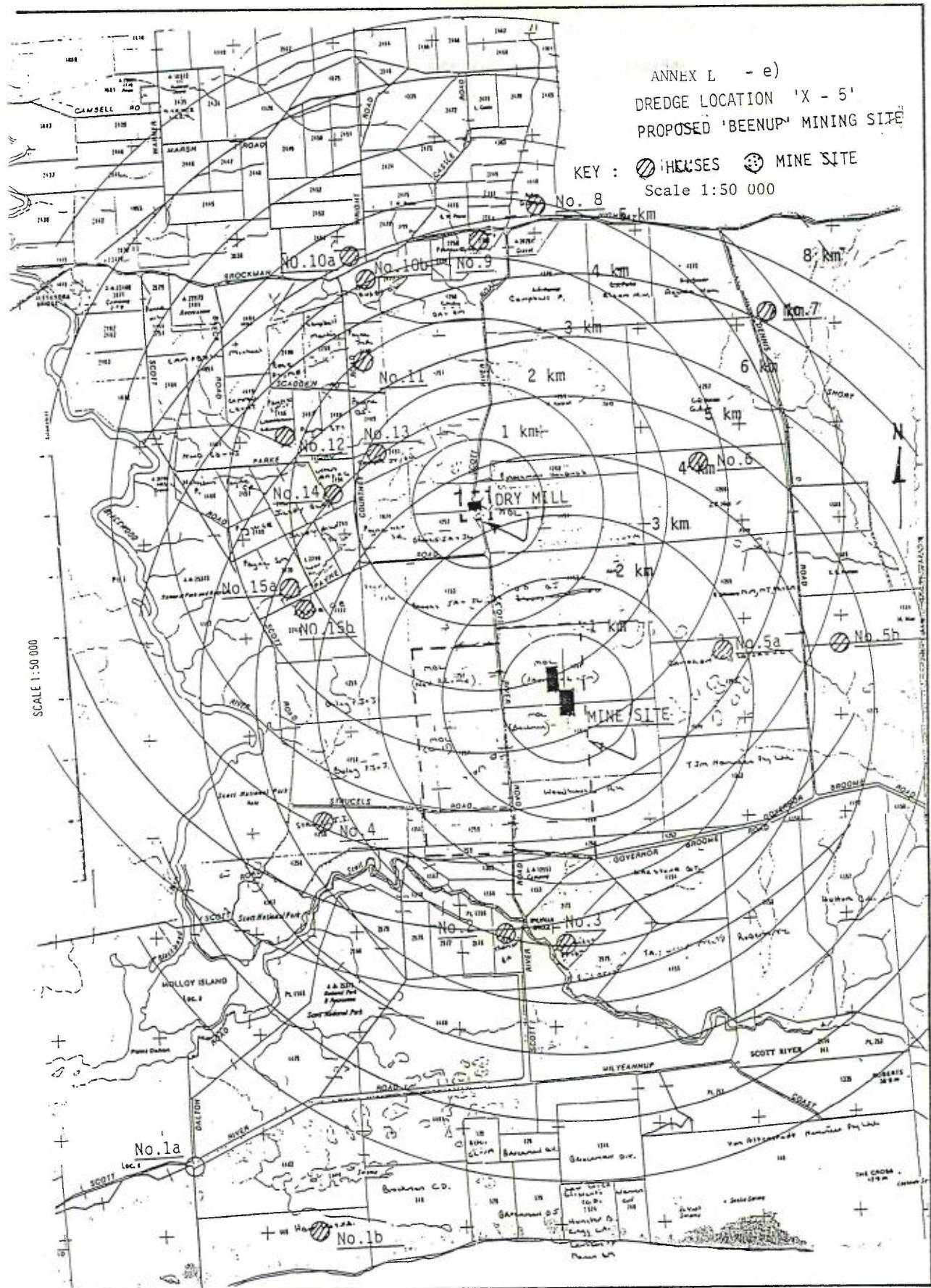
ANNEX L - c)
 DREDGE LOCATION 'X - 3'
 PROPOSED 'BEENUP' MINING SITE

KEY :  HOUSES  MINE SITE
 Scale 1:50 000



ANNEX L - e)
 DREDGE LOCATION 'X - 5'
 PROPOSED 'BEENUP' MINING SITE



KEY :  HOUSES  MINE SITE
 Scale 1:50 000

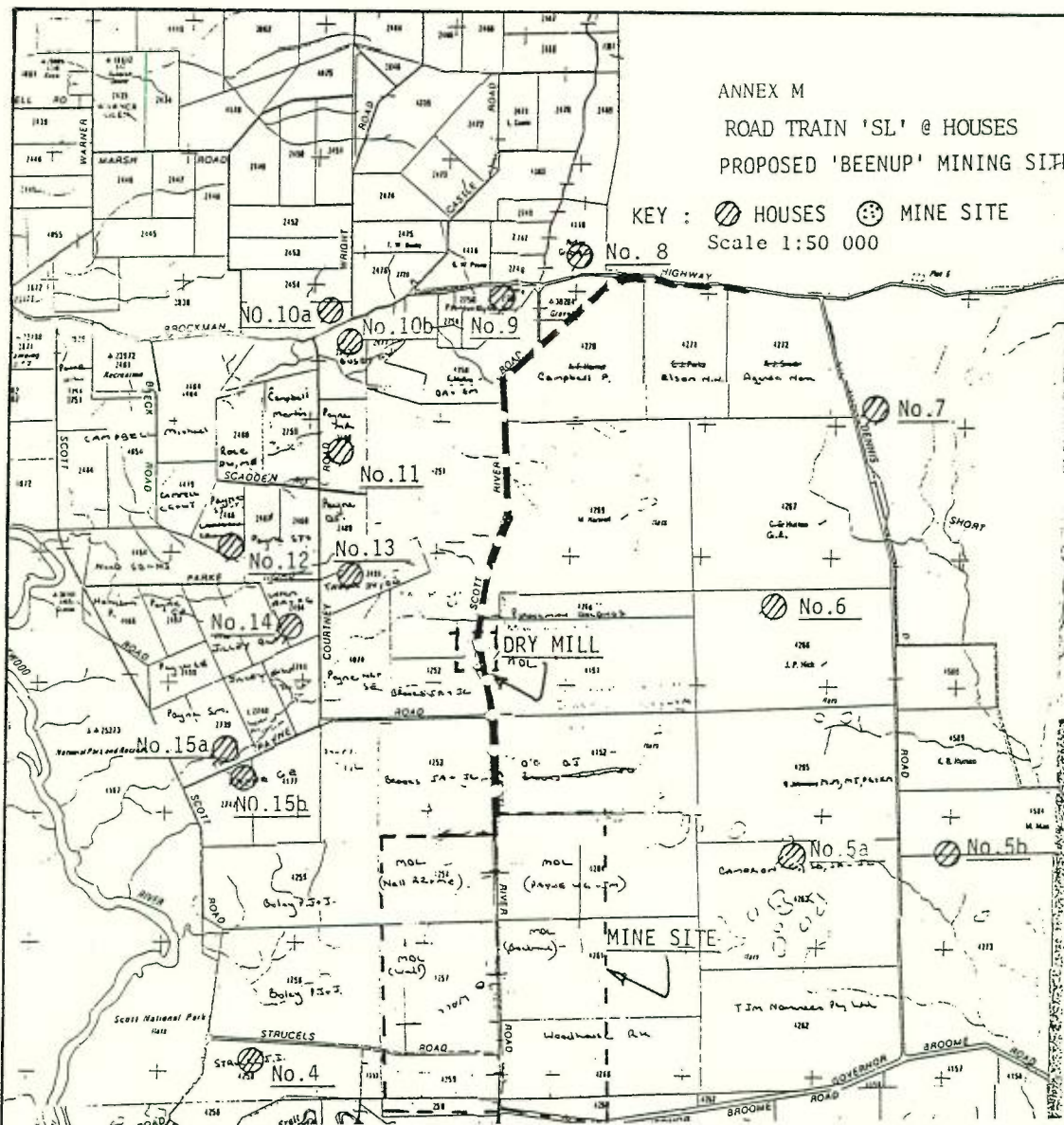


SCALE 1:50 000

ANNEX M

ROAD TRAIN 'SL' @ HOUSES
PROPOSED 'BEENUP' MINING SITE

KEY :  HOUSES  MINE SITE
Scale 1:50 000



DETAIL ASSESMENT OF ROAD TRAIN NOISE AT NEAREST RESIDENCES TO ROUTE

1	2	3	4	5	6	7	8
14	2.5	113	31	-10	+5	26	Acceptable always
13	1.5	113	35	-10	+5	30	" "
10 b & 11	2	113	33	-10	+5	28	" "
8 & 9	-----See Annex N -----						

Column 1 = Residence No.

Column 2 = Distance from road

Column 3 = $L_w(A)$ of Road Train

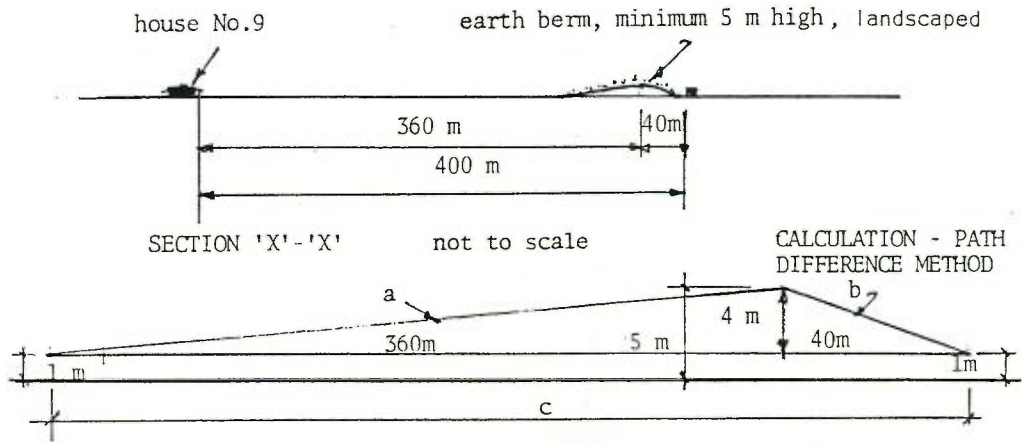
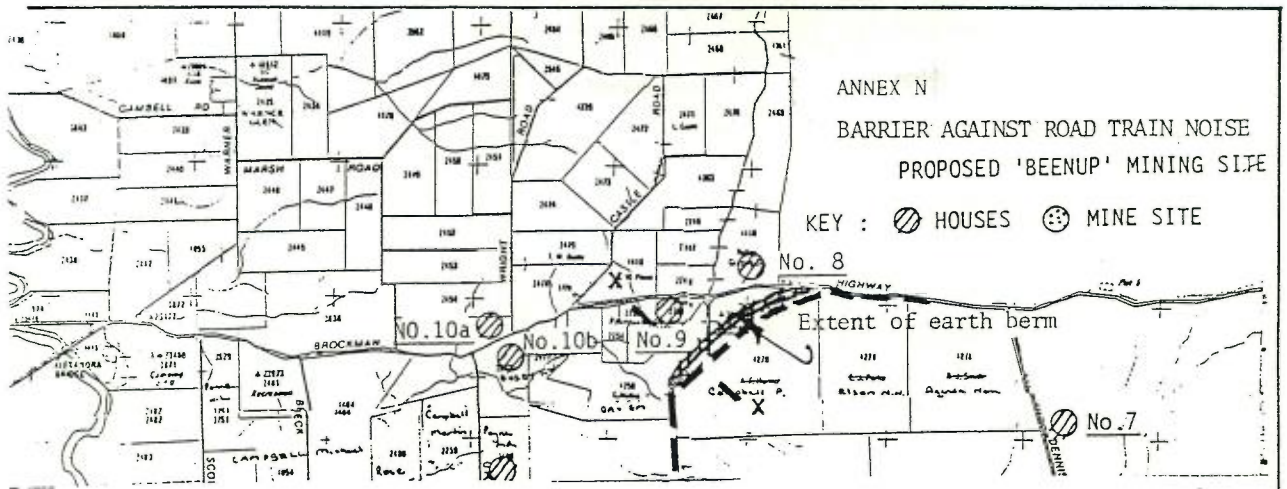
Column 4 = $L_p(A)$ at residences

Column 5 = Reduction due to inter-mittance, Regs. Table 3

Column 6 = Add for tonal component, see Regs. Table 4

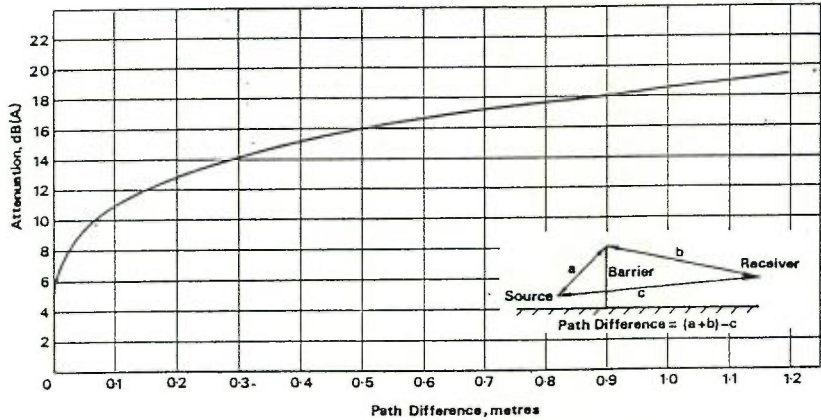
Column 7 = Resultant SL at residence

Column 8 = Acceptable/non acceptable



Path difference = (a + b) - c , For assessment see below (Fig.1)

a = 360.02 ; b = 40.2; c = 400; Path difference = 0.22 = 12 dB(A)
Reduction potential by a very long barrier : 12 dB(A), see below
SL @ House No.9 = 49 dB(A) (due to distance) - 10¹ + 5² - 12 = 32 dB(A)
which is acceptable always ; No.8 would be similar.



1 *Deduction for intermittent noise. See Regulations page 8, Table 3.
2 *Increase for Special Characteristics. See Regulations page 8, Table 4.

Fig.1 Reduction of road traffic noise, L₁₀, by a very long barrier (After Scholes & Sargent)

ANNEX O
ATTENUATION DUE TO AIR ABSORPTION

Calculation is based on RECORDING No.22-Page 11 - Part IV, Haul-Pack noise.
Distance from source : 1000m

1/1 oct.Cent.frequency Hz	63	125	250	500	1k	2k	4k	8k
Sound Power Level (SWL)	119	116	116	112	111	102	96	88
Attenuation due to distance	-72	-72	-72	-72	-72	-72	-72	-72
	47	44	44	40	39	30	24	16
'A' weighting	-26	-16	-9	-3	0	+1	+1	-1
'A' weighted SPL	21	28	35	37	39	31	25	15

Resulting in 43 dB(A)

Attenuation, air absorption	0	0	0	-2	-4	-10	-20	-42
See Fig.1 below	21	28	35	35	35	21	5	-

Resulting in 40 dB(A)

Woods Practical Guide to Noise Control (I.Sharland-1973)

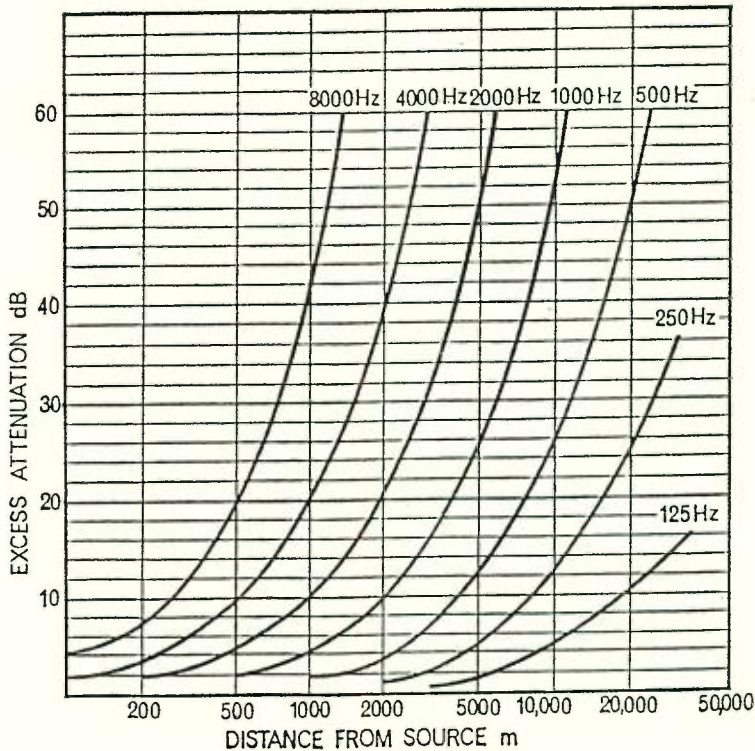


Fig.1

Approximate additional attenuation due to air absorption

Appendix VII

FLORA AND VEGETATION

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FLORA AND VEGETATION

by

E.M. Matiske and Associates

1.0 INTRODUCTION

1.1 PHYTOGEOGRAPHY OF THE REGION

The Beenup survey area (Figures VII-2 and VII-3) occurs within the Warren Botanical Sub-District of the Darling Botanical District within the South Western Botanical Province (Beard, 1980). The plant communities in the area are dominated by tall forests of Karri (*Eucalyptus diversicolor*) on the deep loams, forests of Jarrah-Marri (*Eucalyptus marginata* - *Eucalyptus calophylla*) on the leached sands and extensive areas of Paperbark (*Melaleuca* spp.) and sedge swamps in the valleys. All of these communities except the Karri forests were recorded within the proposed mining area for the Beenup project. A localised pocket of Karri forest occurred on Location 4255, to the west of the proposed Beenup mining area. In the areas to the west, east and north of the Scott River Plain the soils are dominated by lateritic gravels. A local example included the pocket of Jarrah - Marri forest (*Eucalyptus marginata* - *Eucalyptus calophylla*) on the shallow lateritic soils on Location 4255. This latter community was not recorded within the proposed Beenup mining area.

Few ecological studies have been undertaken in the region. Several vegetation mapping projects have been undertaken on the south coast area by Smith (1972), Beard (1981), the Department of Conservation and Land Management (1987) and Martinick and Associates (1989).

The distinctive flora on the Scott River Plain appears to occur on selected soil types in the area. As indicated by the recent study by Tille and Lantzke (in press) these specific soil types are restricted in occurrence to the localised area which encompasses the Beenup survey area. Therefore it is not surprising that a range of flora species have been recorded as being geographically restricted (Department of Conservation and Land Management Reserve Flora) to the area near the proposed Beenup project.

The nearby State Forests, Reserves and Scott National Park were inspected during the survey to assess the potential for coverage of the flora species in conservation

areas which were highlighted as being potentially significant. Comparisons in the text are made with adjacent areas to summarise these findings.

1.2 STUDY OBJECTIVES

The Beenup survey area is the area mapped in Figure VII-2 and the dry mill and office site (Figure VII-3). The objectives of the flora and vegetation survey of the Beenup survey area were to:

- (1) produce an inventory of the flora species on the Beenup survey area;
- (2) assess the conservation significance of the flora on a regional and local basis;
- (3) define and map the plant communities on the Beenup survey area;
- (4) assess the regional and local significance of the plant communities;
- (5) by means of reconnaissance and site inspections, assess the similarity of the flora and vegetation to nearby areas of State Forests, National Parks (in particular - Scott National Park and reserves on the Leeuwin-Naturaliste ridge), Camping Reserve No. A12951/4753, road verges and remnants on private land particularly within B.H.P. mining leases areas and near the proposed mill and office site (part of Location 4151).
- (6) define locations of botanical interest on the Beenup survey area; and
- (7) review methods whereby the impact of mining activity can be minimised.

2.0 METHODS

A reconnaissance survey of the Beenup survey area was undertaken on June 5 and 6, 1989 with intensive flora and vegetation studies being undertaken between September 25 and December 19, 1989. During the intensive study period three botanists were used for systematic recordings on the flora and plant communities and reconnaissance work for rare and restricted flora species.

The reconnaissance and intensive study work covered primarily the Beenup survey area, although additional site inspections were carried out in nearby areas of State Forests, National Parks (in particular - Scott National Park and reserves on the Leeuwin-Naturaliste ridge), Camping Reserve No. A12951/4753, road verges and remnants on private land within the B.H.P. mining leases (including Location 4255) and near the proposed mill and office site (part of Location 4151).

2.1 FLORA

Opportunistic collecting was carried out throughout the survey area. In view of the degree of clearing an emphasis was placed on recording information from uncleared and semi-cleared areas of remnant vegetation. Some sites were also located in semi-cleared areas to enable coverage of the modified communities.

All plant specimens were dried, fumigated and checked at the State Herbarium in South Perth. Consultation with taxonomists in particular groups was also undertaken during this identification time. Their assistance is acknowledged in identifying some of the plant specimens.

2.2 VEGETATION

The vegetation was defined and mapped on the basis of a reconnaissance of the survey area and detailed recordings at 94 sites (Figure VII-4) within the Beenup survey area. The vegetation on the proposed mill and office site was defined on the basis of detailed recordings at 10 sites. Detailed recordings included the ranking of all species. The ranking was based on Havel (1975a).

Recordings at these sites included ranking all tree species within a 20 metre radius, as follows:

- 0 - Absent
- 1 - 1 or 2 trees
- 2 - Three to five trees
- 3 - More than five trees, but contributing less than one third of total stand
- 4 - Between one third and one half of total stand
- 5 - More than one half of total stand

Recordings at these sites included ranking all understorey species within a 10 metre radius, as follows:

- 0 - Absent
- 1 - Very rare, seen only after careful search
- 2 - Present, observable, but in small numbers only
- 3 - Common locally, but not uniformly over the whole area
- 4 - Common over the whole area
- 5 - Completely dominating undergrowth

Additional information was recorded at each site on degree of disturbance, soil type, drainage, topography, physiological stress (e.g. drought, *Phytophthora cinnamomi*) and impact of recent fires.

2.3 DATA ANALYSIS

The data analysis was based on 313 of the 326 total number of species for the 94 recording sites on the Beenup survey area. The data was processed by a computer programme which is based on a Q-Mode clustering technique utilising a coefficient of proportional similarity (Sneath and Sokal, 1973), using the algorithm published by Rohlf (1973) for the Minimum Spanning Tree.

3.0 RESULTS

3.1 FLORA

A total of 55 families, 176 genera and 326 species was recorded in the Beenup survey area, Annex VII-1. The total number of species does not include the sub-species, varieties or affinities of the species, where two or more of these taxonomic subdivisions were identified. A total of 31 introduced species was recorded, Annex VII-1.

The dominant families in the area were Papilionaceae (37 species), Proteaceae (31 species), Myrtaceae (27 species), Cyperaceae (24 species), Restionaceae (23 species), Epacridaceae (21 species) and Stylidiaceae (14 species). The dominance of the families, Papilionaceae, Myrtaceae and Proteaceae reflects the variety of species in the mixed heath and scrub communities, while the dominance of Cyperaceae, Myrtaceae and Restionaceae reflects the large proportion of sedgeland and winter wet depressions in the Beenup survey area.

3.1.1 Gazetted Rare Species

Two gazetted rare species were recorded in the Beenup survey area, namely - *Darwinia* sp. (G.J. Keighery 3582) and *Lambertia orbifolia*, Table VII-1, Annexes VII-1 and VII-2.

Darwinia sp. (G.J. Keighery 3582)

A total of 1000+ mature plants and seedlings were recorded on the uncleared areas of the mixed Proteaceae-Myrtaceae heath and scrub (Vegetation Code 3.2) in the north-east corner of the survey area. In addition a few small populations were recorded on the sedgeland with low emergent heath (Vegetation Code 4.3).

Reconnaissance for this species was carried out in nearby areas of State Forest, Camping Reserve (No. A12951/4753), Scott National Park, adjacent private property within the B.H.P. mining leases (including Location 4255), near the proposed mill and office site (part of Location 4151) and the road verges. With the exception of additional locations on the Governor Broome road verges, near

the original collection of G.J. Keighery, no additional locations for this species were recorded outside the Beenup survey area which were not previously known by the Officers of the Department of Conservation and Land Management.

The species appears to occur on the moister red-brown sandy loams over shallow iron pan, near seasonally inundated depressions. The seedlings of this species were largely recorded in recently burnt areas.

Lambertia orbifolia

A total of 100+ mature plants and seedlings were recorded on the uncleared areas of the mixed Proteaceae-Myrtaceae heath and scrub (Vegetation Code 3.2) in the north-east corner of the survey area.

Reconnaissance for this species was carried out in nearby areas of State Forest, Camping Reserve (No. A12951/4753), Scott National Park, adjacent private property on B.H.P. mining leases (including 4255), the proposed mill and office site (part of Location 4151) and on the road verges. No additional locations for this species were recorded outside the Beenup survey area, besides those already known by the Officers of the Department of Conservation and Land Management.

The species appears to occur on the moister grey sandy loams over shallow iron pan. This species appears to avoid the red-brown sandy loams and wetter areas.

During the reconnaissance work a number of recent deaths were recorded. Consequently the Officers of the Department of Conservation and Land Management were contacted. During a subsequent field inspection, samples were collected from three recently dead plants for *Phytophthora cinnamomi* testing. The samples collected were processed by the Department of Conservation and Land Management. The results are discussed further in the section on Dieback.

In general, the two gazetted rare species were recorded along Governor Broome Road and or in the north east corner of the survey area. The majority of the rare plants were relatively healthy, with the exception of the occasional *Lambertia orbifolia*. In view of the limited number of plants of *Lambertia orbifolia* and the recent localised deaths of individuals, the conservation needs of the latter species become even more critical.

The management implications of the occurrence of these two gazetted rare species are summarised in Section 4.0, Discussion.

3.1.2 Reserve Flora

A total of 10 species from the Reserve Flora Priority List (unpublished - Department of Conservation and Land Management) was recorded in the Beenup

VII-6

survey area, Table VII-1, Annexes VII-1 and VII-2. The Priority Codes used in Table VII-1 are extracted from the unpublished document of the Department of Conservation and Land Management. All these species for varying reasons are potentially rare, depending on their future management and monitoring. In some cases the lack of information and data has resulted in their inclusion on this list. Nevertheless the conservation status of all these species is under consideration and being monitored by the Department of Conservation and Land Management.

Adenanthos detmoldii - Priority Code 5

This species was previously on the Gazetted Rare List, but was removed when additional populations were found. It is known to occur in the Scott and Blackwood River areas. In this study it was found growing in sedgelands and mixed Proteaceae-Myrtaceae closed heaths and scrubs (Vegetation Codes 3.2 and 4.3), in the north-east corner of the survey area. It was also recorded on roadside verges on the Scott River and Governor Broome Roads (Vegetation Codes 3.2 and 3.3). In addition it was observed along further road verges east of the survey area. A total of 3000+ plants were recorded on these latter road verges outside the Beenup survey area.

Aotus carinata - Priority Code 1

This species is restricted to the Scott River Plain, and is under consideration for declaration as rare, but further surveys are required. In this survey it was associated with seasonally inundated to permanently moist areas supporting mixed heaths, sedgelands and woodlands on a range of sandy soils (Vegetation Codes 1.4, 3.2, 4.2 and 4.3). It also occurs on the fringes of moist sedgelands. It was recorded both west and east of Scott River Road.

Calothamnus crassus - Priority Code 3

Until this survey this species had only been collected from the Stirling Range National Park, so this represents a range extension. In the survey area it was restricted to heaths on shallow sands over iron pan, located in the north-east corner and along Governor Broome Road (Vegetation Code 3.2).

Drosera omissa - Priority Code 3

Known from the Busselton and Augusta areas. Common in mixed woodlands of *Eucalyptus marginata* with well developed understorey of *Agonis flexuosa* on sandy dunes scattered in the central and western parts of the survey area (Vegetation Codes 1.2, 2.1, 2.2, 3.2 and 4.3). It also extends onto deeper sandy pockets over iron pan found in the north-east corner.

Grevillea manglesioides ssp. *papillosa* - Priority Code 2

Several specimens collected during this survey were identified as *Grevillea manglesioides* and *Grevillea* aff. *manglesioides*. Further division to the subspecies level was not possible as the taxon is currently under taxonomic revision. Our

collections may be the subspecies *papillosa* which has been recorded for Scott River.

During this survey *Grevillea manglelesioides* and *Grevillea aff. manglelesioides* were restricted to the heaths on shallow sands over iron pan found in the north eastern section of the survey area and also along Governor Broome Road (Vegetation Code 3.2).

Hypocalymma aff. cordifolium - Priority Code 3

(A.S. George 11773)

Known from Scott River and Northcliffe areas. Predominantly in woodlands of *Eucalyptus marginata* - *Eucalyptus calophylla* - *Melaleuca preissiana* on seasonally moist to wet sandy soils. Restricted to western side of Scott River Road (Vegetation Codes 1.4 and 1.5, and to a lesser extent 4.2).

Leucopogon alternifolius - Priority Code 1

This species has been recorded from Albany to Scott River, and is under consideration for declaration as rare, but further surveys are required. In this survey it was predominantly associated with sedgeland and Mixed Proteaceae-Myrtaceae heaths on shallow sandy soils over iron pan (Vegetation Codes 3.2 and 4.3). It was occasionally in low open woodland of *Eucalyptus marginata* - *Banksia attenuata* and the sedgeland on slightly sandier soils (Vegetation Codes 2.1 and 4.2).

Restio ustulatus - Priority Code 3

Known from Busselton and Scott River areas. In this study it was predominantly on the sedgeland to heaths on seasonally moist to wet sands. Also extends to low open woodlands on the deeper sands on small dunes scattered throughout the central and western sections of the survey area (Vegetation Codes 2.2, 3.1, 3.2, 4.2 and 4.3).

Stylidium verticillatum - Priority Code 3

Specimens collected during this survey appeared to be *Stylidium verticillatum*, however the species name cannot be confirmed due to a lack of good flowering material in the State Herbarium collections. *Stylidium verticillatum* has only been recorded for the Stirling Range National Park. This species was predominantly in the heaths on shallow sands over iron pan in the north eastern corner of the survey area (Vegetation Code 3.2). Several occurrences were also recorded in the north-western section in the woodlands over seasonally wet, shallow soils (Vegetation Codes 1.4 and 1.5).

Villarsia lasiosperma - Priority Code 3

Recorded from localities between Busselton and Esperance. Relatively widespread through the survey area on seasonally moist to wet soils (Vegetation Codes 1.5, 2.5, 3.2 and 4.2).

In general, the large number of reserve flora species reflects the high conservation value of the Beenup survey area, in particular the eastern section which supports the restricted communities of sedgelands and mixed heaths and scrubs on the shallow soils over the iron pan. Although selected species were recorded in nearby reserves, the majority still were restricted in occurrence or numbers to very site specific locations. The management implications of the occurrence of these species are summarised in Section 4.0, Discussion.

Two species from the Reserve Flora Priority List were not found on the Beenup survey area, but were recorded nearby. *Banksia meisneri* var. *ascendens* was collected in the sedgelands of the Camping Reserve, immediately south of Governor Broome Road. *Jansonia formosa* was collected on the road verges of Governor Broome Road.

3.1.3 Species of Interest

The following three species and the recently described genus are of special interest, Table VII-1. *Boronia* sp. nov. is a new species which was collected for the first time on this survey. *Hovea stricta* is geographically restricted and has been poorly collected. *Verticordia lehmannii* is geographically restricted and has been only collected from a few locations. Genus nov. (aff. *Loxocarya* sp.) (247,440) is a recently described genus which has not yet been published, therefore identification of the specimen collected during this survey cannot be fully named.

Boronia sp. nov. (360,378)

A specimen collected during this survey was identified as a new, undescribed species (P. Wilson, pers. comm.) A search of *Boronia* specimens at the Western Australian Herbarium was conducted, and no similar specimens were found. This indicates that this species is probably very restricted or even rare.

Predominantly found in sedgelands and heath communities on shallow sands over iron pan in the north-eastern section of the survey area (Vegetation Codes 2.1, 3.2 and 4.3). Also recorded in the sedgeland immediately south of Governor Broome Road within the Camping Reserve (No. A12951/4753) (Vegetation Code 4.3).

Hovea stricta

This species has two disjunct centres of distribution, one in the northern sandplains and the other from the Busselton/Cape Naturaliste area. With one exception, all of the specimens from the southern centre of distribution were

collected last century. The collection of this species represents only the second collection this century. This may indicate a declining population and, therefore a reassessment of its conservation status may be required. *Hovea stricta* was found in open forest of *Eucalyptus marginata* with mixed associated species on the different soil types (Vegetation Codes 1.1, 1.2, 1.4, 1.5, 1.6 and 2.2). This species was recorded predominantly on the western side of Scott River Road, although it also extends into small pockets of mixed *Banksia* on the dunes near Governor Broome Road.

Verticordia lehmannii

This species has not been recorded from this locality before, but the species is confined to the Busselton-Scott River area. Only a dozen or so collections have been made in the area of distribution. Therefore this species appears to be geographically restricted and rare.

This species was collected from the low sedgeland in the north-western section of the proposed Beenup mining area (Vegetation Code 4.3).

Genus nov. (aff. *Loxocarya* sp.)

This genus has recently been described but not published, therefore it was not possible to identify as the species level. This species occurred in the wetland depressions and drainage lines in the low open woodlands of Paperbark (*Melaleuca preissiana*), sedgelands and mixed woodlands of Paperbarks and *Agonis* spp. (Vegetation Codes 2.5, 4.1 and 4.4).

TABLE VII-7

Summary of Gazetted Rare, Restricted and Special Interest Species recorded in the Beenup Survey Area (based on Reserve Flora List - Department of Conservation and Land Management.)

	Code
(i) Gazetted Rare:	
<i>Darwinia</i> sp. (G.J. Keighery 3582)	GR
<i>Lambertia orbifolia</i>	GR
(ii) Reserve Flora (Priority Coding)	
<i>Adenanthos detmoldii</i>	5
<i>Aotus carinata</i>	1
<i>Caloithamnus crassus</i>	3
<i>Drosera omissa</i>	3
<i>Grevillea manglesioides</i> ssp. <i>papillosa</i>	*2
<i>Hypocalymma</i> aff. <i>cordifolium</i> (A.S. George 11773)	3
<i>Leucopogon alternifolius</i>	1
<i>Restio ustulatus</i>	3
<i>Stylidium verticillatum</i>	*3
<i>Villarsia lasiosperma</i>	3
(iii) Species of Interest	
<i>Boronia</i> sp. nov (360,378)	ns
<i>Hovea stricta</i>	pc
<i>Verticordia lehmannii</i>	pc
<i>Genus</i> nov. (aff. <i>Loxocarya</i> sp.)	t

Note: GR: gazetted rare, ns: new, unnamed species, pc: poorly collected. t: see text for further discussion.

*: species and sub-species may be present, but currently State Herbarium collections do not allow confirmation of identifications. See text for further discussion.

Reserve Flora - Priority Codes.

Priority 1: Species which are known from one or a few localities on lands under immediate threat, e.g. road verges, urban areas, active mineral leases, areas grazed

by feral animals, etc. These species are under consideration for declaration as rare flora but are in need of urgent high priority further survey.

Priority 2: Species which are known from one or a few localities on lands not under immediate threat, e.g. nature reserves, national parks, vacant crown land, water reserves etc. These species are under consideration for declaration as rare flora but are in need of urgent high priority further survey.

Priority 3: Species which are known from several localities, some of which are on lands not under immediate threat. These species are under consideration for declaration as rare flora but are in need of further survey.

Priority 4: taxa presumed extinct

Species which have not been collected or reliably observed in the wild over the past 50 years, or whose total known wild population has been destroyed more recently.

Priority 5: taxa for high priority monitoring

Species which are considered to have been adequately surveyed and not endangered or in need of species protection, but could be if present circumstances change. These species are usually represented on reserves.

In general, these species also reflect the high conservation value of the Beenup survey area. The management implications of the occurrence of these species are summarised in the discussion section.

3.2 VEGETATION

The vegetation plot data is summarised by community in Annexes VII-2 and VII-3. Nineteen plant communities were defined. Of these, seventeen were defined from detailed site observations and two were defined from opportunistic observations on the road verges (Vegetation Codes 3.3 and 3.4).

The results for the analysis on the ranking results are presented in Figure VII-1 (page VII-12). The results illustrate the broader groups of:

- (1) *Agonis flexuosa* (Peppermint) - *Banksia* spp. on sands;
- (2) *Banksia attenuata* - *Banksia ilicifolia* - *Eucalyptus marginata* on sands;
- (3) *Eucalyptus marginata* (Jarrah) forests on grey sands;

- (4) *Eucalyptus marginata* (Jarrah) and *Melaleuca preissiana* (Paperbark) on brown sandy loams with variable soil moisture regimes;
- (5) Closed heaths and scrubs of Proteaceae-Myrtaceae species on shallow sands over the iron pan;
- (6) Open heaths and sedgelands on moist to wet sands;
- (7) Mixed communities, ranging from woodlands to sedgelands on swamps;
- (8) *Melaleuca preissiana* (Paperbark) and sedgelands on swamps; and
- (9) *Melaleuca preissiana* (Paperbark) - low open woodlands on drainage lines.

These groupings were then subdivided on the basis of local floristic and shrubland variations into the seventeen main plant communities types (not including the two road verge types). These seventeen community types are summarised in Annex VII-3 and mapped in the uncleared and semi-cleared sections of the Beenup survey area. By utilising the soil map by McArthur it is possible to extrapolate these plant communities into the cleared areas.

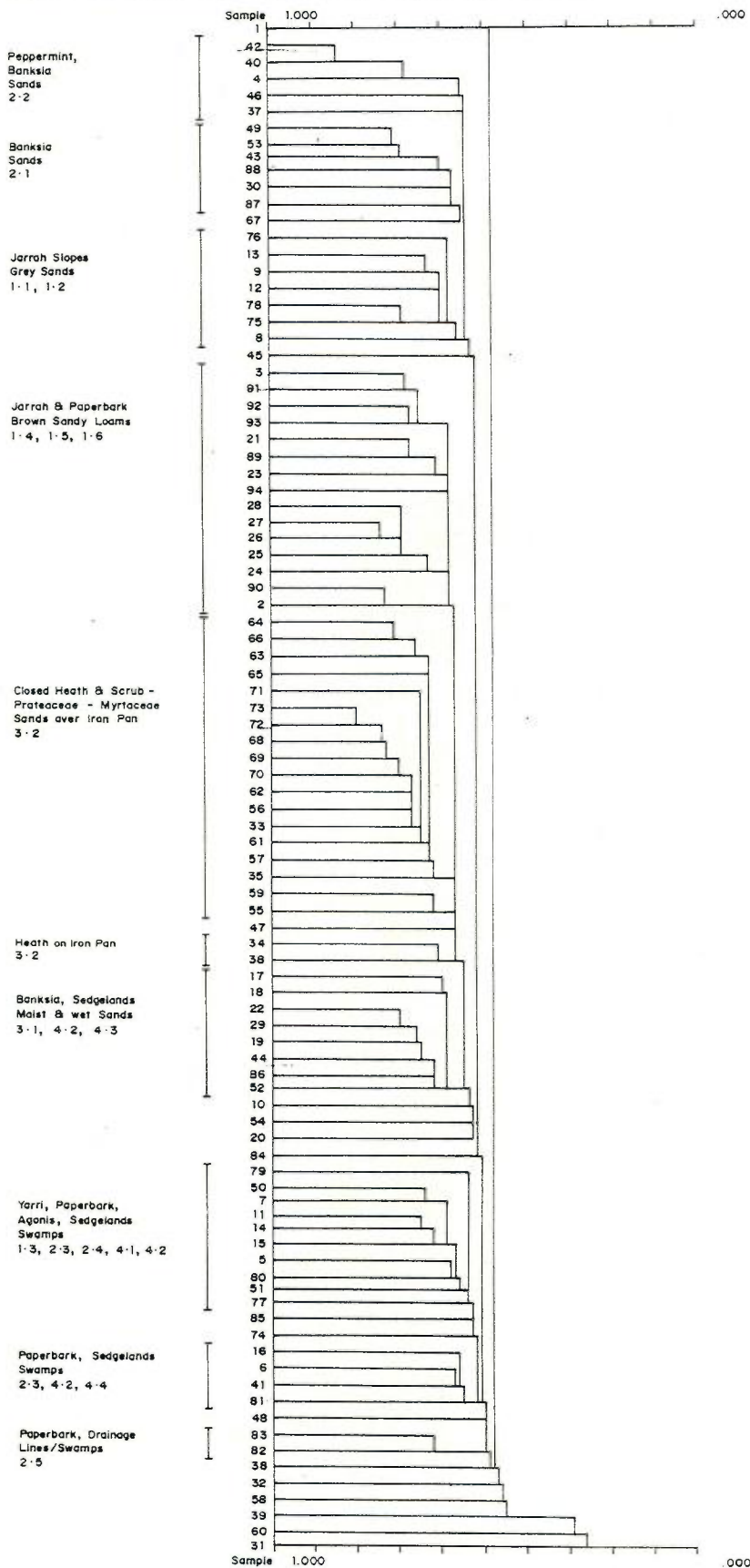
The relationships between the plant communities and the underlying soil and landforms are summarised in Annex VII-3.

The most extensive forest and woodland vegetation occurs on the western section of the survey area. The dominant trees are *Eucalyptus marginata* (Jarrah), *Eucalyptus calophylla* (Marri), *Eucalyptus patens* (Yarri), *Agonis flexuosa* (Peppermint) a range of Banksia species and *Melaleuca preissiana*. The overstorey species reflect the range of soil and moisture conditions, with the range from Banksia species on the sandier sites, Paperbarks on the wetter sites to Yarri on the alluvial sites.

If the understorey species are included the significance of local site conditions is reinforced by other indicator species, see Annex VII-3 for differences in communities 1.1 to 1.6.

No *Eucalyptus diversicolor* (Karri) communities were recorded within the survey area, although a small pocket of Karri was recorded to the west of the Beenup survey area on Location 4255.

SINGLE LINKAGE DENDROGRAM FORMED FROM MINIMUM SPANNING TREE



The total area of forests and woodlands has been markedly affected by clearing for agricultural activities.

The series of sandy rises and dunes scattered through the Beenup survey area support a slightly lower overstorey and a higher proportion of *Agonis flexuosa* and *Banksia* trees. The latter is related to the soils and topographical positions. The two community types (Vegetation Code 2.1 and 2.2) occur throughout the survey area. The pockets within the cleared paddocks in the central section of the survey area provide, in many cases the only relief from the treeless landscape of the paddocks. Consequently few areas within these communities in the paddocks are exempt from grazing and trampling pressures. Therefore the understorey of many of these remnants has been modified. The latter is reflected in the high cover of introduced medics and grasses.

The proposed mill and office site occurs in a disturbed low woodland of *Agonis flexuosa* - *Banksia ilicifolia* - *Eucalyptus marginata* on a small sandy rise (Vegetation Code 2.2). The understorey has been affected by cattle grazing. As a result of this grazing, the understorey includes a range of introduced species. No gazetted rare species were recorded in this area on Location 4151.

In contrast the communities in the north-east and north-west corners (Vegetation Code 2.1) are relatively free of disturbance (except for a few tracks) and introduced species.

The other groups of low woodlands occur on the series of depressions, swamps and drainage lines through the survey area (Vegetation Codes 2.3, 2.4 and 2.5). All these areas support *Melaleuca preissiana* in the overstorey with varying associated species depending on local soil and drainage conditions. The associated species are summarised in Annex VII-3.

The heath and scrub communities occur on the sandier and shallower soils. The dominant families on these areas include Proteaceae, Myrtaceae, Cyperaceae and Restionaceae. Local distinctive features include the thickets of *Banksia occidentalis* ssp. *occidentalis* (Vegetation Code 3.1), the stands of the gazetted rare species - *Lambertia orbifolia* and *Darwinia* sp. (G.J. Keighery 3582), and the high range of species on these heaths, Annex VII-3. Many of the species which are on the Department of Conservation and Land Management Gazetted Rare Flora List and Reserve Flora List (unpublished) occur on the closed heaths on the shallow sands over the iron pan in the north-east corner of the survey area, Annex VII- 3.

The sedgeland occurs on the broad seasonally moist to wet depressions and drainage lines. Dominant families include Cyperaceae, Restionaceae and Myrtaceae, Annex VII-3. The density of plant cover in some areas has been affected by past burning and grazing activities.

The remaining areas mapped include the modified communities along the road verges and in the cleared and semi-cleared farmlands. The dominance of introduced species in these areas and the occurrence of grazing animals have left few areas of significant native vegetation. These largely cleared areas occur in approximately 65% of the Beenup survey area.

3.3 SPECIES RICHNESS

The total number of species recorded in each plant community type is summarised in Table VII-2 and Annex VII-3. The results should be compared in a broad sense only as the data base for different plant communities varies substantially due to the different degrees of clearing in the various plant communities and the sampling regime, Annex VII-3. Nevertheless the large number of species in communities 1.1, 1.5, 2.2, 3.2 and 4.3 reflect the conservation potential of these communities. Further the occurrence of gazetted rare and/or reserved flora on some of these same communities increases the conservation status of these communities. In particular the uncleared sections on the western and eastern sides of the Beenup survey area are:

- ° relatively free of introduced species;
- ° include a significant range of species; and
- ° include a significant number of restricted or rare species (Annex VII-3).

3.4 PHYSIOLOGICAL STRESS

Physiological stress in plant communities can be caused by a variety of factors (Old et al., 1981).

During the intensive survey a series of recent deaths were noted for *Xanthorrhoea preissii* (Blackboys), *Eucalyptus marginata* (Jarrah) and one of the gazetted rare flora species - *Lambertia orbifolia*. Consequently three samples of root and bark material were collected by Officers from the Department of Conservation and Land Management from recently dead *Lambertia orbifolia* and three samples of root and bark material collected from dying or dead Blackboys and Jarrah.

TABLE VII-2

Summary of Species Richness Results for the
Vegetation Types in the Beenup Survey Area

Vegetation Mapping Code	Native	Introduced	Total
1.1	105	6	111
1.2	87	1	88
1.3	78	2	80
1.4	66	4	70
1.5	112	5	117
1.6	56	0	56
2.1	91	7	98
2.2	112	21	133
2.3	30	3	33
2.4	14	0	14
2.5	81	15	96
3.1	48	0	48
3.2	129	9	138
3.3	10	22	32
3.4	19	22	41
4.1	29	0	29
4.2	93	5	98
4.3	121	1	122
4.4	14	10	24

The samples were sent to the Department of Conservation and Land Management laboratories in Dwellingup for testing. The dieback fungus *Phytophthora cinnamomi* was isolated from all three *Lambertia orbifolia* collections in the north-east section of the survey area and from the recently dead *Xanthorrhoea preissii* on the lower moist slopes in the south-west corner of the Beenup survey area.

Although no dieback mapping was carried out, these results confirm the presence of this fungal disease in the Beenup survey area. The pattern of infection in the south-west corner appears to be similar to the frontal pattern seen in other Jarrah forest communities to the north and east of the survey area. In contrast the

pattern on the seasonally wet shallow soils which support the rare *Lambertia orbifolia* appears to be spot infections.

Predictably the impact of this fungus varies with different plant communities, the impact of the fungus on the lower moist slopes supporting Jarrah in the south-west corner is predictable on the basis of findings in the Jarrah forest on the Darling Ranges.

In contrast the impact of this fungus on the closed heath and scrub communities currently appears to be restricted to spot infections, as many dieback susceptible species are healthy and occurring in close proximity to the occasional dead *Lambertia orbifolia*. The latter may relate to the different seasonal conditions on these shallow soils, with the moisture and water being present during primarily the cooler months when the fungal species may not be able to proliferate as rapidly.

The potential impacts of the dieback disease require further consultation with Officers from the Department of Conservation and Land Management. The urgency of the impact on the gazetted rare Proteaceae species has already been discussed with the Department.

In addition it appears that the *Armillaria luteobubalina* root rot is also present. Fruiting bodies were observed during the site inspections on several of the Banksia tree species. This species has resulted in patches of dead and dying trees through the south-west (Kimber, 1981). Despite its occurrence it does not have the same potential for the loss of species as the dieback disease *Phytophthora cinnamomi*.

3.5 SITE REQUIREMENTS OF THE GAZETTED RARE SPECIES

The two gazetted rare species recorded in the Beenup survey area, namely: *Lambertia orbifolia* (family - Proteaceae) and *Darwinia* sp. (G.J.Keighery 3582) appear to be particularly site specific in their occurrence. The latter has major management implications for their future protection.

Lambertia orbifolia

This species occurs on the seasonally wet shallow grey sands over the iron pan in the north-east section of the survey area. It appears to:

- ° Prefer the slightly deeper grey sands;
- ° Avoid the seasonally inundated areas; and
- ° Prefer the seasonally moist soils.

The occurrence of this species beyond the survey area is restricted to several small populations (less than a few hundred) on similar soils and topographical conditions (R.Smith and G.Keighery, pers.comm.). Consequently any changes in local site conditions, including seasonal hydrological patterns may affect this species ability to survive both within the Beenup survey area or on similar nearby areas. Potential direct and indirect impacts of the proposed operations are discussed in Chapter IV of E.R.M.P.

Darwinia sp. (G.J. Keighery 3582)

This species occurs on the fringes of the seasonally inundated depressions. The occurrence of this species on the shallow grey and red-brown sands over the iron pan appears to be particularly site specific. It appears to:

- ° Prefer the red-brown sands over the shallow iron pan;
- ° Avoid the seasonally inundated areas; and
- ° Prefer the seasonally wet soils (water table 10 to 20cm below surface).

The occurrence of this species beyond the survey area is also restricted to similar soils and topographical conditions (R.Smith and G. Keighery pers. comm.). The potential effects of any changes in the local site conditions is discussed in Chapter IV of the E.R.M.P.

4.0 DISCUSSION

4.1 GAZETTED RARE SPECIES

Two gazetted rare flora species were recorded within the Beenup survey area. These species are *Lambertia orbifolia* and *Darwinia* sp. (G.J. Keighery 3582).

Despite several man days of reconnaissance neither of these species were located in the adjacent and nearby areas managed for the conservation of native flora and plant communities. The reconnaissance was carried out in nearby areas of State Forest, National parks (in particular - Scott National Park) and Camping Reserve (No. A12951/4753). In addition the areas of adjacent and adjoining private land on the B.H.P. mining leases (where access was possible), on the proposed B.H.P. mill and office site and nearby road verges were inspected for rare flora. No additional populations were recorded on these areas, with the exception of several locations for *Darwinia* sp. (G.J. Keighery 3582) on Governor Broome Road which were located near the original collecting area of G.J. Keighery. This lack of representation in other nearby reserved land appears to be related to the specific site requirements of these two species. In both instances the additional populations on the north-east section of the Beenup survey area provide substantial additions

to the currently known populations for each species. Therefore the conservation status of this north-east corner is extremely high.

4.2 RESERVE FLORA

Ten reserve flora were recorded within the Beenup survey area and a further two species were recorded near the Beenup survey area. Details for each species are discussed in the previous text, however the regular occurrence of the majority of these species in the plant communities on the eastern section, and in particular the north-east corner, of the Beenup survey area reinforces the high conservation value of this specific location.

4.3 SPECIES OF INTEREST

A total of three species and one recently described genus were highlighted as being particularly significant.

Boronia sp. nov. (360,378) is a new species recorded both within and immediately south of the Beenup survey area. As this species occurs on low sedgelandts there is a high potential for finding further populations within Scott National Park.

Hovea stricta appears to be geographically restricted, as very few collections have been made previously of this species, despite previous botanical studies in the Augusta and Scott River areas. There is potential for utilising this species in rehabilitation areas in a range of communities both west and east of Scott River Road if the project proceeds.

Verticordia lehmannii is geographically restricted and appears to be rare, as only a dozen or so collections have been made in the area between Busselton and Scott River.

Genus nov. (aff. *Loxocarya* sp.) is a recently described genus which is not published. Therefore the identification of the specimen to a species level was restricted. The latter should be classified in the near future when the taxon description is published.

4.4 ASSESSMENT OF NEARBY AREAS

A reconnaissance was carried out on cleared and semi-cleared areas of the nearby State Forest, Scott National Park, Camping Reserve (No. A12951/4753), reserves on the Leeuwin-Naturaliste ridge and private property on B.H.P. mining leases (including Location 4255) and proposed mill and office sites (part of Location 4151).

Despite extensive reconnaissance the plant communities on the Beenup survey area, and in particular the communities which supported the two gazetted rare species, were not well represented in the adjacent areas of State Forest, Scott National Park and Camping Reserve (No.A12951/4753). The shallow iron pan soils do not extend into the areas which occur in the State Forest to the north and north-east. Although these shallow soils do occur on a few hectares on the fringes of Scott National Park, along Scott River Road, the two gazetted rare species were not observed within the National Park.

4.4.1 Proposed Mill and Office Site

The proposed mill and office site on part of Locality 4151 supports a low woodland of *Agonis flexuosa* - *Banksia ilicifolia* - *Eucalyptus marginata* (Vegetation Code 2.2). The area is currently being grazed by cattle. As a result the native understorey has been largely replaced by introduced species. No gazetted rare species were recorded on the proposed mill and office site.

No gazetted rare species were observed on the semicleared and uncleared areas near the proposed mill and office site. The low sedgelands (Vegetation Code 4.3) to the west of the proposed mill and office site, near Scott River Road, were relatively undisturbed and should be protected from further clearing.

4.5 LOCAL AND REGIONAL SIGNIFICANCE OF THE PLANT COMMUNITIES

On the basis of the available literature and a reconnaissance and inspection of areas near the Beenup survey area it was possible to review the local and regional significance of the plant communities recorded in the survey area.

All the woodlands (1.1, 1.2, 1.3, 1.4, 1.5 and 1.6) on the western side typify the alluvial soils of the Blackwood catchment area. These forests and woodlands are represented in nearby areas of the Scott National Park, State Forest and private land. The presence of the geographically restricted species (*Hovea stricta*) and the reserve flora (*Drosera omissa*, *Villarsia lasiosperma*, *Aotus carinata*, *Hypocalymma* aff. *cordifolium*, *Stylidium verticillatum*) in these forests and woodlands highlights the conservation significance of these communities. No gazetted rare flora species were recorded in these forest and woodland areas within the Beenup survey area and nearby private land on BHP mining leases (including Location 4255).

The low woodlands on the sandier soils (Vegetation Codes 2.1 and 2.2) support species which overlap with adjacent communities on sandier soils on the Reserves, Scott National Park, State Forest and uncleared pockets on private land on the BHP mining leases. The presence of the new species (*Boronia* sp. nov. (360, 378)), the geographically restricted species (*Hovea stricta*) and several reserve flora

species (*Drosera omissa*, *Leucopogon alternifolius*, *Restio ustulatus*) in these low woodlands highlights the conservation significance of these communities.

The series of low woodlands of Paperbarks on the wetter soils (Vegetation Codes 2.3, 2.4, 2.5) all are represented in the wetter depressions and drainage lines of the Scott River Plain. Examples of these Melaleuca and Agonis swamps have been recorded to the east by Martinick & Associates (1989). The presence of the reserve flora species (*Villarsia lasiosperma*) and the species of interest (*Genus nov. aff. Loxocarya* sp.) highlights the conservation significance of these communities.

The heaths of *Banksia occidentalis* (Vegetation Code 3.1) are restricted within the survey area to the north-west corner. In a regional review it appears that this community is threatened by the spread of dieback and frequent fires (pers. comm., S.Hopper).

The closed heath and scrubs (Vegetation Code 3.2) are restricted to the shallow soils over iron pan in the eastern section of the Beenup survey area and adjacent areas on the eastern and south-eastern section of the survey area. Despite reconnaissance and inspections of the nearby areas of State Forest, Scott National Park, reserves on the Leeuwin-Naturaliste ridge, road verges and private land on BHP mining leases no extensive areas of this community were recorded beyond the Beenup survey area and nearby private land. After a comparison of the survey area with the maps of Tille and Lantzke (in press) additional inspections were carried out in Scott National Park. Although several small pockets (less than a few hectares) with similar soils were recorded in Scott National Park, no gazetted rare flora species were recorded in these areas of the National Park. The significance of this community to conservation is highlighted by the presence of two gazetted rare flora species in the north-east section of the Beenup survey area. In addition, nine reserve flora species and the new species of *Boronia* (Annex VII-3) were also recorded. The presence of these species within the Beenup survey area highlights the conservation significance of this community. In addition, another reserve flora species (*Jansonia formosa*) was recorded in this community type near the Beenup survey area. The plant community was also recorded in the road verges along Governor Broome Road.

The two road verge communities (Vegetation Codes 3.3 and 3.4) along Scott Road were relatively disturbed by earthworks, burning and the invasion of introduced species. Nevertheless two reserve flora species (*Adenanthos detmoldii* and *Villarsia lasiosperma*) were recorded in these modified communities. Similar communities were recorded on the road verges within the district.

The series of sedgeland and heaths on the wetter depressions within the survey area are represented in nearby areas of Scott National Park and private land. The most significant community from a conservation viewpoint is the low

sedgeland (Vegetation Code 4.3) which occurs in the north-west, south-east (including the Camping Reserve No. A12951/4753) and north-east areas of the Beenup survey area. This community supports the gazetted rare flora species (*Darwinia* sp. G.J. Keighery 3582 in the north-east area of the Beenup survey area only), five reserve flora species (*Adenanthos detmoldii*, *Aotus carinata*, *Drosera omissa*, *Leucopogon alternifolius* and *Restio ustulatus*) and the new species of *Boronia*. In addition, another reserve flora species (*Banksia meisneri* var. *ascendens*) was recorded in this community type near the Beenup survey area.

Despite the relatively high proportion of cleared land (65%) within the survey area, the remnant areas of native vegetation provide the opportunity for maintenance of significant numbers of flora species (326 flora species) and native plant communities (17 types).

There is some continuity with adjacent areas. These connections are particularly obvious in the southern and western sides of the survey area. Despite inspections of the nearby State Forest and Scott National Park, several communities on the eastern section of the Beenup survey area were still locally restricted. The latter was confirmed by reference to the recent soil studies by Tille and Lantzke (in press).

Therefore both in a local and regional review, the significance of several plant communities is substantial. These contributions to the conservation status of the native plant communities in the area can be enhanced by avoiding disturbance of the uncleared areas and/or rehabilitation of the disturbed area with native species.

Despite the high local and regional significance of the plant communities in the Beenup survey area it is still possible to define areas of particular interest for conservation:

- ° the remaining uncleared heath and scrub on seasonally wet shallow soils over iron pan in the north-eastern section (Crown Grant 4264) includes the two gazetted rare flora species, a large proportion of the reserve flora in the survey area and restricted plant communities.
- ° the remaining remnant mosaic of Eucalypt woodlands, forests and sedgeland on the western section of the Beenup survey area includes the geographically restricted and poorly collected species (*Hovea stricta* and *Verticordia lehmannii*) and a large range of flora species and plant communities.
- ° the remaining native communities on the western section of the Beenup survey area provides a link with uncleared adjacent and nearby

communities, in particular those in Scott National Park to the south and south-west.

4.6 REHABILITATION OF VEGETATION

The plant community descriptions and the vegetation map provide the basis for the selection of native species which would be suitable for the rehabilitation of the disturbed areas, Annexes VII-2 and VII-3. The native plant communities reflect the local soil and drainage conditions. Therefore the selection of species and lifeforms should be based on the site preferences of the respective species. For example, Jarrah (*Eucalyptus marginata*) does not tolerate seasonal inundation, while the species on the drainage lines and seasonally inundated swamps and sumplands do tolerate some inundation.

The seed mix requirements can be reduced by immediate respreading of the topsoil (with its associated seed bank). The respreading of the topsoil will also assist in the establishment of plants from propagules.

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ANNEX VII-1

List of Plant Species - Beenup Area 1989
 (Note: * Denotes Introduced Plant Species)

FAMILY	SPECIES
DENNSTAEDTIACEAE	<i>Pteridium esculentum</i>
LINDSAEACEAE	<i>Lindsaea linearis</i>
ZAMIACEAE	<i>Macrozamia riedlei</i>
PODOCARPACEAE	<i>Podocarpus drouynianus</i>
JUNCAGINACEAE	<i>Triglochin calcitrapa</i> <i>Triglochin procera</i>
POACEAE	<i>Amphipogon turbinatus</i> * <i>Anthoxanthum odoratum</i> * <i>Briza maxima</i> * <i>Bromus ? hordeaceus</i> * <i>Holcus lanatus</i> * <i>Hordeum leporinum</i> * <i>Lolium perenne</i> <i>Microlaena stipoides</i> <i>Neurachne alopecuroidea</i> * <i>Poa annua</i> * <i>Vulpia myuros</i>

ANNEX VII-1

List of Plant Species - Beenup Area 1989
 (Note: * Denotes Introduced Plant Species)

FAMILY

SPECIES

CYPERACEAE

Baumea articulata
Baumea vaginalis
Chorizandra cymbaria
Cyathochaeta avenacea
Cyathochaeta clandestina
 **Cyperus tenellus*
Evandra aristata
 **Isolepis prolifer*
Isolepis sp.1 (313)
Isolepis sp.2 (129)
Isolepis sp.3 (149)
Lepidosperma tenue
Lepidosperma tetraquetrum
Mesomelaena stygia
Mesomelaena tetragona
Schoenus bifidus
Schoenus cruentus
Schoenus curvifolius
Schoenus rodwayanus
Schoenus aff. *subflavus*
Schoenus sublaxus
Tetraria capillaris
Tetraria octandra

RESTIONACEAE

Anarthria prolifera
Anarthria scabra
Chaetanthus leptocarpoides
Empodisma gracillimum
Hypolaena exsulca
Leptocarpus scariosus
Leptocarpus tenax
Loxocarya fasciculata
Loxocarya flexuosa
Lyginia barbata

ANNEX VII-1

List of Plant Species - Beenup Area 1989
 (Note: * Denotes Introduced Plant Species)

FAMILY

SPECIES

RESTIONACEAE (continued)

Meeboldina denmarkica
Restio amblyocoleus
Restio applanatus
Restio leptocarpoides
Restio serialis
Restio tremulus
Restio ustulatus
Restio sp. (180)
Restionaceae sp.1 (259)
Restionaceae sp.2 (253)
Restionaceae sp.3 (450)
 Genus nov. (aff. *Loxocarya* sp.)(247,440)

CENTROLPIDACEAE

Aphelia cyperoides
Centrolepis aristata

XYRIDACEAE

Xyris laxiflora

PHILYDRACEAE

Philydrella pygmaea

JUNCACEAE

* *Juncus microcephalus*
Juncus pallidus

DASYPOGONACEAE

Dasyogon bromeliifolius
Lomandra hermaphrodita
Lomandra integra
Lomandra nigricans

ANNEX VII-1

List of Plant Species - Beenup Area 1989
 (Note: * Denotes Introduced Plant Species)

FAMILY	SPECIES
DASYPOGONACEAE (continued)	<i>Lomandra purpurea</i> <i>Lomandra sonderi</i> <i>Lomandra</i> sp.1 (297) <i>Lomandra</i> sp.2 (386)
XANTHORRHOEACEAE	<i>Xanthorrhoea preissii</i>
ANTHERIACEAE	<i>Chamaescilla corymbosa</i> <i>Johnsonia acaulis</i> <i>Johnsonia lupulina</i> <i>Thysanotus dichotomus</i> <i>Thysanotus patersonii</i>
COLCHICACEAE	<i>Burchardia umbellata</i> <i>Wurmbea dioica</i> ssp. <i>alba</i>
HAEMODORACEAE	<i>Anigozanthos flavidus</i> <i>Anigozanthos manglesii</i> <i>Anigozanthos viridis</i> <i>Conostylis aculeata</i> <i>Conostylis serrulata</i> <i>Conostylis ? setigera</i> <i>Conostylis</i> sp.1 (330) <i>Conostylis</i> sp.2 (388) <i>Haemodorum spicatum</i> <i>Phlebocarya ciliata</i> <i>Tribonanthes australis</i>
IRIDACEAE	* <i>Freesia leichtlinii</i> <i>Patersonia juncea</i> <i>Patersonia occidentalis</i> <i>Patersonia umbrosa</i> var. <i>umbrosa</i> <i>Patersonia umbrosa</i> var. <i>xanthina</i>

ANNEX VII-1

List of Plant Species - Beenup Area 1989
 (Note: * Denotes Introduced Plant Species)

FAMILY

SPECIES

ORCHIDACEAE

Caladenia flava
Caladenia gemmata
Caladenia ? marginata
Caladenia latifolia
Diuris longifolia
Elythranthera brunonis
Lyperanthus serratus
Prasophyllum macrostachyum
Prasophyllum ? drummondii
Pterostylis vittata
Thelymitra antennifera
Thelymitra ? nuda

CASUARINACEAE

Allocasuarina fraseriana

PROTEACEAE

Adenanthos detmoldii
Adenanthos meisneri
Adenanthos obovatus
Banksia attenuata
Banksia grandis
Banksia ilicifolia
Banksia littoralis
Banksia meisneri var. *ascendens*
Banksia occidentalis ssp. *occidentalis*
Conospermum caeruleum
Conospermum capitatum
Conospermum flexuosum
Dryandra nivea
Grevillea brachystylis
Grevillea manglesioides
Grevillea aff. manglesioides
Hakea ceratophylla
Hakea linearis

ANNEX VII-1

List of Plant Species - Beenup Area 1989
 (Note: * Denotes Introduced Plant Species)

FAMILY	SPECIES
PROTEACEAE (continued)	<i>Hakea ruscifolia</i> <i>Hakea sulcata</i> <i>Hakea varia</i> <i>Hakea ? varia</i> <i>Isopogon axillaris</i> <i>Isopogon formosus</i> <i>Lambertia orbifolia</i> <i>Persoonia ? elliptica</i> <i>Persoonia longifolia</i> <i>Petrophile diversifolia</i> <i>Petrophile linearis</i> <i>Petrophile longifolia</i> <i>Petrophile squamata</i> <i>Synaphea gracillima</i> <i>Xylomelum occidentale</i>
SANTALACEAE	<i>Leptomeria squarrulosa</i>
LORANTHACEAE	<i>Nuytsia floribunda</i>
POLYGONACEAE	* <i>Rumex acetosella</i>
CARYOPHYLLACEAE	* <i>Cerastium glomeratum</i> * <i>Petrorhagia velutina</i>
RANUNCULACEAE	* <i>Ranunculus muricatus</i>
LAURACEAE	<i>Cassytha racemosa</i>

ANNEX VII-1

List of Plant Species - Beenup Area 1989
 (Note: * Denotes Introduced Plant Species)

FAMILY

SPECIES

DROSERACEAE

Drosera erythrorhiza
Drosera gigantea
Drosera glanduligera
Drosera huegelii
Drosera omissa
Drosera pallida
Drosera subhirtella
Drosera sp. 1 (66)

CRASSULACEAE

**Crassula decumbens*

PITTOSPORACEAE

Sollya heterophylla

MIMOSACEAE

Acacia browniana var. *obscura*
Acacia divergens
Acacia extensa
Acacia hastulata
Acacia myrtifolia
Acacia pulchella var. *pulchella*
Acacia uliginosa

PAPILIONACEAE

Aotus carinata
Aotus aff. *genistoides*
Bossiaea linophylla

PAPILIONACEAE

Bossiaea ornata
Bossiaea rufa
Burtonia scabra
Chorizema ilicifolium
Daviesia angulata

ANNEX VII-1

List of Plant Species - Beenup Area 1989
 (Note: * Denotes Introduced Plant Species)

FAMILY

SPECIES

PAPILIONACEAE (continued)

Daviesia cordata
Daviesia decurrens
Daviesia flexuosa
Daviesia hakeoides ssp. *hakeoides*
Euchilopsis linearis
Eutaxia epacridoides
Eutaxia virgata
Gompholobium capitatum
Gompholobium knightianum
Gompholobium tomentosum
Hovea chorizemifolia
Hovea elliptica
Hovea stricta
Hovea trisperma
Isotropis ? cuneifolia
Jacksonia horrida
Jansonia formosa
Kennedia carinata
Kennedia coccinea
 **Lotus angustissimus*
Mirbelia dilatata
 **Ornithopus pinnatus*
Oxylobium lanceolatum
Oxylobium ? carinatum
Pultenaea reticulata
Sphaerolobium grandiflorum
Sphaerolobium racemulosum
 **Trifolium balansae*
Viminaria juncea

GERANIACEAE

**Erodium moschatum*
 **Geranium molle*

ANNEX VII-1

List of Plant Species - Beenup Area 1989
 (Note: * Denotes Introduced Plant Species)

FAMILY	SPECIES
RUTACEAE	<i>Boronia crenulata</i> var. <i>crenulata</i> <i>Boronia denticulata</i> <i>Boronia spathulata</i> <i>Boronia</i> sp. nov. (360, 378) <i>Eriostemon spicatus</i>
TREMANDRACEAE	<i>Tetratheca setigera</i> <i>Tremandra diffusa</i>
POLYGONACEAE	<i>Comesperma virgatum</i>
EUPHORBIACEAE	<i>Amperea</i> sp. (409) <i>Monotaxis occidentalis</i>
STACKHOUSIACEAE	<i>Stackhousia huegelii</i>
STERCULIACEAE	<i>Thomasia pauciflora</i>
DILLENIAEAE	<i>Hibbertia amplexicaulis</i> <i>Hibbertia hypericoides</i> <i>Hibbertia ? pulchra</i> <i>Hibbertia stellaris</i>
THYMELAEACEAE	<i>Pimelea hispida</i> <i>Pimelea longiflora</i>

ANNEX VII-1

List of Plant Species - Beenup Area 1989
 (Note: * Denotes Introduced Plant Species)

FAMILY

SPECIES

MYRTACEAE

Actinodium cunninghamii
Agonis flexuosa
Agonis juniperina
Agonis linearifolia
Agonis parviceps
Agonis aff. spathulata
Astartea fascicularis
Beaufortia sparsa
Calothamnus crassus
Calothamnus lateralis ssp. *lateralis*
Calytrix flavescens
Darwinia oederoides
Darwinia sp. (G.J.Keighery 3582)
Eucalyptus calophylla
Eucalyptus marginata
Eucalyptus patens
Homalospermum firmum
Hypocalymma aff. cordifolium
 (A.S.George 11773)
Hypocalymma ericifolium
Hypocalymma strictum
Kunzea recurva
Melaleuca densa
Melaleuca preissiana
Melaleuca thymoides
Pericalymma ellipticum
Verticordia densiflora
Verticordia lehmannii

HALORAGACEAE

Gonocarpus benthamii

ANNEX VII-1

List of Plant Species - Beenup Area 1989
 (Note: * Denotes Introduced Plant Species)

FAMILY

SPECIES

APIACEAE

Actinotus glomeratus
Actinotus omnifertilis
Hydrocotyle sp. (325)
Pentapeltis peltigera
Platysace tenuissima
Trachymene pilosa
Xanthosia huegelii

EPACRIDACEAE

Andersonia caerulea
Andersonia lehmanniana
Andersonia sp.1 (349)

Andersonia sp.2 (372)

Leucopogon alternifolius
Leucopogon assimilis var. *rudis*
Leucopogon aff. *assimilis*
Leucopogon australis
Leucopogon capitellatus
Leucopogon gilbertii
Leucopogon aff. *gilbertii*
Leucopogon hirsutus
Leucopogon pendulus
Leucopogon reflexus
Leucopogon verticillatus
Lysinema ciliatum
Lysinema conspicuum
Needhamiella pumilio
Sphenotoma ? *capitatum*
Sphenotoma gracile
Sphenotoma squarrosum

ANNEX VII-1

List of Plant Species - Beenup Area 1989
 (Note: * Denotes Introduced Plant Species)

FAMILY	SPECIES
LOGANIACEAE	<i>Mitrasacme paradoxa</i>
MENYANTHACEAE	<i>Villarsia lasiosperma</i> <i>Villarsia parnassifolia</i>
LAMIACEAE	<i>Hemiandra pungens</i>
SOLANACEAE	* <i>Solanum nigrum</i>
SCROPHULARIACEAE	* <i>Parentucellia latifolia</i> * <i>Parentucellia viscosa</i>
LENTIBULARIACEAE	<i>Polypompholyx multifida</i> <i>Utricularia menziesii</i>
RUBIACEAE	<i>Opercularia echinocephala</i> <i>Opercularia hispidula</i> <i>Opercularia vaginata</i>
GOODENIACEAE	<i>Dampiera hederacea</i> <i>Dampiera leptoclada</i> <i>Dampiera sacculata</i> <i>Diaspasis filifolia</i> <i>Goodenia</i> sp. (83) <i>Lechenaultia biloba</i> <i>Scaevola calliptera</i> <i>Velleia trinervis</i>

ANNEX VII-1

List of Plant Species - Beenup Area 1989
 (Note: * Denotes Introduced Plant Species)

FAMILY

SPECIES

STYLIDIACEAE

Stylidium amoenum
Stylidium bulbiferum
Stylidium calcaratum
Stylidium diversifolium
Stylidium imbricatum
Stylidium junceum
Stylidium ? luteum
Stylidium piliferum
Stylidium repens
Stylidium scandens
Stylidium schoenoides
Stylidium ? verticillatum
Stylidium violaceum
Stylidium sp.1 (373)

ASTERACEAE

**Arctotheca calendula*
 **Conyza ? parva*
Cotula coronopifolia
Hyalosperma cotula
 **Hypochaeris glabra*
Olearia axillaris
Pithocarpa corymbulosa
 **Pseudognaphalium luteo-album*
 **Senecio ? vulgaris*
 **Ursinia anthemoides*
Waitzia citrina
Waitzia suaveolens

ANNEX VII-2

List of Plant Species in the Plant Communities in the Beenup Area - 1989

Vegetation Mapping Codes

PLANT SPECIES	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	Cl.
<i>Acacia browniana</i> var. <i>obscura</i>	-	+	-	+	+	+	-	-	-	-	-	-	+	-	-	-	+	+	-	-
<i>Acacia divergens</i>	+	-	+	+	+	+	+	-	+	-	-	-	-	-	-	-	+	-	-	-
<i>Acacia extensa</i>	+	+	+	+	+	+	-	-	-	-	-	-	-	-	+	-	+	-	-	-
<i>Acacia hastulata</i>	-	-	+	+	-	-	+	+	+	+	+	+	-	-	-	+	+	-	-	-
<i>Acacia myrtifolia</i>	+	-	-	+	+	+	-	+	-	-	+	+	+	-	-	-	+	+	-	-
<i>Acacia pulchella</i> var. <i>pulchella</i>	+	+	-	-	+	-	+	+	+	-	-	-	-	-	+	-	-	-	-	+
<i>Acacia uliginosa</i>	+	-	+	-	-	-	+	+	-	-	+	-	-	-	-	-	+	-	-	-
<i>Actinodium cunninghamii</i>	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	+	-	-
<i>Actinotus glomeratus</i>	-	-	-	-	-	-	+	+	-	-	-	-	+	-	-	-	-	-	-	-
<i>Actinotus omnifertilis</i>	+	-	-	-	+	-	-	-	-	+	+	-	-	-	-	+	+	+	-	-
<i>Adenanthos detmoldii</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	+	-	-
<i>Adenanthos meisneri</i>	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Adenanthos obovatus</i>	+	+	-	+	+	-	+	+	-	-	+	+	+	-	-	-	+	+	-	-
<i>Agonis flexuosa</i>	+	-	-	-	-	+	+	+	-	-	+	-	-	-	-	-	-	+	-	+
<i>Agonis juniperina</i>	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	+	-
<i>Agonis linearifolia</i>	+	-	-	+	+	+	-	-	-	-	+	-	-	-	-	-	+	-	+	-
<i>Agonis parviceps</i>	+	+	+	+	+	+	+	+	+	-	+	+	-	+	+	+	+	+	-	-
<i>Agonis aff. spathulata</i>	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-
<i>Allocasuarina fraseriana</i>	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-
<i>Amperea</i> sp. (409)	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Amphipogon turbinatus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+
<i>Anarthria gracilis</i>	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	+	-	-
<i>Anarthria prolifera</i>	+	+	+	+	+	+	+	+	-	-	-	+	+	-	+	+	+	+	-	-

ANNEX VII-2

List of Plant Species in the Plant Communities in the Beenup Area - 1989

Vegetation Mapping Codes

PLANT SPECIES	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	Cl.
<i>Anarthria scabra</i>	+	+	+	+	-	-	+	+	+	-	+	+	-	-	+	+	+	+	-	-
<i>Andersonia caerulea</i>	-	+	-	-	-	-	+	+	-	-	-	-	+	-	-	-	-	+	-	-
<i>Andersonia lehmanniana</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
<i>Andersonia</i> sp.1 (349)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
<i>Andersonia</i> sp.2 (372)	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Anigozanthos flavidus</i>	+	+	+	+	+	+	-	+	-	-	+	-	+	-	+	-	-	-	-	+
<i>Anigozanthos manglesii</i>	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
<i>Anigozanthos viridis</i>	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
* <i>Anthoxanthum odoratum</i>	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
<i>Aotus carinata</i>	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	+	+	-	-
<i>Aotus</i> aff. <i>genistoides</i>	-	-	-	+	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-
<i>Aphelia cyperoides</i>	-	-	-	-	+	-	-	-	-	-	+	-	+	-	-	-	-	-	-	+
* <i>Arctotheca calendula</i>	-	-	-	-	-	-	-	+	-	-	+	-	+	+	+	-	-	-	-	+
<i>Astartea fascicularis</i>	-	-	+	+	+	+	-	+	+	+	+	+	+	-	-	+	+	-	+	-
* <i>Avena fatua</i>	-	-	-	-	-	-	-	+	-	-	-	-	-	+	+	-	-	-	-	+
<i>Banksia attenuata</i>	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Banksia grandis</i>	+	+	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Banksia ilicifolia</i>	+	+	+	-	-	-	+	+	-	-	-	-	-	-	-	-	-	+	-	-
<i>Banksia littoralis</i>	-	+	-	+	+	+	-	+	-	-	+	+	+	-	-	-	-	+	+	-
<i>Banksia meisneri</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
var. <i>ascedens</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Banksia occidentalis</i>	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
ssp. <i>occidentalis</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Baumea articulata</i>	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	+	-
<i>Baumea vaginalis</i>	-	-	-	+	-	+	-	-	+	-	+	-	-	-	+	+	+	-	-	-

ANNEX VII-2

List of Plant Species in the Plant Communities in the Beenup Area - 1989

Vegetation Mapping Codes

PLANT SPECIES	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	C1.
<i>Beaufortia sparsa</i>	-	-	+	+	+	-	-	-	+	-	+	+	+	-	-	+	+	+	-	-
<i>Boronia crenulata</i> var. <i>crenulata</i>	+	+	+	+	+	-	+	+	-	-	-	-	+	-	-	-	+	+	-	-
<i>Boronia denticulata</i>	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Boronia spathulata</i>	-	-	-	-	+	+	-	+	-	-	+	+	+	-	-	-	+	-	-	-
<i>Boronia</i> sp. nov. (360, 378)	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	+	-	-
<i>Bossiaea linophylla</i>	+	-	-	-	-	+	-	-	-	-	-	+	-	-	-	-	-	+	-	-
<i>Bossiaea ornata</i>	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Bossiaea rufa</i>	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
* <i>Briza maxima</i>	+	-	-	-	-	-	+	+	-	-	-	-	-	+	+	-	-	-	-	+
* <i>Bromus ? hordeaceus</i>	-	-	-	-	-	-	-	+	-	-	-	-	-	+	+	-	-	-	-	+
<i>Burchardia umbellata</i>	+	+	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	+	-	-
<i>Burtonia scabra</i>	-	+	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Caladenia flava</i>	+	+	+	+	+	-	+	+	-	-	-	-	-	-	-	-	+	+	-	-
<i>Caladenia gemmata</i>	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Caladenia latifolia</i>	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-
<i>Caladenia ? marginata</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Calothamnus crassus</i>	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-
<i>Calothamnus lateralis</i> ssp. <i>lateralis</i>	-	-	+	-	-	-	-	-	+	-	-	+	+	-	-	-	+	+	-	-
<i>Calytrix flavescens</i>	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Cassytha racemosa</i>	+	-	+	+	-	-	+	+	-	-	-	-	+	-	-	-	+	+	-	-
<i>Centrolepis aristata</i>	-	-	-	-	+	-	-	+	-	-	+	-	+	-	-	-	-	+	-	-
* <i>Cerastium glomeratum</i>	-	-	-	-	-	-	+	+	-	-	+	-	-	+	+	-	-	-	+	+
<i>Chaetanthus leptocarpoides</i>	-	-	-	-	+	-	-	-	-	-	-	+	+	-	-	-	+	+	-	-

ANNEX VII-2

List of Plant Species in the Plant Communities in the Beenup Area - 1989

Vegetation Mapping Codes

PLANT SPECIES	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	Cl.	
<i>Chamaescilla corymbosa</i>	+	+	-	-	+	-	+	+	-	-	+	-	+	-	-	-	-	-	+	-	-
<i>Chorizandra cymbaria</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-
<i>Chorizema ilicifolium</i>	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Comesperma virgatum</i>	+	-	+	-	+	-	-	+	-	-	-	-	+	+	-	-	-	-	-	-	-
<i>Conospermum caeruleum</i>	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	+	+	-	-	-
<i>Conospermum capitatum</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Conospermum flexuosum</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
<i>Conostylis aculeata</i>	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
<i>Conostylis serrulata</i>	+	-	+	-	+	-	-	+	-	-	+	+	+	-	-	-	-	-	-	-	-
<i>Conostylis sp.1 (330)</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-
<i>Conostylis sp.2 (388)</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-
<i>Conostylis ? setigera</i>	-	+	-	+	+	+	-	+	-	-	-	+	-	-	-	-	-	+	+	-	-
* <i>Conyza ? parva</i>	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+
<i>Cotula coronopifolia</i>	-	-	-	-	+	-	-	+	-	-	+	-	+	-	-	-	-	-	-	+	+
* <i>Crassula decumbens</i>	+	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+
<i>Cyathochaeta avenacea</i>	+	-	+	-	+	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-
<i>Cyathochaeta clandestina</i>	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	+	-
* <i>Cyperus tenellus</i>	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+
<i>Dampiera hederacea</i>	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Dampiera leptoclada</i>	+	+	+	-	+	-	+	+	-	-	+	-	+	-	-	+	+	+	-	-	-
<i>Dampiera sacculata</i>	+	+	+	+	+	-	+	+	-	-	-	-	+	-	-	-	+	-	-	-	-
<i>Darwinia oederoides</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
<i>Darwinia sp.</i> (G.J.Keighery 3582)	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	+	-	-
<i>Dasyogon bromeliifolius</i>	+	+	+	+	+	-	+	+	-	-	+	-	+	-	-	-	+	+	-	-	+

ANNEX VII-2

List of Plant Species in the Plant Communities in the Beenup Area - 1989

Vegetation Mapping Codes

PLANT SPECIES	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	Cl.
<i>Daviesia angulata</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-
<i>Daviesia cordata</i>	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
<i>Daviesia decurrens</i>	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Daviesia flexuosa</i>	+	+	+	-	-	-	+	+	-	-	-	-	-	-	-	-	-	+	-	-
<i>Daviesia hakeoides</i> ssp. <i>hakeoides</i>	-	+	-	-	+	-	-	-	-	-	-	+	+	-	-	-	+	+	-	-
<i>Diaspasis filifolia</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
<i>Diuris longifolia</i>	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Drosera erythrorhiza</i>	+	-	-	+	-	-	+	+	-	-	+	-	+	-	-	-	-	+	+	-
<i>Drosera gigantea</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
<i>Drosera glanduligera</i>	-	-	-	-	-	-	+	+	-	-	-	-	+	-	-	-	-	-	+	-
<i>Drosera huegelii</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-
<i>Drosera omissa</i>	-	+	-	-	-	-	+	+	-	-	-	-	+	-	-	-	-	-	+	-
<i>Drosera pallida</i>	+	+	+	+	+	-	+	+	-	-	+	+	+	-	-	+	+	+	-	-
<i>Drosera subhirtella</i>	-	-	-	-	+	-	-	+	-	-	-	-	+	-	-	-	-	+	-	-
<i>Drosera</i> sp. 1 (66)	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Dryandra nivea</i>	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	+	-
<i>Elythranthera brunonis</i>	+	+	+	-	+	-	+	+	-	-	-	+	+	-	-	-	-	-	+	-
<i>Empodisma gracillimum</i>	-	-	+	+	+	+	-	-	+	+	-	-	-	-	-	+	+	-	-	-
<i>Eriostemon spicatus</i>	+	+	-	-	-	-	+	+	-	-	-	+	+	-	-	-	-	+	-	-
* <i>Erodium moschatum</i>	-	-	-	-	-	-	+	+	-	-	-	-	-	+	+	-	-	-	-	+
<i>Eucalyptus marginata</i>	+	+	+	+	+	+	+	+	-	-	+	+	-	-	+	-	+	+	-	+
<i>Eucalyptus patens</i>	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
<i>Euchilopsis linearis</i>	+	-	+	+	-	-	+	-	-	-	-	-	+	-	-	-	-	+	-	-
<i>Eutaxia epacridoides</i>	-	+	+	+	+	+	+	-	-	-	-	-	+	-	-	-	+	-	-	-

ANNEX VII-2

List of Plant Species in the Plant Communities in the Beenup Area - 1989

Vegetation Mapping Codes

PLANT SPECIES	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	Cl.
<i>Eutaxia virgata</i>	-	-	-	-	+	-	-	-	-	-	-	+	+	-	-	-	-	+	-	-
<i>Evandra aristata</i>	-	-	+	-	-	-	-	-	+	-	-	+	+	-	-	+	+	+	-	-
* <i>Freesia leichtlinii</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+
Genus nov. (aff. <i>Loxocarya</i> sp.) (247,440)	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-	+	-
* <i>Geranium molle</i>	-	-	-	-	-	-	+	+	-	-	-	-	-	+	+	-	-	-	-	+
<i>Gompholobium capitatum</i>	-	+	-	-	-	-	+	+	-	-	-	-	+	-	-	-	-	-	+	-
<i>Gompholobium knightianum</i>	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Gompholobium tomentosum</i>	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Gonocarpus benthamii</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Goodenia</i> sp. (83)	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
<i>Grevillea brachystylis</i>	-	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	+	-	-	-
<i>Grevillea manglesioides</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-
<i>Grevillea</i> aff. <i>manglesioides</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
<i>Haemodorum spicatum</i>	+	+	+	-	+	-	-	+	-	-	-	+	-	-	-	-	+	-	-	-
<i>Hakea ceratophylla</i>	-	-	-	-	+	-	-	-	-	-	-	+	+	-	-	-	+	+	-	-
<i>Hakea linearis</i>	-	+	-	+	-	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-
<i>Hakea ruscifolia</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
<i>Hakea sulcata</i>	-	-	-	-	-	-	-	+	-	-	-	+	+	-	-	-	+	+	-	-
<i>Hakea varia</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-
<i>Hakea ? varia</i>	+	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
<i>Hemiandra pungens</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
<i>Hibbertia amplexicaulis</i>	+	+	+	-	+	+	-	-	-	-	+	-	+	-	-	-	-	-	-	-
<i>Hibbertia hypericoides</i>	+	+	+	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Hibbertia ? pulchra</i>	-	+	-	-	-	-	+	+	-	-	-	-	-	-	-	+	+	+	-	-

ANNEX VII-2

List of Plant Species in the Plant Communities in the Beenup Area - 1989

Vegetation Mapping Codes

PLANT SPECIES	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	C1.
<i>Hibbertia stellaris</i>	-	-	-	-	+	-	+	+	-	-	-	-	+	-	-	-	+	+	-	-
* <i>Holcus lanatus</i>	-	-	-	+	+	-	-	+	+	-	+	-	-	+	+	-	+	-	+	+
<i>Homalospermum firmum</i>	-	-	+	-	-	-	-	-	+	+	+	-	-	-	-	+	+	-	-	-
* <i>Hordeum leporinum</i>	-	-	-	-	-	-	-	+	-	-	-	-	-	+	+	-	-	-	-	+
<i>Hovea chorizemifolia</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Hovea elliptica</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Hovea stricta</i>	+	+	-	+	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Hovea trisperma</i>	+	+	-	-	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Hyalosperma cotula</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Hydrocotyle</i> sp. (325)	-	-	-	-	+	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-
<i>Hypocalymma</i> aff. <i>cordifolium</i> (A.S.George 11773)	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
<i>Hypocalymma ericifolium</i>	-	-	+	+	-	-	-	-	+	-	+	+	+	-	-	-	+	+	-	-
<i>Hypocalymma strictum</i>	-	+	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	+	-	-
* <i>Hypochaeris glabra</i>	+	+	+	+	+	-	+	+	+	-	+	-	+	+	+	-	+	-	+	+
<i>Hypolaena exsulca</i>	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+
* <i>Isolepis prolifer</i>	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	+
<i>Isolepis</i> sp.1 (313)	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-
<i>Isolepis</i> sp.2 (129)	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
<i>Isolepis</i> sp.3 (149)	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Isopogon formosus</i>	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Isotropis ? cuneifolia</i>	+	-	+	-	-	-	+	+	-	-	-	-	-	-	-	-	+	-	-	-
<i>Jacksonia horrida</i>	+	+	-	-	-	-	+	+	-	-	+	-	-	-	-	-	-	+	-	-
<i>Jansonia formosa</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
<i>Johnsonia acaulis</i>	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	+	-	-

ANNEX VII-2

List of Plant Species in the Plant Communities in the Beenup Area - 1989

Vegetation Mapping Codes

PLANT SPECIES	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	Cl.
<i>Johnsonia lupulina</i>	+	+	+	+	+	-	+	+	-	-	-	+	+	-	-	-	+	+	-	-
* <i>Juncus microcephalus</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
<i>Juncus pallidus</i>	-	-	-	+	+	+	-	+	+	-	+	-	-	-	+	+	+	+	+	+
<i>Kennedia carinata</i>	+	+	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Kennedia coccinea</i>	+	-	+	-	-	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-
<i>Kunzea recurva</i>	-	-	-	-	+	-	+	+	-	-	-	-	+	-	+	-	+	+	-	-
<i>Lambertia orbifolia</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
<i>Lechenaultia biloba</i>	-	-	-	-	+	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-
<i>Lepidosperma angustatum</i>	+	-	+	+	+	+	-	-	-	-	+	-	+	-	-	-	+	-	-	-
<i>Lepidosperma tenue</i>	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Lepidosperma tetraquetrum</i>	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Leptocarpus scariosus</i>	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-
<i>Leptocarpus tenax</i>	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-	-
<i>Leptomeria squarrulosa</i>	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Leucopogon alternifolius</i>	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	+	+	-	-
<i>Leucopogon assimilis</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
var. <i>rudis</i>	-	-	-	-	-	-	+	+	-	-	-	-	+	-	-	-	-	+	-	-
<i>Leucopogon aff. assimilis</i>	-	-	-	-	-	-	+	+	-	-	-	-	+	-	-	-	-	+	-	-
<i>Leucopogon australis</i>	+	+	+	+	-	-	-	+	-	+	-	+	-	-	-	+	+	-	-	-
<i>Leucopogon capitellatus</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-
<i>Leucopogon gilbertii</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-
<i>Leucopogon aff. gilbertii</i>	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-
<i>Leucopogon hirsutus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
<i>Leucopogon pendulus</i>	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-
<i>Leucopogon reflexus</i>	+	+	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-

ANNEX VII-2

List of Plant Species in the Plant Communities in the Beenup Area - 1989

Vegetation Mapping Codes

PLANT SPECIES	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	C1.
<i>Leucopogon verticillatus</i>	+	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Liliaceae</i> sp. (351)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
<i>Lindsaea linearis</i>	-	+	+	+	+	+	+	+	+	-	+	-	+	-	-	-	-	-	-	-
* <i>Lolium perenne</i>	-	-	-	-	-	-	-	+	-	-	-	-	-	+	+	-	-	-	-	+
<i>Lomandra hermaphrodita</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Lomandra integra</i>	+	+	-	-	+	+	+	+	-	-	-	+	+	-	-	-	-	-	-	-
<i>Lomandra nigricans</i>	+	-	+	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Lomandra purpurea</i>	+	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-
<i>Lomandra sonderi</i>	+	+	-	-	+	+	-	+	-	-	-	+	-	-	-	-	-	-	-	-
<i>Lomandra</i> sp.1 (297)	-	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Lomandra</i> sp.2 (386)	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
* <i>Lotus angustissimus</i>	+	-	-	+	+	-	+	+	-	-	+	-	+	+	+	-	-	-	+	+
<i>Loxocarya fasciculata</i>	+	+	+	+	+	+	-	+	-	-	+	-	+	-	-	-	+	+	-	-
<i>Loxocarya flexuosa</i>	-	+	-	+	+	+	-	+	-	-	+	-	+	-	-	-	-	-	-	-
<i>Lyginia barbata</i>	+	+	-	+	+	-	+	+	-	-	-	+	+	-	-	-	+	+	-	-
<i>Lyperanthus serratus</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Lysinema ciliatum</i>	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Lysinema conspicuum</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Macrozamia riedlei</i>	+	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
<i>Meeboldina denmarkica</i>	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Melaleuca densa</i>	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-
<i>Melaleuca preissiana</i>	-	-	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+
<i>Melaleuca thymoides</i>	+	+	-	-	-	-	+	+	-	-	+	-	-	-	+	-	-	+	-	-
<i>Mesomelaena stygia</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-
<i>Mesomelaena tetragona</i>	+	+	+	+	+	+	-	+	-	-	+	+	+	-	+	-	+	+	-	-

ANNEX VII-2

List of Plant Species in the Plant Communities in the Beenup Area - 1989

Vegetation Mapping Codes

PLANT SPECIES	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	C1.	
<i>Microlaena stipoides</i>	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+
<i>Mirbelia dilatata</i>	+	-	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Mitrasacme paradoxa</i>	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Monotaxis occidentalis</i>	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-
<i>Needhamiella pumilio</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-
<i>Neurachne alopecuroidea</i>	+	+	-	-	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Nuytsia floribunda</i>	-	+	+	-	+	-	+	+	+	-	+	-	+	+	+	-	+	+	-	-	+
<i>Olearia axillaris</i>	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Opercularia echinocephala</i>	-	+	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Opercularia hispidula</i>	+	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Opercularia vaginata</i>	-	-	+	+	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	-	+
* <i>Ornithopus pinnatus</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+	-	-	-	-	-	+
<i>Oxylobium ? carinatum</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Oxylobium lanceolatum</i>	-	-	-	-	-	-	-	-	+	+	-	-	+	-	-	+	-	-	-	-	-
* <i>Parentucellia latifolia</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	-	+
* <i>Parentucellia viscosa</i>	-	-	-	-	-	-	-	-	-	-	+	-	-	+	+	-	-	-	-	-	+
<i>Patersonia juncea</i>	-	-	-	-	+	-	+	+	-	-	-	-	+	-	-	-	-	-	-	-	-
<i>Patersonia occidentalis</i>	+	+	-	-	+	-	+	+	-	-	+	-	+	-	-	+	+	+	-	-	-
<i>Patersonia umbrosa</i>	+	+	-	-	+	+	+	+	-	-	+	-	+	-	-	+	+	+	-	-	-
var. <i>umbrosa</i>																					
<i>Patersonia umbrosa</i>	+	+	-	-	+	+	+	+	-	-	+	-	+	-	-	+	+	+	-	-	-
var. <i>xanthina</i>																					
<i>Pentapeltis peltigera</i>	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Pericalymma ellipticum</i>	+	-	-	+	+	-	+	+	+	-	+	+	+	-	+	-	+	+	-	-	-
* <i>Petrorhagia velutina</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+

ANNEX VII-2

List of Plant Species in the Plant Communities in the Beenup Area - 1989

Vegetation Mapping Codes

PLANT SPECIES	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	Cl.
<i>Persoonia ? elliptica</i>	+	+	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Persoonia longifolia</i>	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Petrophile diversifolia</i>	-	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Petrophile linearis</i>	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	+	-	-
<i>Petrophile longifolia</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-
<i>Petrophile squamata</i>	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	+	-	-
<i>Philydrella pygmaea</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-
<i>Phlebocarya ciliata</i>	+	+	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-	+	-
<i>Pimelea hispida</i>	-	-	-	+	+	+	-	+	-	-	-	-	+	-	-	-	-	-	+	-
<i>Pimelea longiflora</i>	+	-	+	+	-	-	+	+	-	-	-	+	-	-	-	-	-	+	+	-
<i>Pithocarpa corymbulosa</i>	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
<i>Platysace tenuissima</i>	+	+	+	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* <i>Poa annua</i>	-	-	-	-	+	-	+	+	-	-	+	-	+	+	+	-	-	-	+	+
<i>Podocarpus drouynianus</i>	+	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Polypompholyx multifida</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
<i>Prasophyllum ? drummondii</i>	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
<i>Prasophyllum macrostachyum</i>	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* <i>Pseudognaphalium luteo-album</i>	+	-	-	-	+	-	-	+	-	-	+	-	+	+	+	-	+	-	+	+
<i>Pteridium esculentum</i>	-	+	+	-	-	+	-	-	-	+	+	-	-	-	-	-	-	-	+	+
<i>Pterostylis vittata</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	+
<i>Pultenaea reticulata</i>	+	+	+	-	-	-	+	-	-	-	-	-	-	-	-	-	+	-	-	-
* <i>Ranunculus muricatus</i>	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+
<i>Restio amblyocoleus</i>	-	-	-	-	+	-	-	-	-	-	-	-	+	-	-	-	+	+	-	-
<i>Restio appianatus</i>	-	-	-	-	-	-	-	+	-	-	-	+	+	-	-	-	+	+	-	-
<i>Restio leptocarpoides</i>	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-	-	-	-	-	-

ANNEX VII-2

List of Plant Species in the Plant Communities in the Beenup Area - 1989

Vegetation Mapping Codes

PLANT SPECIES	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	Cl.
<i>Restio serialis</i>	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	+	-	-
<i>Restio tremulus</i>	-	+	-	-	-	-	-	-	-	+	-	-	+	-	-	-	-	+	-	-
<i>Restio ustulatus</i>	-	-	-	-	-	-	-	+	-	-	-	+	+	-	-	-	+	+	-	-
<i>Restio</i> sp. (180)	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Restionaceae</i> sp.1 (259)	-	-	-	+	-	-	-	-	+	-	-	+	-	-	-	-	+	-	-	-
<i>Restionaceae</i> sp.2 (253)	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-
<i>Restionaceae</i> sp.3 (450)	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* <i>Rumex acetosella</i>	-	-	-	-	-	-	-	+	+	-	+	-	-	+	+	-	+	-	+	+
<i>Scaevola calliptera</i>	+	+	+	+	+	+	+	+	-	-	+	-	-	-	-	-	-	+	-	-
<i>Schoenus bifidus</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
<i>Schoenus cruentus</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	+	-	-
<i>Schoenus curvifolius</i>	-	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	+	+	-	-
<i>Schoenus rodwayanus</i>	-	-	-	-	-	-	-	+	+	-	+	-	+	-	-	+	+	+	-	-
<i>Schoenus</i> aff. <i>subflavus</i>	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	+	-	-
<i>Schoenus sublaxus</i>	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	+	-	-
* <i>Senecio ? vulgaris</i>	-	-	-	-	-	-	-	-	-	-	+	-	-	+	+	-	-	-	-	+
* <i>Solanum nigrum</i>	-	-	-	-	-	-	-	+	-	-	+	-	-	+	+	-	-	-	+	+
<i>Sollya heterophylla</i>	+	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Sphaerolobium grandiflorum</i>	-	+	-	-	+	-	-	+	+	-	+	-	+	-	-	-	+	+	-	-
<i>Sphaerolobium racemulosum</i>	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Sphenotoma ? capitatum</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
<i>Sphenotoma gracile</i>	+	+	+	+	+	-	+	-	-	-	-	+	-	-	-	+	+	+	-	-
<i>Sphenotoma squarrosom</i>	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	-	+	-	-	-
<i>Stackhousia huegelii</i>	+	-	+	-	+	-	-	+	-	-	-	-	+	-	-	-	-	+	-	-
<i>Stylidium amoenum</i>	+	+	-	+	+	-	-	+	-	-	+	-	-	-	-	-	-	-	-	-

ANNEX VII-2

List of Plant Species in the Plant Communities in the Beenup Area - 1989

Vegetation Mapping Codes

PLANT SPECIES	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	C1.
<i>Stylidium bulbiferum</i>	-	-	-	-	-	-	-	+	-	-	-	-	+	-	-	-	-	+	-	-
<i>Stylidium calcaratum</i>	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Stylidium diversifolium</i>	-	+	-	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Stylidium imbricatum</i>	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Stylidium junceum</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Stylidium ? luteum</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
<i>Stylidium piliferum</i>	+	+	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Stylidium repens</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
<i>Stylidium scandens</i>	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	+	-	-
<i>Stylidium schoenoides</i>	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Stylidium ? verticillatum</i>	-	-	-	+	+	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
<i>Stylidium violaceum</i>	-	-	+	-	+	-	+	+	-	-	+	-	+	-	-	-	+	+	-	-
<i>Stylidium sp.1 (373)</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-
<i>Synaphea gracillima</i>	-	-	-	-	+	-	-	-	-	-	+	-	+	-	-	-	+	+	-	-
<i>Tetraria capillaris</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Tetraria octandra</i>	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Tetratheca setigera</i>	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Thelymitra antennifera</i>	-	-	-	-	+	-	-	-	-	-	+	-	+	-	-	-	-	+	-	-
<i>Thelymitra ? nuda</i>	-	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	+
<i>Thomasia pauciflora</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Thysanotus dichotomus</i>	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-	-
<i>Thysanotus patersonii</i>	+	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	+	-	-	-
<i>Trachymene pilosa</i>	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Tremandra diffusa</i>	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
* <i>Trifolium balansae</i>	+	-	-	-	-	-	-	+	-	-	+	-	+	+	+	-	+	+	+	+

ANNEX VII-2

List of Plant Species in the Plant Communities in the Beenup Area - 1989

Vegetation Mapping Codes

PLANT SPECIES	1.1	1.2	1.3	1.4	1.5	1.6	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4	Cl.
<i>Triglochin calcitrapa</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-
<i>Triglochin procera</i>	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	+	-	+	-
* <i>Ursinia anthemoides</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	+	+	-	-	-	-	+
<i>Utricularia menziesii</i>	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	+	-	-
<i>Velleia trinervis</i>	-	-	-	-	+	-	-	+	-	-	+	-	+	-	-	-	-	+	-	-
<i>Verticordia densiflora</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Verticordia lehmannii</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
<i>Villarsia lasiosperma</i>	-	+	-	-	+	-	-	-	+	-	+	-	+	+	+	-	+	-	-	+
<i>Villarsia parnassifolia</i>	-	-	-	-	+	-	-	-	-	-	+	-	+	+	-	-	-	+	-	-
<i>Viminaria juncea</i>	-	-	-	-	+	-	-	-	-	-	+	-	+	+	-	-	-	-	-	+
* <i>Vulpia myuros</i>	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-
<i>Waitzia citrina</i>	+	-	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	+	-
<i>Waitzia suaveolens</i>	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Wurmbea dioica ssp. alba</i>	-	+	-	+	+	-	+	+	-	-	+	+	+	+	+	-	+	+	-	-
<i>Xanthorrhoea preissii</i>	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+
<i>Xanthosia huegelii</i>	+	+	+	-	+	+	-	+	-	-	+	-	-	-	-	-	-	+	-	-
<i>Xylomelum occidentale</i>	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
<i>Xyris laxiflora</i>	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

- Community Code:** 1.1
- Plots:** 8, 9, 12, 13, 75 and 78
- Indicator Species:** Tree Species - *Eucalyptus marginata*, *Eucalyptus calophylla*, *Agonis flexuosa* and *Personia longifolia*
- Understorey Species - *Acacia divergens*, *Acacia extensa*, *Anarthria scabra*, *Chorizema ilicifolium*, *Daviesia flexuosa*, *Hibbertia hypericoides*, *Macrozamia riedlei*, *Pteridium esculentum*, *Scaevola calliptera* and *Xanthorrhoea preissii* (Appendix B).
- Species Richness:** 105 Native Species
6 Introduces Species
111 Species
- Composition:** Open forest to woodland of *Eucalyptus marginata* - *Eucalyptus calophylla*.
- Topography & Soils:** Undulating low sandy to sandy-clay loams. Occasional occurrence of lateritic gravels (Sites 9,12 and 13). Seasonally moist soils, but generally sheet run off.
- Other:** Local physiological stress recorded in this community. Dieback sampling confirmed presence of *Phytophthora cinnamomi* near Site 78, in association with some recently dead *Xanthorrhoea preissii*.
- Species Conservation Status:**
Species of Interest:
Hovea stricta, poorly collected and possibly geographically restricted.

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

- Community Code:** 1.2
- Plots:** 21 and 76
- Indicator Species:** Tree Species - *Eucalyptus marginata*, *Eucalyptus calophylla*, *Banksia grandis*, *Banksia ilicifolia* and *Nuytsia floribunda*.
- Understorey Species - *Adenanthos obovatus*, *Anarthria scabra*, *Dasyogon bromeliifolius*, *Hibbertia ? pulchra*, *Leucopogon australis*, *Mesomelaena tetragona*, *Scaevola calliptera* and *Xanthorrhoea preissii* (Appendix B).
- Species Richness:** 87 Native Species
1 Introduced Species
88 Species
- Composition:** Open forest to woodland of *Eucalyptus marginata* - *Eucalyptus calophylla* with *Banksia grandis* and *Banksia ilicifolia*.
- Topography & Soils:** Upper slopes of sands to sandy loams. Slightly drier sandy soils, compared with Community 1.1.
- Other:** Community dominated by sandy indicators, many overlap with species from Donnybrook Sunkland or Blackwood Plateau.
- Species Conservation Status:**
Reserve Flora: *Drosera omissa*
Villarsia lasiosperma
Species of Interest:
Hovea stricta, poorly collected and possibly geographically restricted.

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

- Community Code:** 1.3
- Plots:** 77 and 79
- Indicator Species:** Tree Species - *Eucalyptus marginata*, *Eucalyptus calophylla*, *Eucalyptus patens* and the occasional *Nuytsia floribunda* and *Melaleuca preissiana*.
- Understorey Species - *Astartea fascicularis*, *Daviesia cordata*, *Evandra aristata*, *Leptocarpus scariosus*, *Pultenaea reticulata* and *Xanthorrhoea preissii* (Appendix B).
- Species Richness:** 78 Native Species
2 Introduced Species
80 Species
- Composition:** Open forest to woodland of *Eucalyptus marginata* - *Eucalyptus calophylla* - *Eucalyptus patens*.
- Topography & Soils:** Seasonally moist sandy loams to sandy-clay loams. On lower slopes and small spurs near seasonal swamps.
- Other:** This community forms a mosaic with Paperbarks and Jarrah, depending on the localized soil conditions.
- Species Conservation Status:**
Species of Interest:
None recorded in this community.

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

- Community Code:** 1.4
- Plots:** 25, 26 and 84
- Indicator Species:** Tree Species - *Eucalyptus marginata*, *Eucalyptus patens*, *Banksia littoralis* and *Melaleuca preissiana*.
- Understorey Species - *Acacia extensa*, *Acacia myrtifolia*, *Agonis linearifolia*, *Agonis parviceps*, *Eutaxia epacridioides*, *Hypocalymma* aff. *cordifolium* and *Pimelea hispida* (Appendix B).
- Species Richness:** 66 Native Species
4 Introduced Species
70 Species
- Composition:** Open forest *Eucalyptus marginata* - *Eucalyptus patens* with *Banksia littoralis*.
- Topography & Soils:** Drainage line on brown sandy loams. Seasonally moist to wet soils.
- Other:** This community overlaps with 1.5 and 1.6 where the drainage line becomes broader, near plots 25 and 26.
- Species Conservation Status:**
- Reserve Flora: *Aotus carinata*
Hypocalymma aff. *cordifolium*
Stylidium verticillatum
- Species of Interest:
Hovea stricta, poorly collected and possibly geographically restricted.

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

- Community Code:** 1.5
- Plots:** 2, 3, 27, 28, 47, 48, 89, 90, 91, 92, 93 and 94.
- Indicator Species:** Tree Species - *Eucalyptus marginata*, *Eucalyptus calophylla* and *Melaleuca preissiana*.
- Understorey Species - *Astartea fascicularis*, *Daviesia cordata*, *Evandra aristata*, *Leptocarpus scariosus*, *Pultenaea reticulata* and *Xanthorrhoea preissii* (Appendix B).
- Species Richness:** 112 Native Species
5 Introduced Species
117 Species
- Composition:** Open forest to woodland of *Eucalyptus marginata* - *Eucalyptus calophylla* - *Melaleuca preissiana*.
- Topography & Soils:** Seasonally moist to wet red brown sandy loams over relatively shallow iron pan, with occasional exposures of iron pan.
- Other:** This community forms a mosaic with Paperbarks and Jarrah, depending on the localized soil depths over the iron pan. In areas of exposure the tree cover is reduced to a woodland.
- Species Conservation Status:**
- Reserve Flora: *Hypocalymma* aff. *cordifolium*
Stylidium verticillatum
Villarsia lasiosperma
- Species of Interest:
Hovea stricta, poorly collected and possibly geographically restricted.

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

Community Code: 1.6

Plots: 23 and 24

Indicator Species: Tree Species - *Eucalyptus marginata*, *Eucalyptus calophylla* with *Banksia littoralis*, *Banksia grandis*, *Agonis flexuosa*, *Persoonia longifolia* and *Xylomelum occidentale* in lower tree layer.

Understorey Species - *Acacia browniana* var. *obscura*, *Acacia myrtifolia*, *Agonis parviceps*, *Anigozanthos flavidus*, *Grevillea brachystylis* and *Hakea linearis* (Appendix B).

Species Richness: 56 Native Species
No Introduced Species
56 Species

Composition: Open forest *Eucalyptus marginata* - *Eucalyptus calophylla* - *Agonis flexuosa*.

Topography & Soils: On lower slopes with brown sandy loams. Seasonally moist soils, associated with the drainage lines flowing through the western section of the survey area.

Other: This community overlaps with 1.4 and 1.5.

Species Conservation Status:

Species of Interest:

Hovea stricta poorly collected and possibly geographically restricted.

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

Community Code: 2.1

Plots: 49, 53, 87 and 88.

Indicator Species: Tree Species - *Banksia attenuata* - *Banksia ilicifolia* - *Eucalyptus marginata* and to a lesser extent *Nuytsia floribunda*.

Understorey Species - *Adenanthos obovatus*, *Adenanthos meisneri*, *Anarthria scabra*, *Andersonia caerulea*, *Burtonia scabra*, *Daviesia flexuosa*, *Euchilopsis linearis*, *Gompholobium capitatum*, *Hibbertia ?pulchra*, *Jacksonia horrida*, *Kunzea recurva*, *Leptocarpus scariosus*, *Lyginia barbata*, *Melaleuca thymoides* and *Xanthorrhoea preissii*. (Appendix B).

Species Richness: 91 Native Species
7 Introduced Species
98 Species

Composition: Low open woodland to low woodland of *Banksia attenuata* - *Banksia ilicifolia* - *Eucalyptus marginata*.

Topography & Soils: Localized sandy dunes interspersed amongst lower lying sedgelands with low heath species.

Other: This community differs structurally and floristically from 4.3, through the occurrence of a low tree layer and a range of shrub species which reflect the slightly drier and deeper sandy soils.

Species Conservation Status:

Reserve Flora: *Drosera omissa*
Leucopogon alternifolius

Species of Interest:

Boronia sp. nov. (360, 378), new species.

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

Community Code: 2.2

Plots: 1, 4, 30, 32, 37, 38, 40, 42, 43, 46 and 60.

Indicator Species: Tree Species - *Agonis flexuosa* - *Banksia ilicifolia* - *Eucalyptus marginata* and to a lesser extent *Allocasuarina fraseriana*, *Nuytsia floribunda* and *Banksia attenuata*.

Understorey Species - *Acacia pulchella* var. *pulchella*, *Agonis parviceps*, *Anarthria prolifera*, *Anarthria scabra*, *Dasyogon bromeliifolius*, *Eriostemon spicatus*, *Isotropis ? cuneifolia*, *Jacksonia horrida*, *Juncus pallidus*, *Leptocarpus scariosus*, *Lyginia barbata*, *Melaleuca thymoides*, *Pericalymma ellipticum*, *Pimelea hispida* and *Xanthorrhoea preissii* (Appendix B).

Species Richness: 112 Native Species
21 Introduced Species
133 Species

Composition: Low woodland to low open forest of *Agonis flexuosa* - *Banksia ilicifolia* - *Eucalyptus marginata*.

Topography & Soils: On localized sandy dunes scattered through the survey area.

Other: This community has largely been affected by clearing activities and grazing, with a high proportion of introduced species in the communities (Appendix B).

Species Conservation Status:

Reserve Flora: *Drosera omissa*
Restio ustulatus

Species of Interest:

Hovea stricta, poorly collected and possibly geographically restricted.

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

Community Code: 2.3

Plots: 7, 15, 16 and 41

Indicator Species: Tree Species - *Melaleuca preissiana* and the occasional *Nuytsia floribunda*.

Understorey Species - *Acacia histulata*, *Agonis parviceps*, *Agonis* aff. *spathulata*, *Astartea fascicularis*, *Beaufortia sparsa*, *Evandra aristata*, *Homalospermum ericifolium*, *Hypocalymma ericifolium*, *Juncus pallidus*, *Leptocarpus scariosus*, *Oxylobium lanceolatum*, *Pericalymma ellipticum*, *Sphenotoma squarrosus* and *Villarsia lasiosperma* (Appendix B).

Species Richness: 30 Native Species
3 Introduced Species
33 Species

Composition: Low open woodland of *Melaleuca preissiana*.

Topography & Soils: On seasonally inundated loamy and gritty sands of the swamps and depressions.

Other: This community is similar to 2.5, but differs in the species that tolerate lack of drainage. This community has been affected by grazing and past agricultural activities, e.g. regular burning.

Species Conservation Status:

Reserve Flora:

Villarsia lasiosperma

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

Community Code: 2.4

Plots: 51

Indicator Species: Tree Species - *Melaleuca preissiana* - *Agonis juniperina*.

Understorey Species - *Acacia histulata*, *Aotus* aff. *genistoides*, *Astartea fascicularis*, *Leptocarpus scariosus*, *Leucopogon australis*, *Oxylobium lanceolatum* and *Sphenotoma squarrosus* (Appendix B).

Species Richness:

14 Native Species

No Introduced Species

14 Species

Composition: Low woodland to low open forest of *Melaleuca preissiana* - *Agonis juniperina*.

Topography & Soils: On the seasonally inundated loamy and gritty sands of the swamp in the north-east corner of the survey area.

Other: This community is restricted within the survey area to the north-east corner. Several of the dominant species occur in 2.3 and 2.5.

Species Conservation Status:

Species of Interest:

None recorded in this community.

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

- Community Code:** 2.5
- Plots:** 31, 36, 45, 70, 74, 82 and 83
- Indicator Species:** Tree Species - *Melaleuca preissiana* and the occasional *Agonis juniperina*.
- Understorey Species - *Agonis linearifolia*, *Agonis parviceps*, *Anigozanthos flavidus*, *Astartea fascicularis*, *Baumea articulata*, *Cotula coronopifolia*, *Hakea varia*, *Juncus pallidus*, *Hypocalymma ericifolium*, *Leptocarpus scariosus*, *Lindsaea linearis*, *Melaleuca densa*, *Pericalymma ellipticum*, *Restio serialis*, *Triglochin procera* and *Villarsia lasiosperma* (Appendix B).
- Species Richness:** 81 Native Species
15 Introduced Species
96 Species
- Composition:** Low open woodland of *Melaleuca preissiana* - *Agonis* spp.
- Topography & Soils:** On loamy sands of the drainage lines.
- Other:** This community is similar to 2.3, but differs in the species that tolerate drainage. This community has been affected by grazing and past agricultural activities, e.g. regular burning.
- Species Conservation Status:**
Reserve Flora: *Villarsia lasiosperma*
Species of Interest:
Genus nov. (aff. *Loxocarya* sp.),
recently described genus, unpublished.

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

- Community Code:** 3.1
- Plots:** 19 and 20
- Indicator Species:** Tree Species - Occasional very low *Melaleuca preissiana* and *Eucalyptus marginata*.
- Understorey Species - *Adenanthos obovatus*, *Agonis parviceps*, *Anarthria scabra*, *Beaufortia sparsa*, *Banksia occidentalis* ssp. *occidentalis*, *Calothamnus lateralis* ssp. *lateralis*, *Evandra aristata*, *Hakea varia*, *Hakea linearis*, *Hypocalymma ericifolium*, *Leptocarpus scariosus* and *Pericalymma ellipticum* (Appendix B).
- Species Richness:** 48 Native Species
No Introduced Species
48 Species
- Composition:** Open heath of *Banksia occidentalis*.
- Topography & Soils:** On the low brown sand dunes in the north-west section of the survey area.
- Other:** This community is restricted within the survey area to the north-west corner. Although many species overlap with the nearby sedgelands with low heath species, the dominance of the *Banksia occidentalis* ssp. *occidentalis* and Proteaceae species warranted separation on the vegetation map.
- This community has recently been subjected to a intense, but localized fire. The regularity of the fires should be reviewed for the Proteaceae species in the area.
- Species Conservation Status:**
Reserve Flora: *Restio ustulatus*

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

- Community Code:** 3.2
- Plots:** 33, 34, 35, 55, 56, 57, 58, 59, 61, 62, 63, 64, 65, 66, 68, 69, 71, 72 and 73
- Indicator Species:** Tree Species - Very occasional *Melaleuca preissiana* and *Nuytsia floribunda*.
- Understorey Species - *Acacia myrtifolia*, *Actinodium cunninghamii*, *Adenanthos obovatus*, *Adenanthos detmoldii*, *Anarthria prolifera*, *Boronia spathulata*, *Calothamnus crassus*, *Comespermum caeruleum*, *Darwinia* sp. (G.J. Keighery 3582), *Dryandra nivea*, *Grevillea manglesioides*, *Hakea ceratophylla*, *Hakea sulcata*, *Hakea varia*, *Hibbertia stellaris*, *Kunzea recurva*, *Leptocarpus scariosus*, *Mesomelaena tetragona*, *Pericalymma ellipticum*, *Restio serialis*, *Schoenus rodwayanus*, *Velleia trinervis*, *Viminaria juncea* and *Xanthorrhoea preissii* (Appendix B).
- Species Richness:** 129 Native Species
9 Introduced Species
138 Species
- Composition:** Closed heath to scrub of mixed Proteaceae - Myrtaceae species.
- Topography & Soils:** On the red-brown and grey sandy loams over shallow iron pan. The area is also subjected to seasonal inundation, which appears to be critical for some of the species.
- Other:** This community is restricted to the eastern side of the survey area. Some of the species overlap with the nearby sedgelands with low heath species. This community has recently been subjected to a intense, but localized fire. The regularity of the fires should be reviewed for the Proteaceae and rare species in the area.

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

Community Code: 3.2 (Continued)

Species Conservation Status:

Gazetted Rare: *Darwinia* sp. (G.J. Keighery 3582)
Lambertia orbifolia

Reserve Flora: *Adenanthos detmoldii*
Aotus carinata
Calothamnus crassus
Drosera omissa

* *Grevillea manglesioides* ssp.
papillosa

Jansonia formosa
Leucopogon alternifolius
Restio ustulatus
Stylidium ?verticillatum
Villarsia lasiosperma

(Note: * Denotes awaiting taxonomic
verification for subspecies)

Species of Interest: *Boronia* sp. nov. (360, 378),
new species.

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

- Community Code:** 3.3
- Plots:** No plots, all modified road verges.
- Indicator Species:** Tree Species - Very occasional *Melaleuca preissiana* and *Nuytsia floribunda*.
- Understorey Species - *Adenanthos detmoldii*, *Agonis parviceps*, *Darwinia oederoides*, *Viminaria juncea*, *Xanthorrhoea preissii* and range of introduced species (Appendix B).
- Species Richness:** 10 Native Species
22 Introduced Species
32 Species
- Composition:** Open heath of mixed Proteaceae - Myrtaceae species over sedgelands.
- Topography & Soils:** On the red-brown and grey sandy loams over shallow iron pan. The area is also subjected to seasonal inundation.
- Other:** This community has been modified by previous clearing and activities associated with road verge maintenance, access routes to agricultural properties and burning. The floristic composition of the communities has some similarities with nearby uncleared communities on the shallow soils over the iron pan (see McArthur soil map).
- Species Conservation Status:**
Reserve Flora: *Adenanthos detmoldii*
Villarsia lasiosperma

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

- Community Code:** 3.4
- Plots:** No plots, all modified road verges.
- Indicator Species:** Tree Species - Very occasional *Melaleuca preissiana*, *Eucalyptus marginata* and *Nuytsia floribunda*.
- Understorey Species - *Acacia extensa*, *Acacia pulchella* var. *pulchella*, *Anarthria prolifera*, *Anarthria scabra*, *Anigozanthos flavidus*, *Baumea vaginalis*, *Juncus pallidus*, *Leptocarpus scariosus*, *Xanthorrhoea preissii* and range of introduced species (Appendix B).
- Species Richness:** 19 Native Species
22 Introduced Species
41 Species
- Composition:** Open heath of mixed Myrtaceae species over sedgelands.
- Topography & Soils:** On the brown and grey sandy loams, sections subjected to seasonal moisture.
- Other:** This community has been modified by previous clearing and activities associated with road verge maintenance, access routes to agricultural properties and burning. The floristic composition of the communities has some similarities with nearby uncleared communities (see McArthur soil map).
- Species Conservation Status:**
Reserve Flora: *Villarsia lasiosperma*

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

Community Code: 4.1

Plots: 14 and 50

Indicator Species: Tree Species - occasional *Melaleuca preissiana*.

Understorey Species - *Acacia hastulata*, *Agonis parviceps*, *Astartea fascicularis*, *Baumea vaginalis*, *Beaufortia sparsa*, *Evandra aristata*, Genus nov. (aff. *Loxocarya* sp.), *Homalospermum firmum*, *Juncus pallidus*, *Leptocarpus scariosus*, *Oxylobium lanceolatum* and *Xanthorrhoea preissii* (Appendix B).

Species Richness: 29 Native Species
No Introduced Species
29 Species

Composition: Sedgeland with pockets of closed heath of Myrtaceae spp.

Topography & Soils: On dark greyish brown loamy sands in the extensive wetlands.

Other: This community is similar to 4.2, but differs in the species that tolerate higher levels of seasonal inundation.

Species Conservation Status:

Species of Interest:

Genus nov. (aff. *Loxocarya* sp.),
recently described genus, unpublished.

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

- Community Code:** 4.2
- Plots:** 5, 6, 10, 11, 16, 17, 18, 41, 79, 80 and 85
- Indicator Species:** Tree Species - occasional *Melaleuca preissiana*.
- Understorey Species - *Acacia hastulata*, *Acacia uliginosa*, *Adenanthos obovatus*, *Agonis parviceps*, *Anarthria scabra*, *Astartea fascicularis*, *Beaufortia sparsa*, *Boronia spathulata*, *Calothamnus lateralis* ssp. *lateralis*, *Dasyogon bromeliifolius*, *Hakea ceratophylla*, *Homalospermum firmum*, *Hypocalymma ericifolium*, *Johnsonia lupulina*, *Leptocarpus scariosus*, *Pericalymma ellipticum*, *Restio ustulatus* and *Xanthorrhoea preissii* (Appendix B).
- Species Richness:** 93 Native Species
5 Introduced Species
98 Species
- Composition:** Sedgeland with pockets of open heath of Proteaceae and Myrtaceae spp.
- Topography & Soils:** On dark greyish brown loamy sands in the extensive depressions.
- Other:** This community is similar to 4.1, but differs in the species that tolerate lower levels of seasonal inundation.
- Species Conservation Status:**
Reserve Flora: *Aotus carinata*
Hypocalymma aff. *cordifolium*
Leucopogon alternifolius
Restio ustulatus
Villarsia lasiosperma

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

- Community Code:** 4.3
- Plots:** 22, 29, 39, 44, 52, 54, 55, 67 and 86
- Indicator Species:** Tree Species - occasional *Eucalyptus marginata*, *Nuytsia floribunda*, *Melaleuca preissiana* and *Banksia ilicifolia*.
- Understorey Species - *Acacia myrtifolia*, *Acacia uliginosa*, *Adenanthos obovatus*, *Agonis parviceps*, *Anarthria prolifera*, *Anarthria scabra*, *Beaufortia sparsa*, *Dasyogon bromeliifolius*, *Eriostemon spicatus*, *Gompholobium capitatum*, *Hakea sulcata*, *Homalospermum firmum*, *Hypocalymma ericifolium*, *Hypocalymma strictum*, *Kunzea recurva*, *Leptocarpus scariosus*, *Lyginia barbata*, *Melaleuca thymoides*, *Pericalymma ellipticum*, *Phlebocarya ciliata*, *Restio ustulatus*, *Schoenus curvifolius*, *Sphenotoma gracile* and *Xanthorrhoea preissii* (Appendix B).
- Species Richness:** 121 Native Species
1 Introduced Species
122 Species
- Composition:** Low sedgeland with pockets of low open heath of Proteaceae and Myrtaceae spp.
- Topography & Soils:** On brown and grey sands in the extensive depressions. The soils are relatively shallow in some areas over the iron pan.
- Other:** This community is relatively widespread in the survey area, occurring both west and east of Scott River Road and in adjacent reserves to the south. However the communities over the very shallow soils (less than 20 cm) are restricted.

ANNEX VII-3

Summary of Plant Communities for the Beenup Survey Area

Community Code: 4.3 (Continued)

Species Conservation Status:

Gazetted Rare: *Darwinia* sp. (G.J. Keighery 3582)

Reserve Flora: *Adenanthos detmoldii*

Aotus carinata

Banksia meisneri var. *ascendens*

potential in survey area as
recorded immediately south of
Beenup project area.

Drosera omissa

Leucopogon alternifolius

Restio ustulatus

Species of Interest:

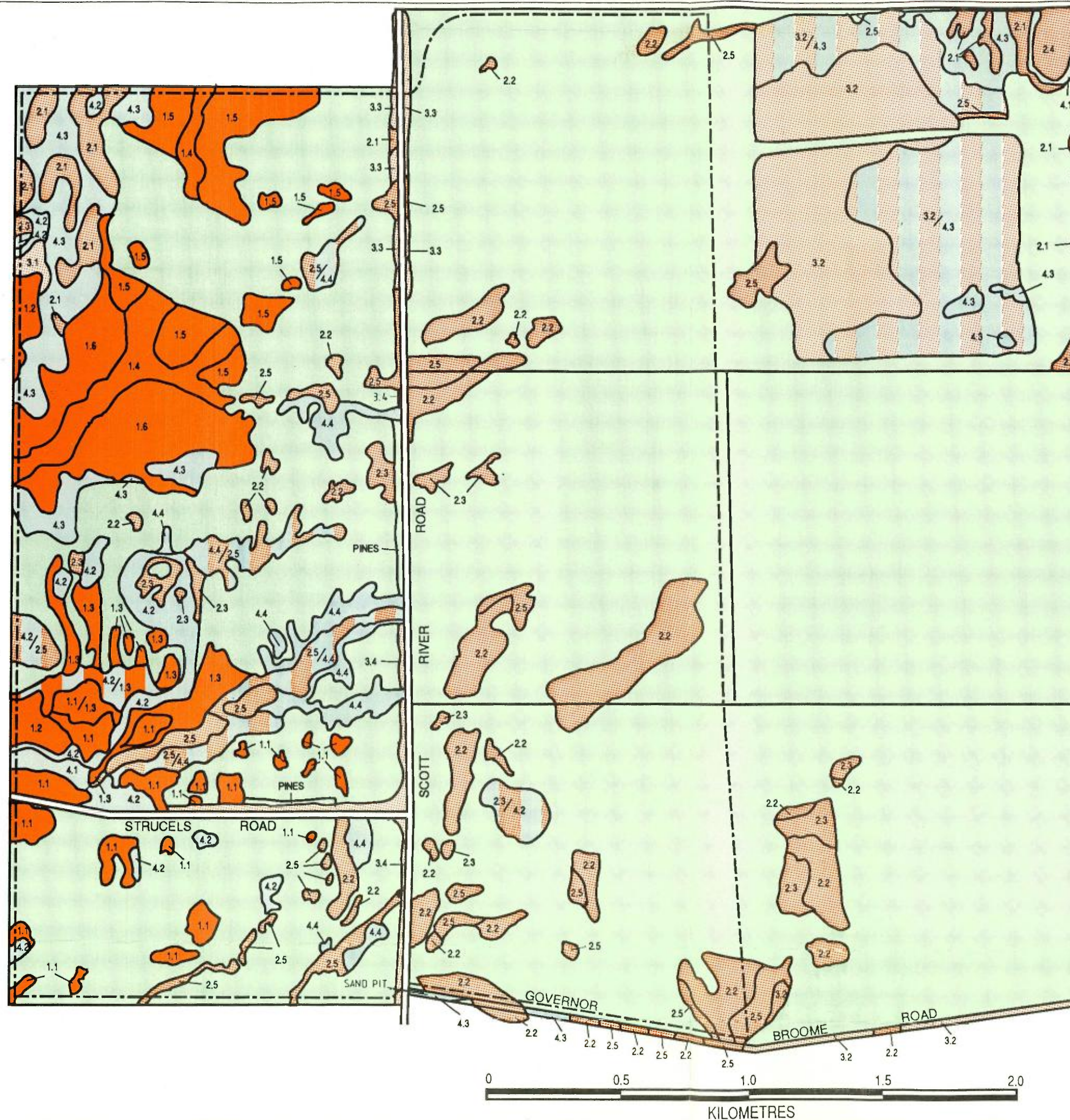
Boronia sp. nov. (360, 378), new
species.

Verticordia lehmannii, geographically
restricted.

ANNEX VII-3

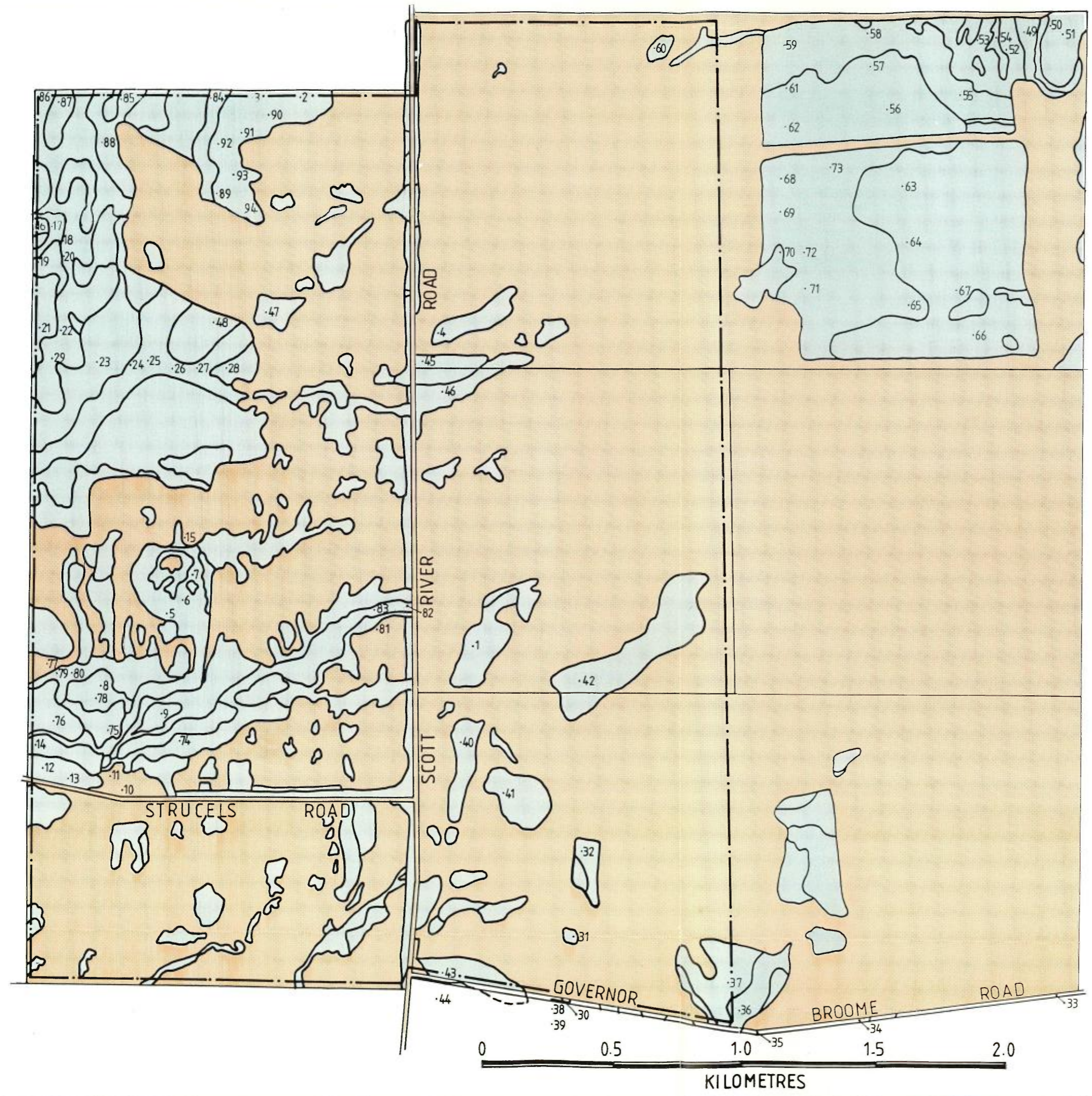
Summary of Plant Communities for the Beenup Survey Area

- Community Code:** 4.4
- Plots:** 81
- Indicator Species:** Tree Species - occasional *Melaleuca preissiana* and *Banksia littoralis*.
- Understorey Species - *Agonis juniperina*, *Agonis linearifolia*, Genus nov. (aff. *Loxocarya* sp.), *Holcus lanatus*, *Juncus pallidus*, *Triglochin procera* and *Xanthorrhoea preissii* (Appendix B).
- Species Richness:** 14 Native Species
10 Introduced Species
24 Species
- Composition:** Sedgeland of *Juncus pallidus*.
- Topography & Soils:** On dark brown and brown sands on the edges of the drainage lines and swamps.
- Other:** This community is relatively widespread in the survey area, and has been severely affected by past clearing and agricultural activities.
- Species Conservation Status:**
Species of Interest:
Genus nov. (aff. *Loxocarya* sp.),
recently described genus, unpublished.



- 1.1** OPEN FOREST OF EUCALYPTUS MARGINATA - EUCALYPTUS CALOPHYLLA.
- 1.2** WOODLAND OF EUCALYPTUS MARGINATA - EUCALYPTUS CALOPHYLLA - BANKSIA SPP.
- 1.3** OPEN FOREST OF EUCALYPTUS MARGINATA - EUCALYPTUS CALOPHYLLA - EUCALYPTUS PATENS.
- 1.4** OPEN FOREST OF EUCALYPTUS MARGINATA - EUCALYPTUS PATENS - BANKSIA LITTORALIS.
- 1.5** OPEN FOREST EUCALYPTUS MARGINATA - EUCALYPTUS CALOPHYLLA - MELALEUCA PREISSIANA.
- 1.6** OPEN FOREST OF EUCALYPTUS MARGINATA - EUCALYPTUS CALOPHYLLA - AGONIS FLEXUOSA.
- 2.1** LOW OPEN WOODLAND OF BANKSIA ATTENUATA - BANKSIA ILCIFOLIA - EUCALYPTUS MARGINATA.
- 2.2** LOW WOODLAND OF AGONIS FLEXUOSA - BANKSIA ILCIFOLIA - EUCALYPTUS MARGINATA.
- 2.3** LOW OPEN WOODLAND OF MELALEUCA PREISSIANA.
- 2.4** LOW OPEN FOREST OF MELALEUCA PREISSIANA - AGONIS JUNIPERINA.
- 2.5** LOW OPEN WOODLAND OF MELALEUCA PREISSIANA AGONIS SPP.
- 3.1** OPEN HEATH OF BANKSIA OCCIDENTALIS.
- 3.2** CLOSED HEATH TO SCRUB OF MIXED PROTEACEAE - MYRTACEAE SPP.
- 3.3** OPEN HEATH OF MIXED PROTEACEAE - MYRTACEAE SPP., MODIFIED ROAD VERGE.
- 3.4** OPEN HEATH OF MIXED MYRTACEAE SPP, MODIFIED ROAD VERGE.
- 4.1** TALL SEDGELANDS OF LEPTOCARPUS SPP.
- 4.2** SEDGELANDS OF LEPTOCARPUS SPP.
- 4.3** LOW SEDGELANDS OF CYPERACEAE - RESTIONACEAE SPP.
- 4.4** SEDGELANDS OF JUNCUS PALLIDUS.
- CLEARED**
- MINING AREA**

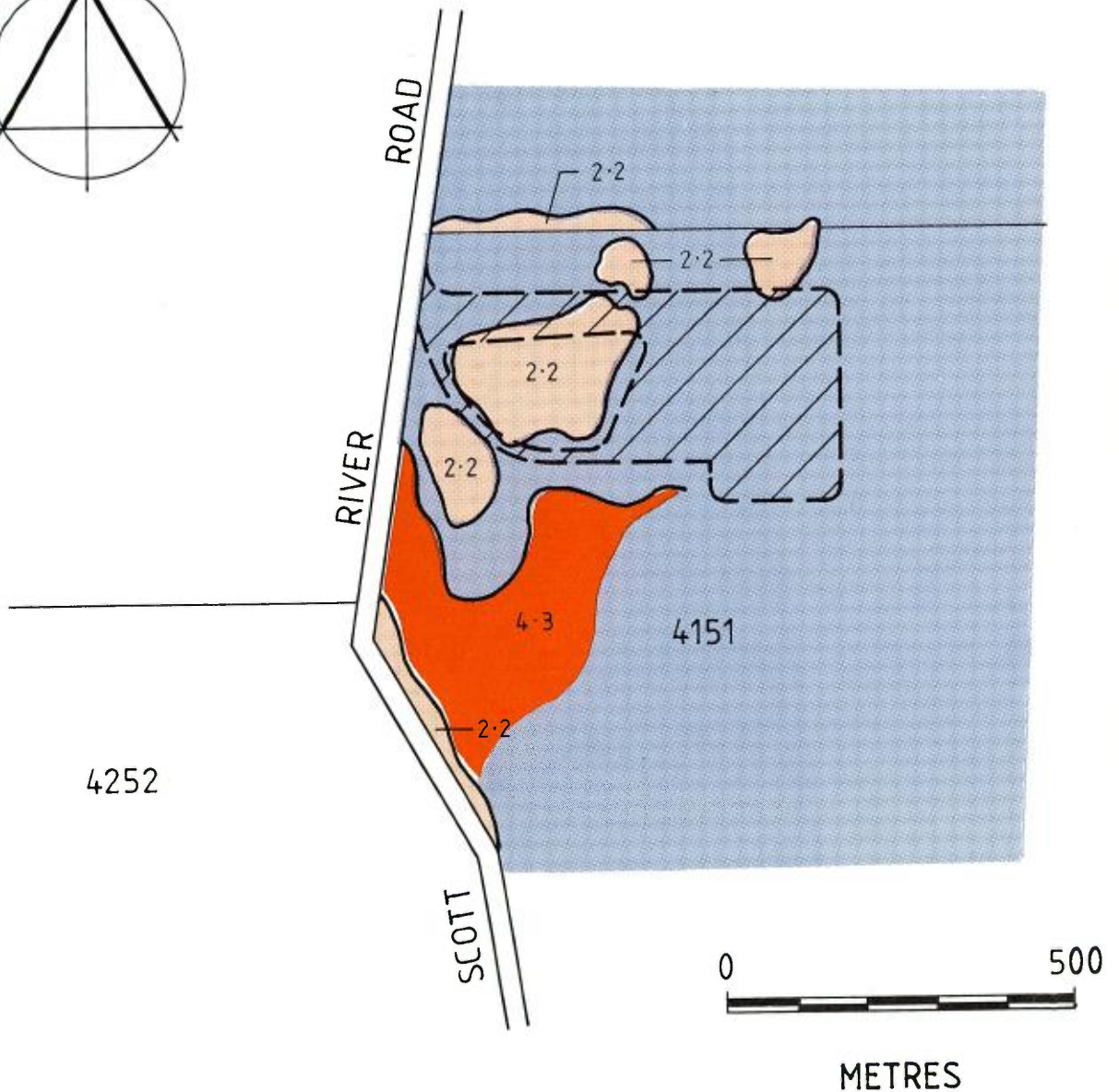
FIGURE VII-1
Vegetation



Legend

- 1 - 94 VEGETATION PLOT SITES
- REMNAANT UNCLEARED AND SEMI-CLEARED VEGETATION
- MINING AREA

FIGURE VII - 2
 Vegetation Plot Sites







-  2.2 LOW WOODLAND OF AGONIS FLEXUOSA - BANKSIA ILICIFOLIA - EUCALYPTUS MARGINATA
-  4.3 LOW SEDGELANDS OF CYPERACEAE - RESTIONACEAE SPP.
-  CLEARED
-  AREA OF DISTURBANCE

FIGURE VII-3
Vegetation, Dry Mill and Office Site

Appendix VIII

TERRESTRIAL VERTEBRATE FAUNA

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REFERENCES

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The assistance of G. Harold during the reconnaissance trip in June and the December field work is gratefully acknowledged. His expert knowledge of the distribution of amphibians and reptiles and his survey experience in the Scott River Plains greatly facilitated the compilation of predicted species lists for the study area. We are grateful to Dr. R.A. How and Mr. J. Dell of the Western Australian Museum who kindly allowed us access to their unpublished bird notes from a series of vertebrate fauna surveys of the coastal areas between Busselton and Albany. Their data specifically referring to the Beenup area were invaluable. We wish to thank E. Cannella for freely giving his assistance during the main survey period.

TERRESTRIAL VERTEBRATE FAUNA

by

Ninox Wildlife Consulting

1.0 INTRODUCTION

This report provides a detailed assessment of the vertebrate fauna conservation status of the land within and adjacent to the Beenup heavy minerals project. It is based on a brief reconnaissance survey conducted in June 1989, an intensive, integrated flora, vegetation and vertebrate fauna survey in late September/October, and an opportunistic summer assessment in mid-December of the same year.

1.1 ZOOGEOGRAPHY OF THE REGION

In any assessment of the significance of an area to fauna it is important that zoogeographic considerations are reviewed. A pioneer in this field was Baldwin Spencer (1896) who recognised three major, distinct, zoogeographic sub-regions in Australia. His concept took into account broad faunal distribution patterns which aligned fairly well with the wetter south-eastern zone of Australia (Bassian Sub-region), the northern, hot, wet, coastal area (Torresian Sub-region), and inland, arid Australia (Eyrean Sub-region).

Spencer's concept was carefully considered by Serventy and Whittell (1976) who examined bird distributions in Western Australia and concluded that there was a need to define a fourth, and much smaller sub-region: the south-western corner of Western Australia where an intermingling of two faunas, the Eyrean and Bassian, occurred. The Beenup project area is situated within this small south-west sub-region. The south-west of Western Australia has a number of species of vertebrates identical to those found in southern Victoria but which no longer have a continuous distribution across the continent. More importantly, however, it supports several endemic species with no equivalent populations in eastern Australia. Examples recognised by Serventy and Whittell as being of special significance are: Western Rosella *Platycercus icterotis*, Red-capped Parrot *Purpureicephalus spurius*, Baudin's Cockatoo *Calyptorhynchus baudinii*, White-breasted Robin *Eopsaltria georgiana*, Red-winged Fairy-wren *Malurus elegans*, Western Thornbill *Acanthiza inornata* and the Western Spinebill *Acanthorhynchus superciliosus*. All of these endemics have been recorded or are likely to be present in the project area (Table VIII-2, Annex VIII-2) and all have geographic ranges covering the southern portion of the State.

VIII-2

Consideration has also been given to evaluating the importance of different regions for other faunal groups. Storr (1964) confirmed that the distinctness of the south-west for reptiles paralleled the situation previously indicated for birds and believed that geographical influences, especially the presence of a large belt of forest-covered laterite, explained some of the speciation which had occurred in reptiles and frogs. The discontinuous distributions of some reptiles and birds from the Western Australian Wheatbelt to the east and the coastal plain to the west of the forested block can also be attributed to this feature. In examining the distribution patterns of south-western reptiles Chapman and Dell (1985) concluded that a previously defined south-western sub-region encompassing the area south of a line from Shark Bay to Israelite Bay was not valid since many species with wide distributions in arid Australia extended well to the west and south of this line; they instead drew attention to a much smaller region within the south-west. This area has a number of mesio-temperate elements from south-eastern Australia as well as a significant number of endemic species. Some typical examples of the latter are *Leiopisma trilineatum*, *Ctenotus labillardieri*, several snakes from the genera *Notechis* and *Rhinoplocephalus* and the frog genera *Crinia* and *Ranidella*. Representatives of all of these and several other endemics were recorded during the fauna surveys of the Beenup project area and all have distribution patterns limited to the higher rainfall, southern portion of Western Australia.

Several mammals are also endemic to the south-west. In many cases they do not fit into the south-western sub-region outlined for reptiles but have a larger distribution defined by the previously mentioned line from Shark Bay to Israelite Bay. Examples of these are the Brush Wallaby *Macropus irma* and the Honey Possum *Tarsipes rostratus*, both of which were recorded during this study. Others are restricted to the south-west sub-region either because of their specialised habitat requirements or because their geographic range has contracted since European settlement.

Heavier rainfall coupled with a higher clay content in the soil has resulted in denser understoreys in the Warren sub-district of the South-West Botanical Province (Beard 1977). This, and other influencing factors, has produced a fauna peculiarly adapted to an unique environment (Mulcahy 1980). The south-west of Western Australia, particularly the heavier forested portion, is therefore an area of zoogeographical significance and a number of species have evolved in its mesio-temperate environment which provided refuge as the continent became more arid. Its proximity to population centres, the presence of valuable mineral deposits, water catchments and timber resources, however, has placed this very limited area under ever increasing development pressure.

The preceding comments provide a broad perspective on the region as a whole. Specifically discussing the near-coastal portions of the lower south-west between Busselton and Albany Western Australia, a narrow strip which includes the project area, How et al. (1987), after conducting a series of vertebrate surveys for the

W.A. Museum and reviewing specimens in the State reference collection, considered that:

"In the last decade the region has become the focus of major developments for agriculture, mining and tourism; these have exacerbated the fragmentation of the unique landforms and biota of the region."

The above authors conclude that the mammal and bird faunas of coastal and near-coastal areas between Busselton and Albany have considerably changed since European settlement, resulting in the disappearance of several species and a continuing contraction of range in others.

Their study, part of which included sampling in the Scott National Park immediately adjacent to the Beenup project area, also showed that for the reptile fauna at least, a zoogeographic boundary was apparent in the area between Margaret River and Augusta, with a northward and southward termination of the geographic range of a number of species. Such boundaries are of scientific interest since they assist in clarifying the environmental parameters influencing the geographic range of species and defining habitats of special significance to fauna.

These findings have important implications for the Beenup mineral sands project because of its position on this zoogeographical boundary and the documented faunal attrition which has taken place in the south-western sub-region as a direct result of clearing since European settlement. In addition, the importance of vegetated remnants to native vertebrates has attracted much attention in recent years (Saunders et al. 1987; Breckwoldt 1986) and because of this, the significance of these remaining fragments in proposed development sites such as the Beenup project area has, and will continue to require attention during the statutory environmental review process.

The following terrestrial vertebrate fauna report is structured to deal with these specific aspects and provide a realistic management framework within which any potentially adverse impacts of the project can be anticipated and minimised.

1.2 STUDY OBJECTIVES

The primary objectives of the terrestrial vertebrate fauna survey of the project area were to:

- (1) produce an inventory of the vertebrate fauna of the area and, based on the habitats present, a provisional list of unrecorded species;
- (2) assess the conservation significance of the fauna on a regional and local basis;

- (3) give particular attention to species declared rare under Schedules 1 and 2 of the Western Australian Wildlife Conservation Act;
- (4) relate the fauna recorded to the major vegetation types of the area;
- (5) where possible, carry out systematic data collection from representative sites to allow for valid statistical comparisons between the various habitats;
- (6) compare faunal habitats i.e. vegetation and soil types, in terms of their fauna species richness and abundance;
- (7) by means of site inspections, assess the similarity and conservation status of fauna habitats in nearby areas;
- (8) assess the potential impact of mining activity on the fauna of the area and define locations of particular concern;
- (9) review methods whereby the impact of mining activity can be minimised.

2.0 METHODS

A reconnaissance survey of the Beenup project area was conducted on June 5 and 6, 1989 with intensive vertebrate studies taking place between September 25 and October 6, 1989. An opportunistic summer survey was commissioned from December 16 to December 21 of the same year.

During the intensive sampling period in September/October, two skilled field observers carried out systematic bird censusing along fixed transects and a general assistant serviced the terrestrial vertebrate traplines. Inventory sampling was carried out opportunistically by all field personnel including members of the flora and vegetation team. For reasons of efficiency and relevance to conservation, sampling focused on areas of remnant vegetation rather than on pasture. The depauperate nature of cleared land is well recognised and it was therefore considered that this habitat, which represents some two thirds of the study area, did not warrant detailed sampling sites. Opportunistic sampling in this habitat, however, was conducted on a daily basis.

In the following description of sampling methods there are two categories of data collection: Census Sampling and Inventory Sampling. Census Sampling refers to data systematically gathered during the main survey period over a fixed time in an area of known size and of a discrete vegetation type. These locations have been called Intensive Study Areas (ISA's). The resulting information, specifically

bird densities, has been used as a standardised base for statistical site comparisons within the project area.

Inventory Sampling includes all opportunistically gathered, non-systematic data such as that recorded during the reconnaissance period, the opportunistic summer survey, transect/trapline establishment or while team members were traversing the study area. Thirty-two Opportunistic Sampling Areas (OSA's) were selected in order to assess the many remnant patches of vegetation, variations on the vegetation associations chosen as Intensive Sampling Areas and the extensive areas of pasture. These are shown in Figure VIII-1. The combined results of systematic and inventory sampling have been used to produce an inventory of the fauna of the study area (Table VIII-2). Annex VIII-2 provides a list of unrecorded species expected to occur within the proposed mining area.

2.1 CENSUS SAMPLING - BIRDS

Depending on the size of an individual vegetation remnant, a minimum of two and a maximum of four 200m bird sampling transects were established in each of the six Intensive Sampling Areas (ISA's) shown in Figure VIII-1 and briefly described in Annex VIII-1. A total of 21 replicate transects were marked out. Weather permitting, each group of transects was sampled on consecutive days for five days between 0700hrs and 1200hrs, with a minimum of 45 minutes being spent in each ISA during individual sampling periods. Two observers were rotated between transects and sampling times were staggered to minimise variations in observer bias, weather and peak activity periods. Observers slowly moved along each transect and noted all bird species within five 10m distance categories either side of the transect centreline, effectively sampling 10 hectares of habitat in five days. (One 200 X 100m transect sampled five times equals 10ha.). Information such as species, number of individuals, distance of the birds from the observer, breeding activity, feeding behaviour and plant species utilised were logged on to field data sheets for future analysis.

This technique is known as the "strip transect method" and its applications are fully described in Emlen (1971) and Harden et al. (1986). Censusing methods such as these are designed to estimate the density per unit area of the "effective limits" of observation which varies between bird species and from habitat to habitat. These variations are a result of differing bird sizes, behaviour and the effect of vegetation structure on line of sight. The technique allows a more effective standardisation of such variables.

2.2 BIRD DATA ANALYSIS

Raw data made up of the bird observations recorded in the five distance categories either side of the transect centreline were processed by a computer programme which is structured to define the optimum limits of observation for individual species and calculate the density per unit area from this point back to the observer. The combined density figures for each species in each set of ISA transects were introduced into a hierarchical clustering analysis to define site affinities based on the species recorded and their relative site densities. The Modified Sorensen Coefficient (Southwood 1978) was the algorithm used.

2.3 INVENTORY SAMPLING - BIRDS

All opportunistic bird sightings outside of systematic transect sampling were recorded and added to an inventory listing. Included in this data were records from habitats such as farmland, road verges and wetlands both within and adjacent to the project area. Data from the reconnaissance survey and the opportunistic follow-up work in summer are also included.

2.4 INVENTORY SAMPLING - OTHER TERRESTRIAL VERTEBRATES

The original intention during the September/October intensive survey period was to sample mammals, amphibians and reptiles in a strictly systematic fashion by establishing two replicate traplines in each of the six major habitat types of the proposed mining area. These were to be monitored over a six day period and the results included in a statistical analysis. However, the presence of shallow ironstone cap rock in some locations and an extremely high water table in others precluded a systematic approach to sampling although, where possible, equal effort was applied. In addition, consistently poor weather conditions such as hail, rain and gales strongly influenced trap results and a decision was made to extend the main sampling period beyond the originally scheduled six days to increase returns. Details on trapping effort are given in Table VIII-1.

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TABLE VIII-1

Summary of trapping effort in the Beenup project area during September/October 1989. The number of trap nights in Intensive Sampling Areas only are shown.

INTENSIVE SAMPLING AREA	1	2	3	4	5	6	TOTAL
TYPE OF TRAP							
PIT TRAP	90	80	-	80	70	70	390
ELLIOTT TRAP	135	120	120	120	105	105	705
CAGE TRAP	9	8	8	8	7	7	47
BAT TRAP	-	-	-	-	-	7	7
TOTAL	234	208	128	208	182	189	1149

Where ground conditions allowed, each trapping site consisted of two sets of five 20 litre plastic pitfall traps connected and bisected across the top by 30 metre fly-wire drift fences 200mm high. Ten medium Elliott box traps (320 x 100 x 100mm) and one Tomahawk cage trap (660 x 250 x 250mm) were placed between the two pitfall lines. All traps were baited and their location marked with plastic flagging tape. Traplines were cleared each morning and all animals identified, marked and released.

Two extended spotlight sampling runs were carried out during the reconnaissance survey in June 1989. However, it was only possible to conduct one night of mist netting and head torching in the main September/October survey because of the constant rain and wind. Bats, nocturnal birds and geckos are rarely active in these conditions and the reflections from raindrops and wet foliage makes head torching for the occasional straggler virtually impossible. An automatic bat trap was established at the forested site ISA-6 and operated without results for seven days, highlighting the poor sampling conditions. This lack of nocturnal sampling was addressed during the opportunistic summer sampling period when 120 metres of mist net were established at ISA-3 and ISA-6 for two nights. The automatic bat trap was set at the latter site for four nights and all six Intensive Sampling Areas were head torched for a minimum of two personnel hours.

A minimum of five personnel hours was spent in each of the six ISA's during the main sampling period when intensive, diurnal hand-foraging for vertebrates was conducted. Techniques included identification of active animals, raking bulldozer spoil heaps, abandoned ant nests and deep leaf litter, turning over rocks and logs,

stripping bark from dead trees, investigating burrow systems and recording tracks or scats. An appraisal of vertebrate micro-habitat habitat quality and critical resources was conducted in order to facilitate the production of a list of unrecorded species. This latter aspect included an assessment of the number of tree-hollows, the frequency of logs on the ground, leaf litter depth and distribution, the capacity of the soil to support burrows and the density of flowering shrubs.

Because of the poor weather conditions during the main sampling period, the proponents commissioned a further, opportunistic survey in mid-December, 1989. A minimum of four personnel hours were spent foraging in each Intensive Sampling Area utilising the techniques described above.

In addition to the sampling of ISA's, a series of supplementary sites representing variations on the six major fauna habitats and representative examples of wetlands, farmland and road verge were also investigated using the same foraging methods. These sites gave broad scale inventory cover of the study area, have been designated as Opportunistic Sampling Areas (OSA's) and are shown on Figure VIII-1. Three of these were sampled with partial traplines (OSA-1: 35 trap nights; OSA-2: 75 trap nights; OSA-3: 75 trap nights).

2.5 ASSESSMENT OF ADJACENT AREAS

In order to place the mining area into a broader local perspective, a series of adjacent areas were inspected and assessed by means of a series of vehicle and foot traverses. Principal among these in terms of the amount of time spent in assessment were the Scott National Park, Camping Reserve 12951 and the largely uncleared area of private land to the north-east of the mining area, Location 4255. All of these locations were presumed to have a higher conservation value because of their relatively intact native vegetation.

The following areas of adjacent land were also assessed in less detail since they are mainly cleared farmland: Locations 4258, 4256, 4253, 4152. Visits to these areas, especially the principal sites, took place during all sampling periods and a total of five personnel days were allocated to this assessment.

2.5.1 Dry mill and office site

The dry mill, office site and its environs were assessed on December 20, 1989. The techniques used are described in Section 2.4. Four personnel hours were spent in this limited area.

2.6 NOMENCLATURE AND TAXONOMY

Nomenclature and taxonomy in this report follow: Blakers et al. (1984); Strahan (1983); Storr et al. (1981, 1983, 1986) and Tyler et al. (1984).

3.0 RESULTS

In the following table the results of systematic and inventory studies within the project area have been combined in order to present in a single list all species recorded during the surveys. Because major differences in faunal communities usually occur in response to gross physiographical changes such as the presence of wetlands and major variations in substrate, rather than minor changes in vegetation communities, it is possible to structurally group broad habitat categories as shown in Table VIII-2. This facilitates extrapolation to nearby areas outside the actual minesite, particularly structurally similar remnants of native vegetation, all of which fall within the categories listed below. For a discussion and assessment of these adjacent sites including habitats not represented in the project area, see Section 4.0.

More detailed data such as the absolute numbers of vertebrates recorded, bird densities in sampling sites, bird breeding records and predicted species lists for the project area are presented in text or as annexes to this report.

TABLE VIII-2

Inventory of vertebrates recorded in the fauna habitats of the Beenup project area between June 5 and 6, September 25 to October 6, and December 16 to 21, 1989.

KEY

X = Species recorded within Intensive Sampling Areas

* = Species recorded within Opportunistic Sampling Areas

**FAUNA
HABITAT****DESCRIPTION**

1	Tall Eucalypt forests (includes ISA-4, ISA-6)
2	Low woodlands dominated by <i>Banksia</i> species and/or <i>Agonis flexuosa</i> (includes ISA-1, ISA-2)
3	Heathlands (includes ISA-3, ISA-5)
4	Wetlands (swamps, creeks, temporary pools)
5	Road verge (undifferentiated habitats)
6	Farmland

HABITAT TYPE	1	2	3	4	5	6
BIRD SPECIES						
DROMAIIDAE						
Emu		*		X		*
PHALACROCORACIDAE						
Little Pied Cormorant				*	*	*
ARDEIDAE						
Pacific Heron		*	*		*	
White-faced Heron	X		X		*	*
PLATALEIDAE						
Straw-necked Ibis		*			*	
Royal Spoonbill				*		

HABITAT TYPE	1	2	3	4	5	6
BIRD SPECIES - Contd.						
ANATIDAE						
Australian Shelduck						*
Pacific Black Duck		*		*	*	*
Maned Duck	X		X			*
ACCIPITRIDAE						
White-bellied Sea-Eagle		*				
Wedge-tailed Eagle			*			*
Marsh Harrier						*
FALCONIDAE						
Peregrine Falcon			X			
Australian Hobby	X					
Brown Falcon		X				*
Australian Kestrel	X		X		*	*
PHASIANIDAE						
Brown Quail			*		*	
COLUMBIDAE						
Common Bronzewing	X	X	X	*	*	*
CACATUIDAE						
Red-tailed Black-Cockatoo	X					
White-tailed Black-Cockatoo	X	X	X			
LORIIDAE						
Purple-crowned Lorikeet						*
PLATYCERCIDAE						
Western Rosella	X	X		*		*
Port Lincoln Ringneck	X	X	X	*	*	*
Elegant Parrot	X	X	*			*
CUCULIDAE						
Pallid Cuckoo	X	*	X			*
Fan-tailed Cuckoo	X	*	*			
Horsfield's Bronze-Cuckoo	*	*			*	
Shining Bronze-Cuckoo	X	X	X	*		

HABITAT TYPE	1	2	3	4	5	6
BIRD SPECIES - Contd.						
PODARGIDAE						
Tawny Frogmouth	X	X				
AEGOTHELIDAE						
Australian Owlet-nightjar	X					
ALCEDINIDAE						
Laughing Kookaburra	X	X		*	*	
Sacred Kingfisher	X	*				
HIRUNDINIDAE						
Welcome Swallow			X		*	*
Tree Martin	X	X	*		*	*
MOTACILLIDAE						
Richard's Pipit			X		*	*
CAMPEPHAGIDAE						
Black-faced Cuckoo-shrike	X	X	X	*	*	*
White-winged Triller	X				*	*
MUSCICAPIDAE						
Scarlet Robin	X					
White-breasted Robin	X					
Golden Whistler	X	X	X			
Rufous Whistler	X	X				
Grey Shrike-thrush	X					
Grey Fantail	X	X	X	*		
Willie Wagtail	X	X			*	*
SYLVIIDAE						
Little Grassbird				*		
Rufous Songlark			X			*
Brown Songlark						*
MALURIDAE						
Splendid Fairy-wren	X	X	X		*	*
Red-winged Fairy-wren	X		X	*		
Southern Emu-wren	X		X			

HABITAT TYPE	1	2	3	4	5	6
BIRD SPECIES - Contd.						
ACANTHIZIDAE						
White-browed Scrubwren	X	X	X	*		
Western Gerygone	X	*				
Inland Thornbill	X	X	X			
Western Thornbill	X	X				
Yellow-rumped Thornbill	X	X	X		*	*
NEOSITTIDAE						
Varied Sittella	X					
MELIPHAGIDAE						
Red Wattlebird	X	X	X	*	*	
Little Wattlebird	X	X		*		
White-naped Honeyeater	X					
Brown Honeyeater	X	X				
New Holland Honeyeater	X	X	X			
White-cheeked Honeyeater	X					
Tawny-crowned Honeyeater	X	X				
Western Spinebill	X	X	X	*		
EPHETHIANURIDAE						
White-fronted Chat	X	X	X		*	*
PARDALOTIDAE						
Spotted Pardalote	X			*		
Striated Pardalote	X		X			
ZOSTEROPIDAE						
Silvereye	X	X	X		*	
PLOCEIDAE						
Red-eared Firetail			X			
GRALLINIDAE						
Australian Magpie-lark	X	X	X		*	*
ARTAMIDAE						
Dusky Woodswallow	X	X	X		*	*
Black-faced Woodswallow	X				*	

HABITAT TYPE	1	2	3	4	5	6
BIRD SPECIES - Contd.						
CRACTICIDAE						
Grey Butcherbird	X	X	X		*	*
Australian Magpie	X	*	X	*		*
Grey Currawong		X				
CORVIDAE						
Australian Raven	X	X	X		*	*
MAMMAL SPECIES						
TACHYGLOSSIDAE						
Short-beaked Echidna	X					
DASYURIDAE						
Common Dunnart	X					
PERAMELIDAE						
Southern Brown Bandicoot	*	X	X			
TARSIPEDIDAE						
Honey-possum			X			
MACROPODIDAE						
Western Brush Wallaby			X			
Western Grey Kangaroo	X	X	X	*	*	*
VESPERTILIONIDAE						
Lesser Long-eared Bat	*					
Chalinolobus morio	X					
Eptesicus regulus	X					
MURIDAE						
Water-rat			X			
Bush Rat	X	X	X	*		
Black Rat				*		
House Mouse			X			*
LEPORIDAE						
Rabbit	*	X	X	*	*	*

HABITAT TYPE	1	2	3	4	5	6
MAMMAL SPECIES - Contd.						
CANIDAE						
Fox	X	X	X	*	*	*
FELIDAE						
Feral Cat			X		*	
BOVIDAE						
Domestic Cattle		*	*			*
Sheep						*
AMPHIBIAN AND REPTILE SPECIES						
LEPTODACTYLIDAE - Frogs						
<i>Crinia georgiana</i>	X	X	X	*		
<i>Geocrinia leai</i>	*			*		
<i>Heleioporus psammophilus</i>	X	X	X		*	
<i>Limnodynastes dorsalis</i>		X			*	
<i>Pseudophryne guentheri</i>	X					
<i>Ranidella glauerti</i>	X	X	X	*		
<i>R. pseudinsignifera</i>	X	X	X	*	*	
HYLIDAE						
<i>Litoria adelaidensis</i>	X		X	*		
GEKKONIDAE - Geckos						
<i>Phyllodactylus m. marmoratus</i>	X	X	X			
PYGOPODIDAE - Legless Lizards						
<i>Pygopus lepidopodus</i>			X			
SCINCIDAE - Skinks						
<i>Ctenotus catenifer</i>		X	X			
<i>C. labillardieri</i>	X	X	X			*
<i>Egernia napoleonis</i>	X	X	*			
<i>Hemiergis p. peronii</i>	X	X				
<i>Leiopisma trilineatum</i>	X	X	X			
<i>Lerista microtis</i>	*					
<i>Sphenomorphus australis</i>			X			
<i>Tiliqua r. rugosa</i>	*	X	X		*	

HABITAT TYPE	1	2	3	4	5	6	
AMPHIBIAN AND REPTILE SPECIES - Contd.							
TYPHLOPIDAE - Blind Snakes							
Ramphotyphlops australis	*	X	X				
ELAPIDAE - Elapid Snakes							
Notechis coronatus	X	X	X				
N. scutatus occidentalis	*		*		*		
Pseudonaja a. affinis		X	X		*		
Rhinoplocephalus bicolor	X	X	X				
<u>SUMMARY OF TABLE VIII-2</u>			<u>NUMBER OF SPECIES</u>				
Birds		52	44	43	18	26	33
Native Mammals		8	3	6	2	1	1
Introduced Mammals		2	3	5	3	3	5
Amphibians		7	5	5	5	3	-
Reptiles		11	11	13	-	3	1
TOTAL SPECIES RICHNESS		80	66	72	28	36	40

3.1 BIRDS

3.1.1 Distribution Patterns

Seventy-six species of birds were recorded in the project area during this study (Table VIII-2). Based on the current distribution patterns shown in Blakers et al. (1984) and the available habitats within the mining area, a further 34 species can be expected. Annex VIII-2 shows that 21 of these predicted species have been recorded in the narrow coastal strip between Augusta and Northcliffe (How et al. 1987, Christensen *et al.* 1985, Martinick and Associates 1989) and are almost certainly present within the mining area. Three of these: Southern Boobook *Ninox novaeseelandiae* Western Yellow Robin *Eopsaltria australia* and Rufous Treecreeper *Climacteris rufa* were recorded 500 metres west of the mining area in Location 4256 during the summer survey suggesting that with longer term seasonal studies the number of species is likely to slowly rise.

The remaining 13 species have geographic ranges which include the project area and, while there is some uncertainty about the local status of birds such as the Great Egret, Barn Owl, and Restless Flycatcher, it is highly probable that these birds would eventually be recorded given several years of seasonal sampling. Apart from the declared rare species discussed in Section 5.1, none of the birds recorded or expected to occur in the project area are of particular conservation significance. Most have distribution patterns covering the southern portions of the State and in some cases, most of Australia.

In summarising other survey work, species with a preference for seashores, large bodies of permanent water, Karri forest and Wandoo woodland have been excluded since these habitats and several other minor elements are not present within the study area. Typical examples of the birds involved are: Curlew Sandpiper *Calidris ferruginea* Chestnut Teal *Anas castanea* White-browed Babbler *Pomatostomus superciliosus* and the rare and endangered Crested Shrike-tit *Falcunculus frontatus*.

3.1.2 Species Richness

This analysis is based on systematic transect studies in the six representative vegetation types chosen for detailed study. Brief descriptions of these Intensive Sampling Areas are given in Annex VIII-1 (this report) and can be expanded by referring to Flora and Vegetation (Appendix VII).

The two extensive Jarrah/Yarri *Eucalyptus marginata/E. patens* open forest sites (ISA-4, ISA-6) had the highest bird species richness because of their structural complexity and connection with larger areas of similar habitat (Figure VII-1, Flora and Vegetation). These habitats had 32 and 28 species respectively. ISA-1, the isolated patch of Holly-leaf Banksia *Banksia ilicifolia* low woodland followed with 23 species, a surprisingly high figure considering it was only about four hectares in area. The floristically rich lateritic open heath/scrub (ISA-3) ranked next with 18 species, closely followed by ISA-2, the low open woodland of *Banksia attenuata* on dunes with associated swales which supported 17 species. The open heath/sedgeland on sands, ISA-5, where only 13 species were recorded, was the poorest site.

3.1.3 Abundance

The results from the analysis of bird densities for individual species in each site are given in Table VIII-3 and have been converted to the number of birds per 10 hectares for ease of reference. Table VIII-4 summarises these data and ranks the combined densities for all bird species in each site.

TABLE VIII-3

Bird density figures per 10 hectares for the results from Intensive Sampling Areas in the Beenup project area during September/October 1989. (Brief descriptions of vegetation communities are given in Annex VIII-1 and can be expanded by reference to Appendix VII, Flora and Vegetation).

INTENSIVE SAMPLING AREA	1	2	3	4	5	6
BIRD SPECIES						
ARDEIDAE						
White-faced Heron					1.3	
ANATIDAE						
Maned Duck			1.3	0.6		
FALCONIDAE						
Australian Kestrel			0.6	0.9		
COLUMBIDAE						
Common Bronzewing				1.3		2.5
CACATUIDAE						
Red-tailed Black-Cockatoo						12.5
White-tailed Black-Cockatoo		1.7			0.8	
PLATYCERCIDAE						
Western Rosella	27.5			5.6		6.3
Port Lincoln Ringneck	8.8	23.3		17.5	0.6	1.5
Elegant Parrot	1.3	0.8				
CUCULIDAE						
Pallid Cuckoo			0.3			0.5
Fan-tailed Cuckoo				0.3		0.6
Shining Bronze-Cuckoo	2.5		0.5	1.5		0.6
PODARGIDAE						
Tawny Frogmouth	7.5					
ALCEDINIDAE						
Laughing Kookaburra	0.8			0.8		1.3
Sacred Kingfisher				0.3		

INTENSIVE SAMPLING AREA	1	2	3	4	5	6
BIRD SPECIES - Contd.						
HIRUNDINIDAE						
Tree Martin	5.8			37.5		5.0
MOTACILLIDAE						
Richard's Pipit					0.3	
CAMPEPHAGIDAE						
Black-faced Cuckoo-shrike	3.8	3.3	2.5	0.8		0.6
MUSCICAPIDAE						
Scarlet Robin						2.5
White-breasted Robin				1.3		1.3
Golden Whistler	5.0			1.6		3.3
Rufous Whistler	5.0			1.3		
Grey Shrike-thrush				0.8		0.3
Grey Fantail	7.5	1.7		11.3	0.3	12.5
Willie Wagtail	0.8			8.8		
MALURIDAE						
Splendid Fairy-wren	5.0	2.2		1.3		
Red-winged Fairy-wren				4.2	1.9	18.8
Southern Emu-wren				1.3	2.5	
ACANTHIZIDAE						
White-browed Scrubwren	7.5	3.3	10.0	2.1	0.3	3.8
Western Gerygone						2.1
Inland Thornbill	10.0	1.7	3.1	3.1		1.9
Western Thornbill	2.5			8.8		
Yellow-rumped Thornbill	72.5	1.7		2.5		18.8
NEOSITTIDAE						
Varied Sittella				12.5		0.8
MELIPHAGIDAE						
Red Wattlebird	30.0	33.3	6.3	3.3		
White-naped Honeyeater						1.3
Brown Honeyeater			0.3	1.3		
New Holland Honeyeater	57.5	6.7	28.8			12.5
White-cheeked Honeyeater			0.3			

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INTENSIVE SAMPLING AREA	1	2	3	4	5	6
BIRD SPECIES - Contd.						
Tawny-crowned Honeyeater	6.7	6.9				
Western Spinebill	6.7	2.5	5.0			6.3
EPHTHIANURIDAE						
White-fronted Chat	1.7	1.3				
PARDALOTIDAE						
Spotted Pardalote						0.6
Striated Pardalote					1.3	3.8
ZOSTEROPIDAE						
Silvereye	5.0	8.8	5.0			7.5
GRALLINIDAE						
Australian Magpie-lark	1.3	0.8	0.4			
ARTAMIDAE						
Dusky Woodswallow	5.0	2.5	13.8	1.7		
CRACTICIDAE						
Grey Butcherbird					0.6	
Australian Magpie			1.3	3.8		
Grey Currawong	0.3					
CORVIDAE						
Australian Raven	5.0	16.7	0.5	0.4	2.5	0.8
TOTAL PER 10HA	274.3	114.0	79.7	157.2	17.9	130.3

TABLE VIII-4

Ranking of Intensive Sampling Areas based on the density of birds per 10 hectares recorded in each.

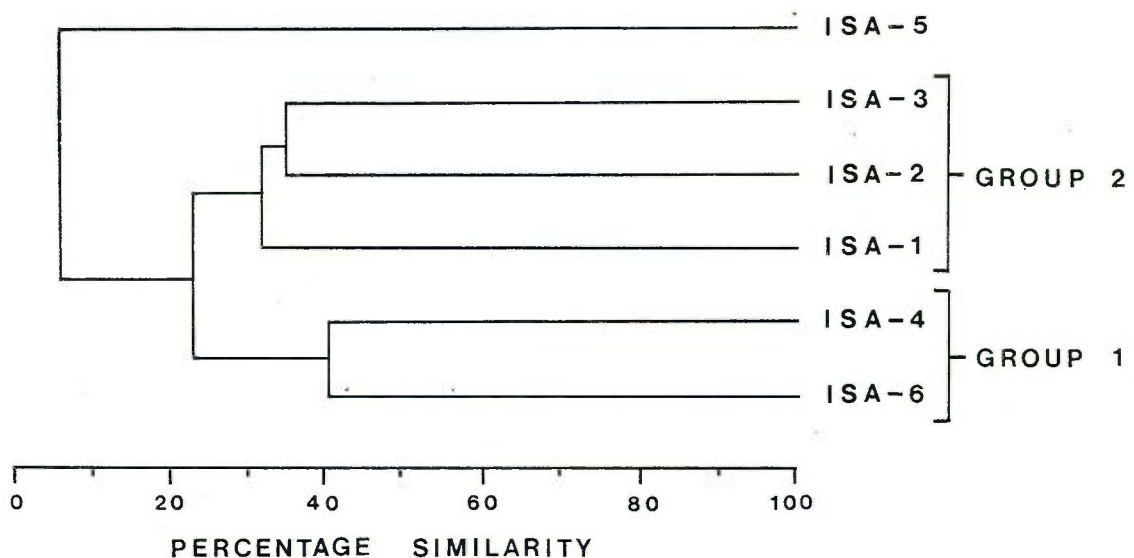
ISA CODE	DENSITY	RANK
ISA-1	274.3	1
ISA-4	157.2	2
ISA-6	130.3	3
ISA-2	114.0	4
ISA-3	79.7	5
ISA-5	17.9	6

3.1.4 Community Analysis

Introducing the bird density figures listed in Table VIII-3 into a clustering matrix gives the three loose community groupings shown below.

FIGURE VIII-2

Classificatory dendrogram of six bird census sites in the Beenup project area (Modified Sorensen Coefficient).



Group 1, the Eucalypt open forests ISA-4 and ISA-6 are most similar in their bird species composition and density figures. Group 2 consists of the low woodland and taller heath sites ISA-1, 2 and 3. The open heath/sedgeland site ISA-5 was seasonally unproductive, structurally simple and as a result, differs substantially from all other sites.

Group 1 are similar in vegetation structure in that they are both Eucalypt open forest dissected by well-vegetated stream zones. They are also connected to other areas of native vegetation as shown in Figure VII-1 (Flora and Vegetation) and are evidently advantaged by this proximity which allows fauna to freely move throughout the area without crossing extensive areas of open ground. This situation particularly facilitates movement of small territorial birds since it provides better protection from predators. Seasonal transect studies would almost certainly result in these two forest habitats aligning more closely in terms of their species composition, although their density figures could still differ as a result of ISA-6 being less disturbed than ISA-4 which has been heavily logged. These two sites have relatively low densities of nectivorous birds in comparison to floriferous Banksia woodlands, but support many representatives of the insectivorous group of birds usually associated with this type of forest. For example, both species of whistler were only recorded on one other woodland site (ISA-1). The White-breasted Robin, a related species, was typically and exclusively recorded close to the densely vegetated stream zones in ISA-4 and ISA-6.

Group 2 which consists of ISA-1, 2 and 3, has very loose affinities at less than 40% similarity. They are all comparatively species rich habitats (Table VIII-3) but with very different bird species densities. High numbers of individual species within the honeyeater group accounts for the linking of these sites as does the relative scarcity of Eucalypt forest species from the robin/whistler complex.

The dissimilarity of ISA-5 from all other habitats directly relates to its having a depauperate bird fauna (Table VIII-3), although this may well be a seasonal artefact since the dominant flowering shrub in this heath/sedgeland is the Red Swamp Banksia *Banksia occidentalis* which flowers from December to March. During this period it is likely that many honeyeaters and insectivorous birds will be attracted to the blossoms of this plant reflecting not only a seasonal source of nectar, but an increase in insect prey species. Many honeyeaters are highly dispersive in their habits and sequential flowering of shrubs and trees in the heaths and woodlands encourages movement by this group from one habitat to another. The high numbers of New Holland Honeyeaters and Red Wattlebirds in the small vegetated remnant ISA-1, for example, results from the heavy flowering of *Banksia ilicifolia* coinciding with the sampling period. This essentially means that the relative bird densities recorded during this single season survey are not fixed, and that seemingly unproductive habitats such as ISA-5 may well fulfill an important role at other times of the year.

Although the summer survey carried out in mid-December was opportunistic rather than systematic, it was possible to confirm this aspect. Flowering of the Holly-leaf *Banksia* in ISA-1 had nearly ended and the number of individuals of honeyeater birds was markedly reduced. Conversely, the *Banksia attenuata* at ISA-2 was flowering heavily and the number of honeyeaters was much higher than the September/October survey period, effectively fulfilling the earlier role of ISA-1.

The community dendrogram indicates that all sampling sites differ substantially in that no two habitats are more than 40% similar. Seasonal changes in flowering and insect populations could strongly influence population structure at both the species and density level, although it is likely that the essential dissimilarity of all habitats will remain.

3.1.5 Breeding

Fifteen species of bird were recorded breeding during the September/October survey period and three in the December survey. These are listed in Annex VIII-3 with accessory information. Breeding activity was observed in all sampling sites with the exception of ISA-2 and was concentrated on the woodland and forest sites ISA-1, ISA-4 and ISA-6. In the main survey period, most Passerine species (songbirds) were either constructing nests or had already laid eggs whereas Non-Passerines such as parrots were observed in the process of selecting suitable nest hollows in trees.

3.2 MAMMALS

3.2.1 Distribution Patterns

Eleven native and seven introduced species of mammal were recorded in the study area during the field surveys. These results are shown in Table VIII-2 and Annex VIII-1. None of the mammals recorded were unexpected or unusual from the area although there are some anomalies such as the absence of the Yellow-footed *Antechinus Antechinus flavipes*. A further 10 native mammals (including five species of bats) could be expected if longer term studies and saturation trapping were conducted. Most of these predicted species are expected to occur mainly in the taller *Eucalyptus* spp. forested sites such as those represented by ISA-4 and ISA-6, especially where these forest areas are contiguous with either the Scott National Park to the south-west (ISA-4) or with uncleared private land such as Location 4255 to the west of ISA-6.

3.2.2 Species Richness

This section is mainly based on results from ISA sites where effort was concentrated (Annex VIII-1) although complete assemblages of mammal

communities for each habitat have not been ascertained as yet because most species were infrequently recorded. This aspect holds true even in areas where systematic, repeated surveys over many years have taken place (Worsley Alumina Pty Ltd in prep.).

Results from the current study indicate that *Eucalyptus spp.* open forest (ISA-4 and ISA-6) and the open heath/scrub (ISA-3) are the richest in native mammals (Annex VIII-1), although long-term monitoring could alter this ranking. The Common Dunnart *Sminthopsis griseoventer* was only captured in ISA-4 and ISA-6 with two of the three specimens being females with small, hairless pouch young. The Honey Possum *Tarsipes rostratus* was captured in ISA-5 and a supplementary pit trap line (OSA-1) in a heath patch adjacent to ISA-6 (Figure VII-1, Flora and Vegetation). The Bush Rat *Rattus fuscipes* and the Grey Kangaroo *Macropus fuliginosus* were common in most of the vegetation types which were sampled. The Echidna *Tachyglossus aculeatus*, the Short-nosed Bandicoot *Isodon obesulus* and the native Water Rat *Hydromys chrysogaster* were not captured but their characteristic diggings and footprints were noted in various locations (Annex VIII-1).

3.2.3 Abundance

The Grey Kangaroo was the most frequently recorded native mammal in the study area. This animal is not confined to patches of native vegetation and consequently has a greater range and area of habitats to exploit. The Bush Rat was the most commonly captured small native mammal and was only absent from ISA-2 and ISA-5. Most individuals of this species were trapped in the lateritic heath/scrub site ISA-3. How et al. (1987) found a similar situation with the Bush Rat being the most abundant of all ground mammals trapped in their near-coastal study areas.

Rabbits *Oryctolagus cuniculus* were extremely common along vegetated road verges but there were few signs of their presence in the larger remnants of native vegetation within and beyond the project area. Other introduced mammals which were recorded were the House Mouse *Mus musculus* (ISA-3 only) and the Black Rat *Rattus rattus* which was trapped in OSA-3, a supplementary trapline placed in a swamp adjacent to ISA-2. Foxes *Vulpes vulpes* were common throughout the area.

3.3 AMPHIBIANS AND REPTILES

3.3.1 Distribution Patterns

Eight amphibian and 15 reptile species were recorded during the field surveys (Table VIII-2). Based on historical records and distribution patterns, a further four amphibians and 12 reptiles are expected to be present in the study area (Annex

VIII-2). The species shown in this list have all been previously recorded in the general area either by How *et al.* (1987), Christensen *et al.* (1985) or Martinick and Associates (1989).

Two amphibians *Ranidella glauerti*, *R. pseudinsignifera* and two reptiles *Pygopus lepidopodus*, *Rhinoplocephalus bicolor* recorded during this survey have evidently filled a distributional gap in the herptile fauna of the Scott River Plains (How *et al.* 1987). This highlights the fact that the general area has not been surveyed in any detail apart from the intensive, strictly localised work commissioned for this project. In comparison to other areas surveyed by Government instrumentalities for instance, the area remains poorly documented making realistic comparisons difficult. Within these limitations, none of the species found or expected to occur at Beenup are restricted to the Scott River Plains although many, such as the skink *Ctenotus catenifer* are at the limits of their known range.

3.3.2 Species Richness

The number of species present in each ISA varied between seven and 12 with ISA-1 and ISA-3 having 12 species and ISA-4 and ISA-6 having 11. ISA-5 was the least productive with seven species (Annex VIII-1). No pit traps were set in ISA-3 because of its underlying ironstone cap rock and with the weather conditions during the main survey period being unsuitable for nocturnal sampling, the number of frog species in this and all other sites is expected to be higher. The small, isolated patch of *B. ilicifolia* (ISA-1) was particularly rich in frog species because of its sandy soils and a nearby swamp. The Bell Frog *Litoria moorei*, a summer breeder which was not recorded, is expected to be restricted to the permanent water of farm dams.

Poor sampling conditions in the main survey period and low returns for effort in summer preclude any definitive statement on the comparative reptile assemblages of the various vegetation communities, although forested sites are probably richer because of their greater diversity of microhabitat such as fallen logs, standing dead trees and deeper, friable soils suitable for burrowing.

3.3.3 Abundance

With the exception of ISA-1, most frog species of the genus *Crinia* and *Ranidella* were extremely abundant in all habitats judging by the numbers recorded calling. The burrowing frog *Heleioporus psammophilus* was trapped most frequently in areas of sandy soils such as ISA-2. During the reconnaissance trip in June, this frog was the commonest species observed both on roads and in the sandy *Banksia* spp. woodlands of the study area. Also during the June reconnaissance trip, the small frog *Ranidella glauerti* was calling and appeared to be the most abundant frog in the area.

Many species of reptile were represented by single individuals in ISA's, with the exception of the skinks *Ctenotus labillardieri* and *Hemiergus p. peronii* which were most abundant in the *Eucalypt* forest sites ISA-4 and ISA-6. These sample sites had many fallen logs, friable soils suitable for burrowing and a dense understorey associated with a stream zone. Given long term sampling, many of the species listed as possibilities for the area (Annex VIII-2) would be located in these habitats. Hand-foraging in ISA-3 was most productive for the snake *Notechis coronatus* with 14 individuals being recorded, mainly from spoil heaps on the edge of the heath. The actual reptile fauna of this site is difficult to ascertain in the short term since high water levels and ironstone cap rock did not allow for the placement of pit traps.

4.0 ASSESSMENT OF ADJACENT AREAS

Since the proposed mining area cannot be viewed in isolation being intimately connected with two areas of reserved land and adjoining farmland which has been cleared to a greater or lesser degree, time was allocated during all surveys to assess this relationship. The summer survey allowed this aspect to be finalised in more detail since the risk of spreading dieback disease in reserved land was negligible and access along previously flooded boundaries was possible. Earlier inspections during the reconnaissance and main survey period were restricted to limited foot transects from main access routes and did not give the coverage required.

The main objective of these inspections was to assess how each location related to the proposed minesite in terms of habitat representation, conservation of species potentially affected by mining and possible impact of the project. The sampling approach taken was deemed sufficient to allow for such comparisons in that the intensive survey of the minesite and published information on the general area made extrapolation to nearby areas possible. All habitat types surveyed in the mining area were recorded beyond its boundaries and provisional species lists for these adjacent areas can be ascertained by reference to their minesite equivalents in this report. Several additional habitat types were present in adjacent locations with Karri *Eucalyptus diversicolor* forest being a typical example. Vertebrates specific to these habitats are defined in text. A description of the main areas assessed follows.

4.1 SCOTT NATIONAL PARK

Areas surveyed: vehicle transect along northern boundary south of Strucels Road and north of Scott River, with two foot transects down to the river itself; vehicle transect of north-eastern boundary between Payne and Strucels Road with two foot transects west to the Blackwood River; vehicle transect across the park along Scott River Road with excursions south to the southern boundary, north along

western boundary adjacent to Molloy Island and foot transects to several selected habitats such as Karri forest, Banksia woodland and wet heaths north of the main road; numerous spot checks.

Assessment: the park is a large area of relatively undisturbed habitat which has the capacity to support healthy populations of all the vertebrates recorded or expected to occur in the proposed mining area plus several other species adapted to specific habitats not represented at Beenup. Examples of these habitats are the dense fringing formations of the Blackwood and Scott Rivers and fairly extensive areas of Karri. Species expected to be present in the park but not at Beenup are several species of native fish, the rare Western Ringtail Possum and Crested Shrike-tit, the White-browed Babbler and possibly the Quokka.

The tall Eucalypt forest patches in the proposed mining area were found to be species rich but these habitats are well represented and in a better condition in the north-western sections of the park. Variations of Banksia woodlands on sandy ridges are also represented in the National Park but do not show the extensive cattle damage typifying these habitats in the mining area. The only mining area habitat which does not appear to be represented, although pockets may well occur in remote locations, is the wet lateritic heath/scrub. This possible absence has little bearing on vertebrate fauna since there are no species within the mining area which can be considered restricted to this habitat.

Impact: While there may be some short term, localised territorial disruption to fauna populations on the fringes of the park, brought about by displacement of more mobile species from the mining area, the overall impact is considered to be negligible. To bring this into a wider perspective, the National Park and indeed all other nearby areas of uncleared land have been subjected to the long term effects of surrounding pastoral clearing and are still in relatively good condition as fauna habitats. Mining of mainly cleared land followed by rapid rehabilitation is unlikely to have a significant, cumulative effect on this pre-existing situation since the development area is small compared to that currently being used for pastoral activity. Aspects such as the control of downstream siltation emanating from the mining area, changes to hydrology and the reduction of the risk of wildfires are addressed in other technical appendices.

4.2 CAMPING RESERVE A¹²⁹⁵¹

Areas surveyed: complete boundary circuit by vehicle; three north/south and one east/west foot transect covering the major plant communities; numerous spot checks.

Assessment: although small, the camping reserve supports a range of habitats all of which are in better condition than the bulk of the proposed mining area. Three of these are equivalent to habitats in the mining area: Jarrah/Marri forest (ISA-6);

low heath/sedgeland (ISA-5); seasonally wet lateritic heath/scrub (ISA-3). The reserve's vertebrate species potential can therefore be assessed by reference to these sites in Annex VIII-1 and it is unlikely to support any species not recorded on the proposed mining area. Populations, however, may be higher because of the lack of recent stock grazing. Apart from this, the main feature of particular conservation value is the wet lateritic heath/scrub although, as mentioned in relation to the Scott National Park, this is of more significance in terms of vegetation than any unique vertebrate fauna.

Impact: as for Scott National Park.

4.3 LOCATION 4255

Areas surveyed: vehicle transects along eastern boundary to northern limits of uncleared land and one foot transect to western boundary then across the central, northern portion; foot transect along the southern boundary and into the central, southern portion; vehicle transect along the western boundary; numerous spot checks.

Assessment: Location 4255 in its northern portion is basically an extension of the proposed mining area. The stream which flows through ISA-6 is part of a system included in Location 4255 and eventually discharges into the Blackwood River. For the most part, this private land supports large areas of habitat similar to the proposed mining area and in particular the Jarrah/Marri forest typified by ISA-6 and, to a lesser degree, ISA-4. The low heath/sedgeland of the mining area (ISA-5) is also well represented, particularly in the southern, central portions. Both these habitats are likely to support a similar range of vertebrates as was recorded during the minesite field surveys. However, the areas of Jarrah/Marri forest have been severely disturbed by logging to the extent that they are in poorer condition as fauna habitats than most of their project area equivalents.

Two vegetation associations and their attendant fauna set this private land apart from the mining area: the presence of a patch of Karri forest (recently logged heavily) and an area of Jarrah/Marri forest on a low rocky ridge (see Appendix VII for detailed description). It is likely that most of the species with a preference for stands of Karri will occur in the patch on Location 4255. The low rocky ridge country is not represented on the mining area and four previously unrecorded vertebrates were noted here during the inspection: Western Yellow Robin *Eopsaltria australis*, Rufous Tree-creeper *Climacteris rufa*, Southern Boobook *Ninox novaeseelandiae*, Rosenberg's Monitor *Varanus rosenbergi*. This ridge country is also prime habitat for the rare and endangered Chuditch *Dasyurus geoffroyi* since many potential den sites are present amongst the rocks and exposed Marri roots. All of these species are likely to forage into the proposed mining

area but probably show a preference for Location 4255 because of its locally unique features described above.

Impact: any potential effects of nearby mining are likely to be overshadowed by past and current clearing of vegetation within Location 4255.

4.4 LOCATION 4256

Areas surveyed: vehicle transect in north-western and north-eastern corners; foot transects along sections of eastern and northern boundaries.

Assessment: Location 4256 is mainly cleared with remnant, degraded vegetation along creeklines and around swampy country. For the most part its fauna is liable to be depauperate and equivalent to the farmland list given in Table VIII-2. However, an extension of the low, rocky ridge assessed in Location 4255 intrudes into this land and while slightly degraded by stock, still has the conservation potential described earlier.

Impact: as for Location 4255.

4.5 LOCATION 4258

Areas surveyed: vehicle transects along eastern boundary and portions of southern boundary; several spot checks.

Assessment: mainly cleared land with some remnant vegetation along creeklines and near the boundary of the National Park. The fauna is liable to be fairly depauperate except where vegetation is denser, less fragmented and close to the park boundary.

Impact: minimal.

4.6 LOCATION 4253

Area surveyed: vehicle transects along northern and eastern boundaries; foot transect along south-western corner; numerous spot checks.

Assessment: Location 4253 is almost entirely cleared with the remaining vegetation remnants in poor condition as fauna habitats through grazing by stock animals. The south-western corner supports remnant forest and low heath extensions of ISA-5 and ISA-6 but is unlikely have the vertebrate populations of these sites. The

species present, with few exceptions, are likely to be those listed for farmland in Table VIII-2.

Impact: minimal.

4.7 LOCATION 4152

Areas surveyed: vehicle transects along western and southern boundaries; two foot transects into south-eastern portion; numerous spot checks.

Assessment: Location 4152 is mainly cleared and the remaining vegetation has been grazed by stock, some areas more than others. Elements of swamp country, low heath and low *Banksia*/Peppermint woodland are present and are likely to support all the species listed for these habitats in Table VIII-2. Two locations of some significance to fauna were located: an open water swamp surrounded by a Paperbark *Melaleuca preissiana* forest on the southern boundary; a long sandy ridge supporting a low, mixed woodland of *Banksia attenuata*, *B. ilicifolia* and *Agonis flexuosa* extending from the south-eastern to the north-western corner of the block.

The first of these, the open swamp, still contained a large amount of water during the summer survey and evidently plays a role as a drought refuge in dry months of the year. Seasonal studies may show that it acts as a feeding and breeding area for waterbirds, a faunal group poorly represented in the proposed mining area. The sandy ridge area supporting low, mixed woodland is a variation on ISA's 1 and 2, and as such is expected to support all the species listed for these sites in Annex VIII-1. However, its significance to fauna lies in its size, in that it is the largest remnant of this particular type of low woodland in the vicinity of the proposed mining area. While the understorey has been grazed, the overstorey is floristically rich and is evidently part of the seasonal resource base used by the nectivorous and insectivorous birds of the proposed minesite.

Impact: minimal.

4.8 DRY MILL AND OFFICE SITE

Areas surveyed: three foot transects around and throughout the site with inspection of adjoining areas.

Assessment: this area is an isolated patch of remnant vegetation situated in farmland. It is a sandy ridge equivalent to a low woodland composite of the fauna sites ISA-1 and ISA-2 and as such is likely to support many of the vertebrates recorded in these locations (see Annex VIII-1). The understorey, however, is severely degraded by cattle indicating that its terrestrial or understorey

fauna will be depauperate. Because of heavy flowering of *Banksia attenuata* trees, relatively large numbers of nectivorous and small insectivorous birds were present in the overstorey and the area is therefore of some value as a feeding, breeding and refuge area, although too small and degraded to act as a conservation area in the strictest sense. It is part of the system of isolated habitats found throughout the area. A remnant patch of low heath/sedgeland equivalent to ISA-5 lies immediately to the south west but once again is isolated and partly degraded.

Impact: there are no features which set this location aside from the many similar remnants within and beyond the Beenup area. No species of vertebrate of particular conservation significance were recorded and none are expected to be present. The main impact of clearing for siteworks will be a minor, local reduction in the available area of vertebrate feeding, breeding and refuge areas which, while cumulative with other clearing, is unlikely to have an observable impact.

5.0 DISCUSSION AND CONCLUSIONS

5.1 RARE SPECIES

5.1.1 Birds

Only two birds gazetted as "rare, or otherwise in need of special protection" were expected from the study area and both were recorded during the summer survey. These are the Peregrine Falcon *Falco peregrinus* and Red-eared Firetail *Emblema oculata*.

The Peregrine Falcon was seen flying over the wet, lateritic heath/scrub ISA-3 but is a highly mobile bird with little apparent habitat specificity. It is present throughout Australia and while nowhere common, is a species with a cosmopolitan distribution. This rare bird was only recorded in one of five surveys conducted in the Jangardup area east of Beenup (Martinick and Associates 1989) and in two of the 15 study sites sampled by Conservation and Land Management (Christensen *et al.* 1985). Because the Beenup study area is already mainly cleared land, it is unlikely that this species will be affected by the proposed mine. It appears to co-exist with development given that tall structures and prey species such as pigeons and waterbirds are present. Peregrine Falcons have been recorded by the authors on several occasions in the Perth central city block.

The Red-eared Firetail is distributed throughout the wetter portions of the south-west of Western Australia and was recorded twice during the summer survey adjacent to a small dam blasted from the ironstone layer underlying the heath/scrub site ISA-3. This is an atypical habitat. It was observed in 13 of the

15 CALM study areas but only once in the Martinick survey of the Jangardup development project. Its apparent scarcity in the Beenup area, while reflecting to a degree the Jangardup results, is anomalous and may represent either a seasonal artefact or extremely low population levels inland from Augusta. This bird normally requires well vegetated stream zones with native sedges (Restionaceae) typified by ISA-4 and ISA-6, and its presence in the vicinity of an artificial wetland at Beenup has important implications for rehabilitation after mining in that the construction of vegetated wetlands could increase local population levels of this rare species. Firetails are more widespread than originally thought (Nichols et al. 1982; M. Bamford pers. comm.) and are known to eventually re-colonise rehabilitated stream zones in the Darling Range (Nichols *et al.* 1982).

5.1.2 Mammals

No rare mammals were recorded in the Beenup study area although the Chuditch *Dasyurus geoffroii* (Schedule 1, likely to become extinct) is expected to occur in Eucalypt forests especially large, undisturbed remnants. This native marsupial carnivore has undergone a dramatic reduction in range since European settlement and is now mainly confined to the forested areas of south-west Western Australia. In recent years the Chuditch has been the subject of intensive studies on habitat and food requirements by the Department of Conservation and Land Management. Preliminary results show that adult females require 3-4 square kilometres of territory and adult males 4-6. Large, remnant patches of vegetation typified by ISA-6 which are closely connected to extensive areas of native vegetation such as Location 4255 (which is outside the mining area) are the most likely habitat for this rare species. The rocky, lateritic ridge on this latter area is an example of prime Chuditch habitat having refuge and breeding areas, rich stream zones and a range of vegetation types.

5.1.3 Amphibians and Reptiles

No rare species were recorded. One snake, the Carpet Python *Morelia spilota imbricata* (Schedule 2, in need of special protection) is a distinct possibility for the area. This animal is listed in W.A. Museum records for the Augusta district but has not been recorded in recent years. It is not usually captured by normal methods but is occasionally seen active in suitable weather conditions. It could be present in all vegetation types but appears to have a preference for heaths and rocky areas. It is unlikely to be recorded in cleared land except in the immediate vicinity of native vegetation.

5.2 SIGNIFICANT SPECIES

Of the 117 vertebrates recorded during the field survey plus the additional 60 expected to be present as seasonal migrants, nomads, vagrants or cryptic residents, no individual vertebrate including those gazetted as rare, or otherwise in need of special protection, can be considered as being of special conservation significance in that the project represents a long-term threat to its future survival either locally or regionally. In other words, the potential loss of, or disruption to that portion of regional or local vertebrate populations occurring within the zone of influence of the Beenup project is judged to be minimal.

The field surveys have shown that 177 vertebrates are likely to occur within the boundaries of the proposal (Table VIII-2, Annex VIII-2). Leaving aside migratory, nomadic or dispersive birds which, because of their opportunistic habits are unlikely to be affected to any measurable extent by development of the limited area of the proposed minesite, approximately 65% of all vertebrates are judged to be permanent residents or semi-permanent species present for most of the year. This represents the group of vertebrates which will absorb the main impact of habitat loss. Within this group there are two subgroups:

- ° highly mobile vertebrates such as territorial birds, bats, kangaroos, wallabies and monitor lizards;
- ° small, terrestrial vertebrates with a limited capacity to travel relatively large distances i.e. all small marsupials, frogs and reptiles.

The first sub-group has the ability to gradually disperse into adjacent uncleared land as disturbance levels reach a threshold, and while there will be an indeterminate mortality rate through predation, road casualties and territorial conflict over feeding, breeding and refuge areas, the overall impact of this "ripple effect" will probably be no greater than the periodic, accidental or prescribed fires which are a feature of this type of country (given that it takes several years for an area of land to recover after fire and that most territorial disturbance and mortality has already taken place before habitat regeneration occurs).

The nature of heavy mineral mining will inevitably result in a large proportion of the main survey area being totally cleared to allow for efficient and economically sound mining. The end result of this will be that the second sub-group of less mobile species, representing about 25% of the total species list, will eventually lose most of that portion of their local populations occurring in the survey area. Little, if anything, can be done to ameliorate this impact in the short term and it has to be considered as one of the unavoidable costs of mining. However, no rare terrestrial vertebrates are included in this sub-group and all other representatives have distribution patterns covering the south-west of Western Australia.

5.3 SIGNIFICANT HABITATS

In the strictest sense, all remaining patches of native vegetation in the south-west of Western Australia regardless of their current condition are of significance to vertebrates particularly in relation to the amount of clearing which has taken place in the region. Beard and Sprenger (1984), for example, estimate that 65% of the South-west Botanical Province has been cleared and that up to 1984, 31% of the Warren sub-district, within which the proposed development is situated, had been alienated. This represents a significant attrition of faunal habitats and provides a strong argument for retaining as much remnant vegetation within the Beenup area as is commensurate with safe working conditions and the economic viability of the mine.

Within the project area itself it is possible to define habitats of particular significance to vertebrates:

- ° the remaining remnant Eucalypt forests in the north-western and south-western portions of the project area (Locations 4254, 4257) are the most valuable habitats in terms of their species richness (Table VIII-2) and connection with larger areas of uncleared land including Scott National Park and Location 4255;
- ° the seasonally wet lateritic heath/scrubland in the north-eastern section (Location 4264), because it is floristically rich, densely vegetated, poorly represented regionally and provides valuable feeding, breeding and refuge areas for a large range of vertebrates;
- ° the relatively ungrazed, isolated remnants of native vegetation scattered throughout the project area. The four hectare patch of *Banksia ilicifolia* dominated low woodland (ISA-1) is a typical example of this type of habitat in that it was surprisingly rich in vertebrates despite its small size and isolation.

5.4 LOCAL CONSERVATION STATUS

Although approximately 65% of the project area is pasture or grazed native vegetation with very little understorey and therefore represents severely degraded faunal habitat, the remaining patches of uncleared land have a moderately high fauna conservation value judging by the results of this survey. While these remnants do not have the significance of large, cohesive units such as the adjacent National Park, they do fulfill an important role in maintaining populations of the 177 species of vertebrates recorded or expected to occur in the project area.

Seasonal flowering and local fluctuations in invertebrate availability dictate that nomadic, dispersive or migratory birds will use the uncleared land as a feeding, breeding and refuge area. Such activities were recorded during all visits to the survey area, indicating that these vegetated remnants cannot be viewed strictly in isolation. The close proximity of the Scott National Park and the mobility of many vertebrates suggest that there is an interactive relationship between the project area and the park. The summer survey showed that there are seasonal movements of nectivorous birds within the project area (Section 3.1.3, this report) indicating that the proposed minesite, adjacent uncleared land and the park are essentially a continuum and that without the park and surrounding native vegetation acting as a reservoir and major refuge for fauna, it is likely that the productivity of the project area would be lower.

In a broader perspective, the significance of the remnant patches of vegetation to fauna conservation in the Warren sub-district of the South-west Botanical Province is substantial. In recent years much attention has been paid to this aspect with the result that these areas now require careful consideration when management plans are being developed. Authors such as How et al. (1987) and Saunders et al. (1987) discuss the effects of clearing and the contribution of remnants in detail and provide a basis upon which environmental safeguards relevant to the project can be structured.

5.5 IMPACT OF THE PROJECT

The primary impact of mining on fauna is the physical removal of particular habitats through the removal of underlying ore-bodies. Cleared land and areas of remnant vegetation which have been severely degraded by grazing of their understorey make up the bulk of the project area and development of the mine in these relatively depauperate habitats will have a negligible effect on fauna. Clearing of larger, ungrazed remnants will naturally have a greater impact but not to the extent that local and regional vertebrate populations will be placed under threat.

Secondary impacts are potentially more widespread and insidious in their effect. They require careful forward planning and the application of adequate environmental safeguards to minimise disturbance to fauna or, more precisely, to the habitats which support them. Many of these safeguards are standard procedures in major development projects such as this, and are implemented under the relevant statutory acts or in the maintenance of a safe working environment. Some examples are: the minimisation of dust and noise levels; the reduction of spillage and/or the containment of hazardous chemicals; the monitoring of drawdown and salt levels in water supplies; the suppression of wildfires and the careful placement of access roads and site works. All of these contribute to the maintenance of a healthy faunal environment by reducing the impact of secondary effects on vegetation.

Factors which particularly affect wildlife are:

- the excessive clearing of vegetation for access roads, site works and storage areas. The first two aspects can create barriers to the free movement of terrestrial species (Barnett et al. 1978) and in combination with the latter, reduce the amount of habitat available;
- the alteration of seasonal watercourse flow rates and/or increased turbidity and siltation in downstream areas beyond the minesite;
- the raising of the watertable through increased run-off from cleared areas or lowering due to excessive drawdown through de-watering;
- the presence of a work force. This aspect increases the risk of broad scale habitat destruction or modification through accidental wildfires and the uncontrolled use of four-wheel drive vehicles or trail bikes. Dogs brought into the project area by contractors can harass larger vertebrates. A small minority of the work force also tends to see fauna as a recreational resource (indiscriminate hunting) or as an imagined threat (driving over snakes distant from working areas). Increased traffic also has a potentially detrimental effect on wildlife especially when speed is involved.

6.0 RECOMMENDATIONS

The following series of recommendations are structured to specifically maintain or improve the current conservation status of the project area for wildlife while still allowing heavy minerals to be mined both efficiently and economically. To this end a work party report on conservation and rehabilitation in the mineral sands industry (Anon. 1987) has been used as a guide and the particular needs of fauna rather than agriculture given precedence. Both, however, have an extremely important role in the post-mining, rehabilitation phase and need not be mutually exclusive. In strictly faunal terms, i.e. the maintenance of representative breeding populations of native fauna, the four rehabilitation options given below are ranked in descending order of ecological relevance:

- (1) Re-planting cleared areas and farmland with native vegetation and the creation of wetlands from disused pits.
- (2) Wildflower production and tree plantations which include indigenous species such as Karri *Eucalyptus diversicolor*.
- (3) Agro-forestry using the Tasmanian Bluegum *Eucalyptus globulus*.
- (4) Pasture.

In relation to options 1 and 2 when discussing the southern Swan Coastal Plain (an area which has strong similarities with Beenup), the work party believes that:

"There is a need to adapt existing techniques for rehabilitating mined areas with native vegetation, so that they can be applied satisfactorily to the poorer sandy soils on the southern Swan Coastal Plain areas."

"There has not been any extensive use of trees in rehabilitation undertaken on agricultural land in the southern Swan Coastal Plain. The Work Party recommends that companies endeavor to establish more trees on rehabilitated areas, using indigenous species where possible."

"The creation of wetlands is one example where mining rehabilitation can result in improved conservation of bird species, and offset the destruction of natural wetlands that has occurred widely in the South-West through non-mining development."

It is therefore recommended that:

- (1) The integrity of large faunally productive stands of native vegetation such as those occurring on Locations 4254, 4257 and 4264 is maintained as far as possible.
- (2) Access roads and easements follow already existing tracks, and clearing of remnant vegetation is kept to minimum commensurate with safe driving conditions.
- (3) Where it is not strictly necessary to clear small, isolated stands of native vegetation, regardless of their condition, these are left in place.
- (4) Stock animals are excluded from uncommitted company land which supports remnant stands of native vegetation since the presence of these animals is the single most important factor in reducing the faunal productivity of an area and reducing the effectiveness of rehabilitation.
- (5) Rehabilitation of mined land owned by the company is strongly biased towards producing refuge areas for fauna by planting both indigenous shrubs and trees.
- (6) Local land owners are persuaded or provided with incentives to convert rehabilitated pasture into wildflower production, tree plantations or agro-forestry since these usages are more compatible with a larger range of fauna than grazing land.

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- (7) Disused pits are converted into permanent wetlands by maintaining water levels, providing a range of water depths and planting swamp-adapted trees, shrubs and aquatic species such as reeds.
- (8) An environmental awareness programme is established for the itinerant and permanent work force to encourage responsible attitudes to conservation within the minesite.
- (9) Periodic monitoring of fauna takes place in order to anticipate any potential problems which may occur.

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ANNEX VIII-1

List of vertebrate species recorded in Intensive Sampling Areas established and monitored in the Beenup project area during September/October and December 1989.

KEY

+ = Numbers not ascertainable, many heard calling.

S = Signs e.g. scats, tracks, diggings etc.

INTENSIVE SAMPLING AREA	VEGETATION CODE NUMBER	DESCRIPTION
ISA-1	2.2	Low woodland of <i>Banksia ilicifolia</i> , <i>Banksia attenuata</i> , <i>Agonis flexuosa</i> on grey sandy dunes.
ISA-2	2.1	Low open woodland of <i>Banksia attenuata</i> , <i>Nuytsia floribunda</i> and mixed sedgeland and open heath of <i>Myrtaceae</i> species on grey sandy soils.
ISA-3	3.2	Open heath to open scrub of mixed <i>Proteaceae</i> and <i>Myrtaceae</i> species on shallow ironstone soils.
ISA-4	1.1, 1.3	Open forest of <i>Eucalyptus marginata</i> with occasional <i>Eucalyptus patens</i> on moister grey sandy-loam soils.
ISA-5	3.1, 4.3	Mixture of open heath of <i>Myrtaceae</i> and <i>Proteaceae</i> species and sedgeland on grey sandy soils.
ISA-6	1.6, 1.4	Open forest of <i>Eucalyptus marginata</i> with admixtures of <i>Agonis flexuosa</i> and <i>Banksia grandis</i> on yellow sandy-loam soils.

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ANNEX VIII-1 Cont.

INTENSIVE SAMPLING AREA	1	2	3	4	5	6
BIRD SPECIES						
ARDEIDAE						
<i>Ardea novaehollandiae</i> , White-faced Heron					2	
ANATIDAE						
<i>Chenonetta jubata</i> , Maned Duck			2	1		
FALCONIDAE						
<i>Falco cenchroides</i> , Australian Kestrel			1	3		
COLUMBIDAE						
<i>Phaps chalcoptera</i> , Common Bronzewing				1		2
CACATUIDAE						
<i>Calyptorhynchus magnificus</i> , Red-tailed Black-Cockatoo						10
<i>C. baudinii</i> , White-tailed Black-Cockatoo		4			2	
PLATYCERCIDAE						
<i>Platycercus icterotis</i> , Western Rosella	11			12		9
<i>Barnardius zonarius</i> , Port Lincoln Ringneck	7	20		21	2	6
<i>Neophema elegans</i> , Elegant Parrot	1	1				
CUCULIDAE						
<i>Cuculus pallidus</i> , Pallid Cuckoo			1			1
<i>C. pyrrhophanus</i> , Fan-tailed Cuckoo				1		1
<i>Chrysococcyx lucidus</i> , Shining Bronze-Cuckoo	1		2	6		2
PODARGIDAE						
<i>Podargus strigoides</i> , Tawny Frogmouth	3					
ALCEDINIDAE						
<i>Dacelo novaeguineae</i> , Laughing Kookaburra	1			3		5
<i>Halcyon sancta</i> , Sacred Kingfisher				1		
HIRUNDINIDAE						
<i>Cecropis nigricans</i> , Tree Martin	9			65		8
MOTACILLIDAE						
<i>Anthus novaeseelandiae</i> , Richard's Pipit					1	

ANNEX VIII-1 Cont.

INTENSIVE SAMPLING AREA	1	2	3	4	5	6
BIRD SPECIES - Cont.						
CAMPEPHAGIDAE						
<i>Coracina novaehollandiae</i> , Black-faced Cuckoo-shrike	3	4	6	3		2
MUSCICAPIDAE						
<i>Petroica multicolor</i> , Scarlet Robin						3
<i>Eopsaltria georgiana</i> , White-breasted Robin				1		2
<i>Pachycephala pectoralis</i> , Golden Whistler	2			5		10
<i>P. rufiventris</i> , Rufous Whistler	5			1		
<i>Colluricincla harmonica</i> , Grey Shrike-thrush				3		1
<i>Rhipidura fuliginosa</i> , Grey Fantail	6	1		26	1	25
<i>R. leucophrys</i> , Willie Wagtail	1			11		
MALURIDAE						
<i>Malurus splendens</i> , Splendid Fairy-wren	2		7	1		
<i>M. elegans</i> , Red-winged Fairy-wren				12	5	19
<i>Stipiturus malachurus</i> , Southern Emu-wren				1	2	
ACANTHIZIDAE						
<i>Sericornis frontalis</i> , White-browed Scrubwren	6	5	13	5	1	7
<i>Gerygone fusca</i> , Western Gerygone						6
<i>Acanthiza apicalis</i> , Inland Thornbill	8	2	5	5		3
<i>A. inornata</i> , Western Thornbill	2			7		19
<i>A. chrysorrhoa</i> , Yellow-rumped Thornbill	32	2		6		
NEOSITTIDAE						
<i>Daphoenositta chrysoptera</i> , Varied Sittella				13		3
MELIPHAGIDAE						
<i>Anthochaera carunculata</i> , Red Wattlebird	16	35	16	8		
<i>Melithreptus lunatus</i> , White-naped Honeyeater						2
<i>Lichmera indistincta</i> , Brown Honeyeater		1	5			
<i>Phylidonyris novaehollandiae</i> , New Holland Honeyeater	36	5	40			15
<i>P. nigra</i> , White-cheeked Honeyeater			1			

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ANNEX VIII-1 Cont.

INTENSIVE SAMPLING AREA	1	2	3	4	5	6
BIRD SPECIES - Cont.						
<i>P. melanops</i> , Tawny-crowned Honeyeater		16	18			
<i>Acanthorhynchus superciliosus</i> , Western Spinebill		7	5	8		11
EPHTHIANURIDAE						
<i>Ephthianura albifrons</i> , White-fronted Chat	2		1			
PARDALOTIDAE						
<i>Pardalotus punctatus</i> , Spotted Pardalote						2
<i>P. striatus</i> , Striated Pardalote					1	14
ZOSTEROPIDAE						
<i>Zosterops lateralis</i> , Silvereye	3		8	12		11
GRALLINIDAE						
<i>Grallina cyanoleuca</i> , Australian Magpie-lark	1	1		1		
ARTAMIDAE						
<i>Artamus cyanopterus</i> , Dusky Woodswallow		3	3	22	6	
CRACTICIDAE						
<i>Cracticus torquatus</i> , Grey Butcherbird					1	
<i>Gymnorhina tibicen</i> , Australian Magpie				6	3	
<i>Strepera versicolor</i> , Grey Currawong		1				
CORVIDAE						
<i>Corvus coronoides</i> , Australian Raven	4	20	2	1	4	3
MAMMAL SPECIES						
TACHYGLOSSIDAE						
<i>Tachyglossus aculeatus</i> , Short-beaked Echidna				S		
DASYURIDAE						
<i>Sminthopsis griseoventer</i> , Common Dunnart				2		1
PERAMELIDAE						
<i>Isodon obesulus</i> , Southern Brown Bandicoot		S	S			

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ANNEX VIII-1 Cont.

INTENSIVE SAMPLING AREA	1	2	3	4	5	6
MAMMAL SPECIES - Cont.						
TARSIPEDIDAE						
<i>Tarsipes rostratus</i> , Honey-possum					1	
MACROPODIDAE						
<i>Macropus fuliginosus</i> , Western Grey Kangaroo		14	19	3	13	14
VESPERTILIONIDAE						
<i>Chalinolobus morio</i> , Chocolate Wattled Bat						1
<i>Eptesicus regulus</i> , Little Brown Bat						2
MURIDAE						
<i>Hydromys chrysogaster</i> , Water-rat			S			
<i>Rattus fuscipes</i> , Bush Rat	4		9	4		2
<i>Mus musculus</i> , House Mouse			5			
LEPORIDAE						
<i>Oryctolagus cuniculus</i> , Rabbit	S				S	
CANIDAE						
<i>Vulpes vulpes</i> , Fox	S	S	S			1
FELIDAE						
<i>Felis catus</i> , Feral Cat			S			
<u>AMPHIBIAN & REPTILE SPECIES</u>						
LEPTODACTYLIDAE Frogs						
<i>Crinia georgiana</i>	5	4	1	7+	4+	40+
<i>Heleioporus psammophilus</i>	2	38		13	14	7
<i>Limnodynastes dorsalis</i>	3					
<i>Pseudophryne guentheri</i>				1		
<i>Ranidella glauerti</i>	6	11+	2+	27	21+	20+
<i>R. pseudinsignifera</i>	1				15+	1
HYLIDAE						
<i>Litoria adelaidensis</i>			3		1	1
GEKKONIDAE Geckos						
<i>Phyllodactylus m. marmoratus</i>	3	1	1	1		4
PYGOPODIDAE Legless Lizards						
<i>Pygopus lepidopodus</i>			1			
SCINCIDAE Skinks						
<i>Ctenotus catenifer</i>	1				1	
<i>C. labillardieri</i>	1	1	2	9		7
<i>Egernia napoleonis</i>	2			2		1
<i>Hemiergus p. peronii</i>	5			8		5

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ANNEX VIII-1 Cont.

INTENSIVE SAMPLING AREA	1	2	3	4	5	6
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AMPHIBIAN & REPTILE SPECIES - Cont.

<i>Leiopisma trilineatum</i>	3	1	1	3		2
<i>Sphenomorphus australis</i>					4	
<i>Tiliqua r. rugosa</i>	1	3	2	1		
TYPHLOPIDAE Blind Snakes						
<i>Ramphotyphlops australis</i>		4	2			
ELAPIDAE Elapid Snakes						
<i>Notechis coronatus</i>		2	14	1		
<i>Pseudonaja a. affinis</i>		1	2			
<i>Rhinoplocephalus bicolor</i>		3	3			2

Predicted list of species for the Beenup project area. (* = recorded in the coastal strip between Augusta and Northcliffe by How *et al* 1987, Christensen *et al* 1985 or Martinick and Associates 1989).

BIRD SPECIES

PODICIPEDIDAE

<i>Poliiocephalus poliocephalus,</i>	Hoary-headed Grebe	*
<i>Tachybaptus novaehollandiae,</i>	Australasian Grebe	*

PHALACROCORACIDAE

<i>Phalacrocorax sulcirostris,</i>	Little Black Cormorant	*
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ARDEIDAE

<i>Egretta alba,</i>	Great Egret	
<i>Nycticorax caledonicus,</i>	Rufous Night Heron	*

PLATALEIDAE

<i>Threskiornis aethiopica,</i>	Sacred Ibis	*
<i>Platalea flavipes,</i>	Yellow-billed Spoonbill	

ANATIDAE

<i>Stictonetta naevosa,</i>	Freckled Duck	*
<i>Anas gibberfrons,</i>	Grey Teal	*

ACCIPITRIDAE

<i>Elanus notatus,</i>	Black-shouldered Kite	*
<i>Lophoictinia isura,</i>	Square-tailed Kite	*
<i>Haliastur sphenurus,</i>	Whistling Kite	*
<i>Accipiter cirrhocephalus,</i>	Collared Sparrowhawk	
<i>Hieraaetus morphnoides,</i>	Little Eagle	

PHASIANIDAE

<i>Coturnix novaezealandiae,</i>	Stubble Quail	*
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TURNICIDAE

<i>Turnix varia,</i>	Painted Button-quail	
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RALLIDAE

<i>Rallus philippensis,</i>	Buff-banded Rail	
<i>Porzana tabuensis,</i>	Spotless Crake	*
<i>Porphyrio porphyrio,</i>	Purple Swamphen	*

CHARADRIIDAE

<i>Vanellus tricolor,</i>	Banded Lapwing	
<i>Charadrius melanops,</i>	Black-fronted Plover	

COLUMBIDAE

<i>Phaps elegans,</i>	Brush Bronzewing	*
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PLATYCERCIDAE

<i>Purpureicephalus spurius,</i>	Red-capped Parrot	*
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ANNEX VIII-2 Cont.

STRIGIDAE		
<i>Ninox novaeseelandiae</i>	Southern Boobook	*
TYTONIDAE		
<i>Tyto alba</i> ,	Barn Owl	
CAPRIMULGIDAE		
<i>Caprimulgus guttatus</i> ,	Spotted Nightjar	*
MEROPIDAE		
<i>Merops ornatus</i> ,	Rainbow Bee-eater	*
MUSCICAPIDAE		
<i>Melanodryas cucullata</i> ,	Hooded Robin	
<i>Eopsaltria griseogularis</i>	Western Yellow Robin	*
<i>Myiagra inquieta</i> ,	Restless Flycatcher	
SYLVIIDAE		
<i>Acrocephalus stentoreus</i> ,	Clamorous Reed-Warbler	*
CLIMACTERIDAE		
<i>Climacteris rufa</i>	Rufous Treecreeper	*
MELIPHAGIDAE		
<i>Lichenostomus virescens</i> ,	Singing Honeyeater	
DICAEIDAE		
<i>Dicaeum hirundinaceum</i> ,	Mistletoebird	

MAMMAL SPECIES

DASYURIDAE		
<i>Dasyurus geoffroii</i> ,	Chuditch	*
<i>Phascogale tapoatafa</i> ,	Brush-tailed Phascogale	*
<i>Antechinus flavipes</i> ,	Yellow-footed Antechinus	
PHALANGERIDAE		
<i>Trichosurus vulpecula</i> ,	Common Brushtail Possum	
BURRAMYIDAE		
<i>Cercartetus concinnus</i> ,	Western Pygmy-possum	*
MOLOSSIDAE		
<i>Tadarida australis</i> ,	White-striped Mastiff-bat	
VESPERTILIONIDAE		
<i>Nyctophilus major</i> ,	Greater Long-eared Bat	*
<i>N. gouldi</i> ,	Gould's Long-eared Bat	*
<i>Chalinolobus gouldii</i> ,	Gould's Wattled Bat	*
<i>Falsistrellus mackenziei</i> ,	Great Pipistrelle	*

ANNEX VIII-2 Cont.

AMPHIBIAN AND REPTILE SPECIES

LEPTODACTYLIDAE	Frogs	*
<i>Heleioporus eyrei</i>		*
<i>H. inornatus</i>		*
<i>Pseudophryne nichollsi</i>		*
HYLIDAE		*
<i>Litoria moorei</i>		*
PYGOPODIDAE	Legless Lizards	*
<i>Aprasia pulchella</i>		*
AGAMIDAE	Dragon Lizards	*
<i>Pogona m. minor</i>		*
SCINCIDAE	Skinks	*
<i>Egernia kingii</i>		*
<i>E. luctuosa</i>		*
<i>E. p. pulchra</i>		*
<i>Lerista elegans</i>		*
<i>Morethia lineoocellata</i>		*
BOIDAE	Pythons	*
<i>Morelia spilota imbricata</i>		*
ELAPIDAE	Elapid Snakes	*
<i>Notechis curtus</i>		*
<i>N. minor</i>		*
<i>Rhinoplocephalus nigriceps</i>		*

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ANNEX VIII-3

Bird breeding records from the Beenup project area during September/October and December, 1989.

Ardea novaehollandiae White-faced Heron

Sampling Site: ISA-6
Information: Nest in upper branches of 25m Jarrah tree, 1 fledgling with adults

Chenonetta jubata Maned Duck

Sampling Site: ISA-1
Information: Nest in hollow tree

Phaps chalcoptera Common Bronzewing

Sampling Site: ISA-4
Information: Nest on lower branches of Jarrah tree at 2.5m.

Platycercus icterotis Western Rosella

Sampling Site: ISA-6
Information: Adult observed selecting nest site in hollow limbs of Jarrah tree.

Barnardius zonarius Port Lincoln Ringneck

Sampling Site: ISA-4
Information: Adult observed selecting nest site.

Podargus strigoides Tawny Frogmouth

Sampling Site: ISA-1
Information: Two adults with 1 flightless juvenile.

Cecropis nigricans Tree Martin

Sampling Site: ISA-4
Information: Adult observed selecting nest site.

Rhipidura fuliginosa Grey Fantail

Sampling Site: ISA-1
Information: Nest with 2 eggs in Jarrah tree at 2m.

Sampling Site: ISA-4
Information: Adult constructing nest.

ANNEX VIII-3 Cont.

Rhipidura leucophrys Willie Wagtail

Sampling Site: ISA-4
Information: Adult carrying food, nest not found.

Acanthiza chrysorrhoa Yellow-rumped Thornbill

Sampling Site: ISA-1
Information: Nest with 2 eggs in *Nuytsia* tree.

Sampling Site: ISA-3
Information: Nest with 2 eggs in Paperbark foliage.

Daphoenositta chrysoptera Varied Sittella

Sampling Site: ISA-4
Information: Adults feeding young in nest at 9m on upper branches of Marri tree

Phylidonyris melanops Tawny-crowned Honeyeater

Sampling Site: ISA-3
Information: Adult constructing nest.

Acanthorhynchus superciliosus Western Spinebill

Sampling Site: ISA-3
Information: Nest with 3 unfledged young in 3m shrub.

Epthianura albifrons White-fronted Chat

Sampling Site: ISA-4
Information: Nest with 3 eggs in 0.5m shrub.

Grallina cyanoleuca Australian Magpie-lark

Sampling Site: ISA-1
Information: Nest at 3m in Jarrah tree.

Artamus cyanopterus Dusky Woodswallow

Sampling Site: ISA-4
Information: Adult selecting nest site.

Gymnorhina tibicen Australian Magpie

Sampling Site: ISA-4
Information: Nest at 15m in Jarrah tree.

VIII-52

ANNEX VIII-3 Cont.

Sampling Site: ISA-6

Information: Nest at 18m in Jarrah tree.

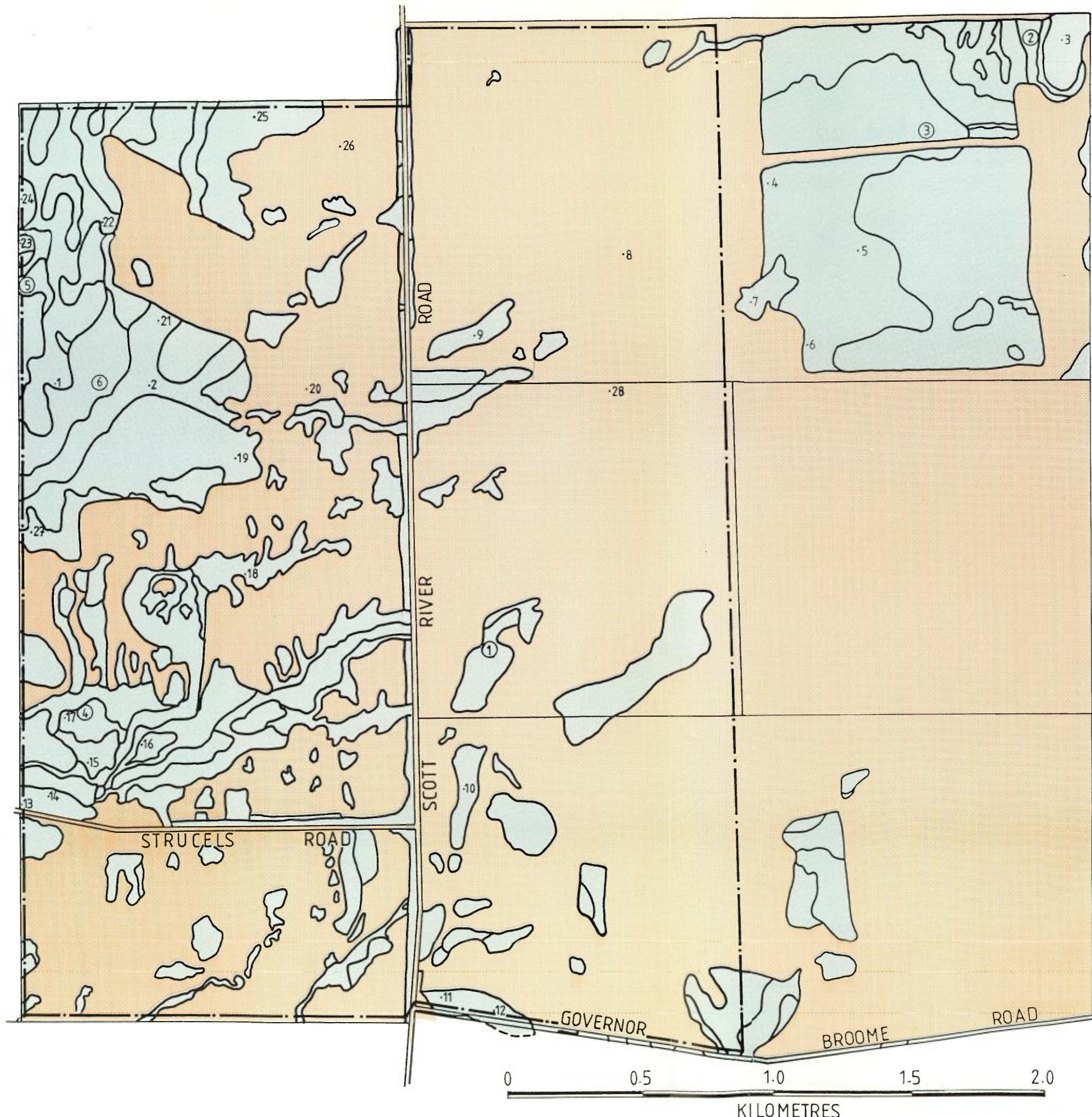
Corvus coronoides Australian Raven

Sampling Site: ISA-4

Information: Nest in upper branches of Jarrah tree.

Sampling Site: ISA-6

Information: Adult constructing nest.



Legend

- ①-⑥ INTENSIVE SAMPLING AREAS
- 1 - ·3 OPPORTUNISTIC SAMPLING AREAS (TRAPS)
- 4 - ·28 OPPORTUNISTIC SAMPLING AREAS (NO TRAPS)
- REMNANT UNCLEARED AND SEMI-CLEARED VEGETATION
- - - MINING AREA

FIGURE VIII - 1
Fauna Sampling Areas

Appendix IX

ARCHAEOLOGY AND ETHNOGRAPHY

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ARCHAEOLOGY AND ETHNOGRAPHY

by

P. Veth and B. Veitch

1.0 **ARCHAEOLOGICAL SURVEY**

1.1 **INTRODUCTION**

1.1.1 **Background to the project**

In April 1989, Lewis Environmental Consultants, acting for their client B.H.P. Exploration, commissioned the Centre for Prehistory to co-ordinate an archaeological and ethnographic survey of a proposed sand mining operation at Beenup, located some 10 km north-east of Augusta.

The archaeological survey was carried out by Peter Veth, with the assistance of Bruce Veitch, between the 16th and 20th of May. The ethnographic survey (Part B) overlapped with the archaeological survey

Following an initial meeting with Dr John Lewis, meetings were held with representatives of B.H.P. Exploration who provided both 1:25,000 scale maps and colour aerial photographs of the proposed project area. Since all of the land to be potentially impacted is, or was until recently, privately owned farmland, a detailed list of landowners was supplied so that access to properties could be arranged in advance.

1.1.2 **Consultancy brief**

The consultancy brief from Lewis Environmental Consultants is divided into two components. The first, titled "Purpose of the study", states

"Mineral Deposits Ltd. proposes to mine heavy minerals in the Beenup area, near Augusta, in the south-west of Western Australia. Lewis Environmental Consultants wishes to retain the services of qualified consultants to conduct an Aboriginal heritage study and prepare a report suitable for incorporation into the Environmental Review and Management Plan for the project."

The second component, titled "Scope of services required", states

"Carry out a survey of the mine site (delineated on the map provided) for Aboriginal relics and artefacts, as required under the existing State Legislation;

Prepare a map or maps at a scale suitable for reporting;

Complete and submit a draft report for review"

1.1.3 Description of survey area

The survey area is all farmland and covers some 15 km². It is situated east of the Scott National Park between the Scott and Blackwood Rivers. It is approximately 10 km north-east from Augusta and 5 km north of the Flinders Bay coastline. The large, and permanently watered, Blackwood River lies 2 km to the west and the Scott River from 250 m to 2 km south of the survey area (Figure IX-1).

The land is flat and featureless and has been largely cleared for pasture. There are no outcrops of hard rock except for a few exposures of laterite in depressions and along drainage lines. The drainage lines that traverse the farming allotments (Figure IX-2) are shallow and ephemeral, being mainly sandy-bottomed. The few depressions shown in Figure 2 possibly represent local expressions of a high water table; they are heavily vegetated, virtually impenetrable and do not provide, even after local rainfall, the free-standing water bodies often associated with south-west wetlands. It is assumed they would not have provided the same economic attractions for Aboriginal hunter-gatherers as those found on the Swan Coastal Plain (see Section 1.3).

1.1.4 Land integrity

There are very few portions of the survey area which have not been impacted by grazing, ploughing or the recontouring of surfaces to provide improved drainage. Pockets of low jarrah-banksia woodland can be found on most properties, usually adjacent and on low-lying areas of poor drainage and rich organic soils. It is estimated that over 90% of the original land surface has been disturbed. Even small, ephemeral creeks are ploughed right up to their flanks. The relict pockets of woodland do not appear to have been fired for a considerable period of time and consequently the understorey vegetation is extremely dense and the leaf litter considerable.

1.2 REGIONAL ENVIRONMENT

1.2.1 Geology and soils

The survey area lies on the Scott Coastal Plain. Geologically, the area comprises Late to Middle Pleistocene sand dunes (Lowry 1967:3). Pleistocene laterites are well developed in these quartz sand dunes. This laterite is so iron-rich as to be classed iron ore (1967:15).

The soils of the area consist of grey podsols, with low ridges formed by dune remnants separated by peaty swamps (Jarvis 1986:75, Lowry 1967:3).

1.2.2 Vegetation and climate

In terms of its vegetation structure, the area belongs in the Scott River System of the Warren Subdistrict of the South-west Botanical Province (Beard 1981:193-4). Prior to European settlement it supported a Jarrah-Banksia low woodland with some *Melaleuca*. The understorey consists of small shrubs and sedges. Where the water table is high, sedgeland occurs, and outside the survey area small swamps occur where water is trapped by dunes (Beard 1981:194-5). The area experiences a strongly seasonal climate with cool, wet winters and hot dry summers (Jarvis 1986:12). The annual average rainfall for this area of the south-west is one of the highest in the state at 1400 mm. The area has a short dry season of only four months (Jarvis 1986:63).

1.3 ETHNOHISTORICAL BACKGROUND TO THE SURVEY AREA

1.3.1 Abstract

The region east and south of the Blackwood River, including the area of the Scott River, comprises one of the ethnographically least known regions of the south-west of Western Australia. Difficulties of access, and clearing for either agricultural or pastoral purposes, resulted in a late penetration of the region by European settlers. Consequently, by the time permanent European homesteads were established in the late 1800s, most Aboriginal people had probably gravitated towards the towns or other settlements, leaving little or no opportunity for the observation or recording of traditional culture or economy. However, a rich variety of ethnographic and historical recordings for adjacent areas and the rest of the south-west Cultural Bloc, allows for a speculative reconstruction of the late prehistoric socio-economy and occupation of the region.

1.3.2 **Ethnographic observation and the European occupation of the south-west of Western Australia**

Ethnohistorical reconstructions in the south-west of Western Australia are based upon 19th century recordings of traditional Aboriginal culture and economy, and are, therefore, dependent upon the quality and quantity of historical data available. A number of the earliest European settlers at Albany (1826) and Swan River (1829) took an academic interest in the Aboriginal population which occupied their immediate hinterlands, and fortunately provided us with comprehensive accounts of traditional Aboriginal life in these areas (Nind 1831, Collie 1834, Lyon 1833). However, many more settlers took little or no interest in Aboriginal life, except to regard Aboriginals as an impediment to settlement. As will be discussed below, the European population at Augusta tended to take the latter stance and this has resulted in a paucity of easily accessible ethnographic material.

Regardless of their inhabitants' interests in the local Aboriginal population, from the moment of their establishment these settlements were also unwittingly (or deliberately) bringing about the transformation or destruction of traditional Aboriginal activity. In addition, the effects of the European colonisation preceded in a bow-wave, so that the Aboriginal inhabitants of other regions were affected by transmission of foreign trade goods, diseases, information, population shifts, or changed social or economic necessities, many years before Europeans actually appeared in their districts.

A major factor of disturbance was the way European settlements attracted Aboriginal people into semi-permanent occupation of fringe camps. Most European homesteads and towns rapidly developed outlying Aboriginal camps, as they became an alternative source of food, usually flour and sugar. Initially these rations were given out gratis, or in return for small services performed, such as bringing wood and water. However, in the earliest phases of settlement, the bulk of the Aboriginal diet was still derived from 'bush' foods, with frequent excursions away from the settlements to hunt or collect animal or vegetable resources. While this meant that Aboriginal people were more generally available for observation, they were not practising fully traditional economies or subsistence strategies.

Eventually, an increasing amount of labour was required in return for food or tobacco, with Aboriginal men and women acting as housemaids, shepherds, farm assistants, mail couriers, boat hands, or as 'native police'. Although various forms of traditional economy were still practised, the diminished Aboriginal population became increasingly dependent upon European supplies, resulting in the traditional Aboriginal lifestyle of the south-west ending by the 1860's (Berndt 1980). Social networks were further weakened and modified by the influx of Aboriginal people from other areas, and forced relocation of people into

settlements, reserves and camps. Many Aboriginal people remained mobile in country areas of the south-west, working as itinerant labourers, picking fruit or helping with harvesting or shearing. This model of attraction and increasing dependence without true integration is common to the Aboriginal history of the whole south-west, although the rate and timing of such changes varied from place to place.

By the late 1800s and early 1900s, the last fully initiated Nyungar men and women who had participated in traditional life had passed away (Bates 1985). The present Aboriginal population of the south-west, however, retains knowledge of traditional economy, especially in regard to plant foods, which have been used to supplement their diets in lean times, or simply because they are still seen as desirable (Bird and Beeck 1988, Meagher 1974). A variety of myths, religious beliefs and strong associations with particular sites and areas within the south-west also remain (Makin 1970, O'Connor, Bodney and Little 1984). However, the full extent of traditional ritual or mythical knowledge still held by Nyungar people has never been adequately investigated.

1.3.3 The Scott River District

Although only about 12 km from Augusta, the Scott River area was rarely visited by Europeans for a variety of reasons. The European settlement established in 1830 was small, with never more than 80 inhabitants closely clustered about the mouth of the Blackwood. The town, and the majority of land grants, was located on and about the western shores. Large areas on the east side, including the Scott River and the survey area, were granted to George Leake and Thomas Turner but were almost certainly never used, and probably rarely visited.

The Blackwood, although fordable at the river mouth, presented a substantial barrier to any planned land clearance or use. Given the immense difficulties in clearing even its town blocks, neither the heavily wooded hills or the coastal heathlands and swamps presented a particularly inviting prospect for the small group. With the exception of J.W. Turner, there was a general reluctance towards expending too much effort in improving large areas of the grants on either side of the Blackwood, as it was correctly felt that the settlement would ultimately be relocated to the Vasse River (Busselton). Contemporary accounts make vague suggestions that the east side of the river was visited sporadically, for either local exploration or hunting and fishing (Hasluck 1955, Shann 1926, Turner 1969). Several contemporary drawings by Thomas Turner (Turner 1969) reinforce the view that the east side was probably the object of occasional excursions, as several of his scenes look westward over the river towards the settlement.

Exploration maps produced by members of the Augusta settlement suggest that by 1831-32 the Scott River had been followed for up to 15 km from its mouth, probably passing by or near to Brennan Ford. However, no mention of these short explorations appears in any of the published accounts of the settlement, although it is probable there may be some mention amongst the voluminous journals and correspondence kept by the Bussell family. A brief survey of this material did not locate any relevant pieces, with all other published and unpublished sources only recording excursions along the west bank, generally with the aim of locating routes to the Vasse. However, it is almost certain that, as with most explorations in the south-west, any journey to the Scott River area would have included an Aboriginal guide, or at the least followed an Aboriginal pathway through the bush.

The European settlers at Augusta did not take the same interest in Aboriginal lifestyles that was shown in the larger colonies. Although interaction with the Aboriginal population was virtually continuous, and at least some people were able to speak Nyungar and were obviously well regarded by the Aboriginal inhabitants, there does not appear to have been any deliberate attempt to record information about them.

In general, relationships between Aboriginals and Europeans were amicable, especially in the first several years. When the first party arrived to establish Augusta, almost the first encounter saw several Aboriginal men lead the Europeans to a water supply. This response might have resulted from earlier encounters with whalers, who would also have been looking for water sources. Further support for pre-settlement contact with whaling and sealing groups is that the word given by the Augusta local group for 'female' was 'woman', (Shann 1926:94), illustrating another main concern of the visiting sailors, who continued to arrive regularly after the foundation of the settlement.

In 1833 Georgina Molloy recorded that:

"The natives are very fond of all the settlers at Augusta, and we live on the most peaceful terms. The natives call Molloy 'King Kandarung', and me 'King-bin'. They are delighted with Sabina [Molloy's daughter] and she is not the least alarmed at their black figures and rude voices. She will dance opposite the native children with great glee; and an old native woman seized her by the leg the other day and embraced it, without producing the slight emotion of fear." (Hasluck 1955:113)

In the same correspondence, she names Mobin as a 'native chief' of the local group. Later in 1833, Captain Molloy, the Government Resident, reported

"In cultivating a friendly intercourse with the native tribes at this residency it becomes necessary to supply them occasionally with small presents of provisions." (Hasluck 1955:120)

As described above, this sort of supply, not to mention the novelty value of the Europeans, led to an Aboriginal fringe camp developing to one side of Augusta.

Relations were not always peaceful though and a small garrison of soldiers was permanently stationed at Augusta to defend against Aboriginal attack, a major fear of the European settlers. However, the barracks were located almost 2 km from the main settlement, (to distance the common soldiery from the settlers), and the delay in reaching any crisis rendered them virtually useless. Although they eventually ended up acting as general labourers about the settlement, there were several occasions when they were called on to apprehend Aboriginal offenders after theft of flour or potatoes. A slightly more serious incident occurred in early 1834, when a group of thirty Aboriginal men and women approached the settlement and threatened Georgiana Molloy, and stole various items from her house. This group was later pursued by the soldiers, and the women were forced, under threat of being bayoneted, to return the saltshakers, etc. Later, the Aboriginal men returned to the settlement with a number of wallabies as 'peace offerings' (Hasluck 1955:122). This incident appears to have been unusual.

The published and unpublished writings by the Bussell family also record a fairly amicable situation at Augusta. Vernon Bussell, in a letter dated 1833 from 'The Adelphi' (near Alexandra Bridge), writes

"The natives are very friendly here. They sometimes come to see us. We ferry them across [the Blackwood] and by that means save them a journey of twelve miles, for they have neither boats or bridges. The other day I brought over a boat load of them, 2 women, 3 girls, 5 men, 2 boys, and a dog... Alfred and I, and Pearce have paid them a fortnightly visit since." (Shann 1926:95)

(Presumably, the 12 miles mentioned was the distance from The Adelphi to the fordable point at Augusta).

During these visits, Vernon and the other party members always took 'a brace of pistols', knowing that at any time they might unwittingly commit 'some heinous offence without being aware of it.' In addition, the women and children were kept away from the main campfire, on a nearby hill, and any attempt by Vernon to visit them was discouraged by the men (Shann 1926:95).

As noted above, the Bussells, Molloy's, and Turners kept diaries and a vast flow of correspondence to each other and to English relatives. In these documents are many such incidental references to Aboriginal activities, and if time allowed, an intensive study of these sources might result in a reasonable account of life in the surrounding regions.

Another limiting factor to ethnographic observation in the region was that in 1834 approval was finally given for most of the land grants to be transferred from Augusta to the more easily cleared country about the Vasse. There was a rapid exodus to the north, although many people moved between their holdings at both settlements for the next several years. By 1840 Augusta was virtually abandoned, with the exception of the Turner family and their servants, who left in the late 1840's.

Two government explorations passed through the coastal area west of the Blackwood during the early 1800s. The first, led by Lt. Preston, was forced to walk from Pt. D'Encastreaux to Augusta in 1831, but failed to record any detail about either the land or its inhabitants (Anon 1833). A second expedition explored from Augusta to Nornalup in 1852, taking notes and plans of the area.

Unfortunately, the manuscript for this journey is in the Mitchell Library and could not be obtained.

From the 1850's a number of pastoralists began to spread southward from the Vasse, concentrating on coastal areas and the grassed plains along the river valleys. It is difficult to assess when they might have penetrated to the east bank of the Blackwood, although it was probably not until the late 1860's or 1870's, and then not in any great numbers. Older European residents in the region suggested that the cattle were moved between the coast and inland on a seasonal basis, and that stock camps and yards can still be found in some of the forest areas adjacent to the Scott River Road. There is unfortunately no readily accessible history of European settlement around either Augusta or the south coast, making it difficult to definitely date this occupation.

The growth of the timber industry in the 1880's was the next major period of European settlement in the region. With major sawmills located at Karridale, Boranup and Kudarup, Augusta was re-established as a port, with another facility at Hamelin Bay. However, this activity was once again concentrated west of the Blackwood, with forest reserves and crown land kept on the east side. The Old Alexandra Bridge was constructed across the Blackwood in the 1890's, providing a long awaited route towards Nannup and other areas to the south-east, and opening the east side of the lower Blackwood to settlement.

It was not until the 1920's and the advent of Group Settlements that any moves were made to occupy the southern forests. Once again, these settlements were mostly to the west of the Blackwood, as well as further east towards

Northcliffe. Although this scheme failed through poor management and infertile soils, it firmly established a European farming presence within the region.

While little of the above information is directly relevant to Aboriginal occupation, it establishes the fact that in a region of otherwise dense European settlement, this one area remained relatively uninhabited until late in the 1800s. In all likelihood the Aboriginal population of the area was attracted to the towns, timber camps and homesteads between the 1860's and 1880's although, as suggested above, a certain degree of mobility may have been maintained by Aboriginal people working as itinerant seasonal labourers.

Mervyn Longbottom, a long-time resident of Darradup, recalled that about the turn of the century there were still Aboriginal groups moving about that area, using traditional foods and camping places. Although they still had some traditional tools, they had European clothes and no longer wore skin cloaks. He also recalled that 200 or so Aboriginal people would annually pass across the Darradup ford on route to visit a 'king' at Karridale (Hallam 1977a). This information is interesting as it suggests not only a late Aboriginal presence in the region, but relationships between different areas of the south-west, and associations with timber camps.

1.3.4 Social organisation and population (see Figure IX-3)

The Aboriginal population of the south-west of Western Australia has been seen as forming a separate Cultural Bloc, defined through the co-incident distribution of Nyungar language groups (Wurm 1972) and a set of socio-religious practices which Berndt (1980:81) has termed the 'Old Australian Tradition.' Unlike the desert and desert-fringe groups to the north and east, the Nyungar (a portmanteau term meaning 'The People', by which the present south-west population identifies itself) did not practise circumcision or subincision. Instead, initiates had their nasal septums pierced and their upper bodies scarred (Bates 1985). Although a number of other cultural and economic factors distinguished the Nyungar from their neighbours, this difference appears to have been one of the most significant.

The late prehistoric boundaries of the Nyungar groups have been debated by several writers, although it would appear that the eastern boundary was a roughly diagonal line between Esperance and Jurian Bay. There is some evidence to suggest that Nyungar groups originally inhabited narrow coastal margins as far north as Geraldton, and for some distance east of Esperance, but that they were under considerable stress to change to the circumcising practices of the inland areas. Prior to the adoption of Nyungar as a group and linguistic name, it appears the south-west people generally recognised their common language and

culture as 'Bibbulman' (Bates 1985), although the original meaning of this word has not been determined.

Tindale (1940, 1974) located thirteen 'tribal groups' within the south-west, based on perceived socio-linguistic boundaries mostly following minor dialect differences amongst clusters of family or local groups. Although the notion of the tribe is no longer generally used, it is still recognised that within a culture-area, such as the south-west, there were groups of bands or families which were united in part by linguistic ties, in part by topography, and in part by historical and political links (Peterson 1976:51). The organisation of these family or band units will be discussed in more detail below.

The 'tribal' group identified as owning the Scott River area has been named in a number of sources as the 'Peopleman', 'Pibelman', 'Bibbulmun', or similar variants (Tindale 1974:255; see Figure 3). Tindale (1974:143) noted this similarity to the general linguistic name for the south-west, and recorded

'...they considered that they were all speakers of what they called ['Bibulman'], although they were to some extent aware that the real Pibelmen lived in the big-tree country a long way away.'

Bates (1985) recorded that the name of the dialect between Augusta and Vasse was *Burrong Wongi*, although Tindale (1974), probably using another Bates source, suggests *Bajong Wongi*. Other names for the district include *Minang* or *Koreng*, which refers to the Pibelmen being located south or east of their neighbours.

The name *Waddarndi* ('sea people') is also offered by Bates (1985) for this area. This term was common for all coastal groups in the south-west, distinguishing them from their inland neighbours, the *Boyungai* ('stone' or 'hill-people'). Further ecologically based divisions within these larger groups included *Darbalung* ('estuary-people') and *Bilgur* ('river-people'), either of which might have applied to people in the Blackwood, Scott River and Hardy Inlet area.

The area inhabited by the Pibelmen is described as "the Lower Blackwood River, chiefly on the hills in country between the Blackwood and Warren Rivers, East to the Gardner River and Broke Inlet; On Scott River; Inland to Manjimup and Bridgetown" (Tindale 1940, 1974:255). Tindale gives the Blackwood as the western boundary of the Pibelmen.

However, Curr's map (1886) suggests that the Pibelmen claimed territory on both sides of the Blackwood and as far north along the coast as Margaret River (see Figure IX-3). There is some evidence in the historical sources (see Vernon Bussell's letter, quoted above) to suggest that Aboriginal people were able to

cross the Blackwood with no apparent fear of infringing on a different local group's territory. Similarly, it appears that relationships and easy communication took place between Aboriginal groups at Augusta and the Vasse. Whether this freedom of movement occurred as a direct result of the European presence is difficult to ascertain.

Bates (1985:77) recorded that Aboriginal people along the south coast "below Augusta and the Donnelly River" followed a system of patrilineal descent, whereas those on the west coast were matrilineal. There was, however, interaction and marriage between the two systems, although it is unclear exactly where the boundary was. Gibbs (1987) has used ethnohistorical material to show that a marked pattern of interaction and trade existed along the western coastal plain, and suggested that the southern coastal groups shared a similar relationship (i.e. within those groups known as 'Waddarndi'). The Scott River area possibly fell along the boundary of these networks, receiving input and interaction from both western and southern coastal groups. Further evidence for trade and movement through this area will be outlined below.

As has been suggested above, the socio-linguistic grouping known as the tribe was composed of a number of smaller band or local groups. In other areas of the south-west these local groups generally consisted of between 15 and 30 individuals, usually a number of related men, their wives, sons, and unmarried daughters, and possibly several 'visiting' people of more distant relationship. The twelve men, women and children ferried across the Blackwood River by Vernon Bussell may well have comprised all or part of one such local group, while the group of thirty people who appeared at Augusta could well have been one or more local groups.

Each local group, often represented in the historical literature as a land owning 'family', was identified with a certain tract of land which they referred to as their *Kalla*, literally, their 'fireplace' (Moore 1884:39). This consisted of the aggregate area of land inherited by the various members of the group, or more particularly, the area in which these people held the most rights to the resources contained in or on the land and water. There remained a certain degree of fluidity in population and land or resource 'ownership', as people could 'own' or act as custodians of sites outside of their local group area, or have distant kinship relationships which allowed them to travel beyond their boundaries. Hallam (1975:42) described this situation as

'...a mosaic of usage rights, or rather a series of overlapping mosaics. A group's range for one resource need not coincide with its range for another, though there will be a core area over which there is the greatest degree of overlap, and which is most frequented by a particular community.'

There is no evidence of what the local group organisation or locations for the Scott River area might have been. The survey area may well have been within the range of one or several groups.

Each 'tribal' group probably consisted of up to ten local groups, with a total population of several hundred persons. Prehistoric and early historic population densities in the south-west are difficult to assess, given the degree and effect of interaction with Europeans before attempts were made to produce accurate figures. Ethnohistorical research has attempted to calculate minimum population densities for several areas:

Swan River	>	17 - 28 persons per 100 km ² (Hallam 1977b)
New Norcia	>	13+ persons per 100 km ² (Hallam 1977b)
Albany	>	4+ persons per 100 km ² (LeSouef 1980)

(The final estimate is almost certainly several times smaller than reality).

There is insufficient material to speculate on the Pibelman population, although it would probably be more comparable to that of Albany rather than the Swan River. A minimum figure of 10 people per 100 km² is reasonable, if it is accepted that the prehistoric population density has been generally underestimated.

1.3.5 Economy and subsistence

A detailed ethnohistoric study of the traditional Nyungar economy has been carried out by Meagher (1973, 1974, Meagher and Ride 1980). The south-west provided a rich environment for hunter-gatherers, with an enormous variety of animal and plant foods available throughout the year.

"Mammals, birds and eggs, many reptiles and frogs, fish (especially marine species from the lower reaches of rivers, and from estuaries and inlets), and some invertebrates (especially the larvae of some beetles and moths) were eaten. So was a wide range of roots, seeds and fruits." (Meagher and Ride 1980:71)

John Bussell, in a letter of 1831, recorded

"The place is beautifully picturesque, but so wild, so savage that a Spencer might see what his imagination so often created of savage wood and cliff and lake. But man, alas! is more uncultivated than all, living on the rind of nuts the interior of which is poisonous, fish which they catch with an ill-constructed spear, and the kangaroo which, however, is a rarity here as is also the opossum, still more the emu. Sometimes they content themselves

with fern roots and grubs which they display great, I was going to say, instinct in finding about the grass tree. (Shann 1926:94)

Plant foods would have provided a major dietary component for the Nyungar, with various roots, bulbs and tubers becoming available on a seasonal basis. Seeds, nuts, fruits and fungi were also eaten, as were nectar from *Banksia*, *Eucalyptus* and *Dryandra* flowers and the gum of *Acacia* (Meagher 1974). Meagher (1974) suggests species names for a small number of the foods mentioned in the historical literature, although it has been difficult to test this without ethnographic study such as undertaken by Bird and Beeck (1988). The 'fern root' mentioned above is difficult to identify without further information, and could be a number of species, or even genera. The 'grass tree' is undoubtedly *Xanthorrhoea*, and the grub found within is almost certainly 'bardi' (*Barbisitis cibarius*).

Although many plant species could be eaten raw or with minimal preparation, others required processing through pounding, roasting, leaching, fermentation, or addition of other elements to neutralise toxicity. The poisonous nut mentioned by Bussell may well be *Macrozamia* which required prolonged leaching, burial, and roasting, and was often unwittingly eaten raw by Europeans after being seen about Aboriginal campfires prior to preparation.

Dortch and Gardner (1976) have suggested a list of plant foods possibly utilised about the Northcliffe district, based on ethnohistory from other areas. These included 'Emu Plum' (*Podocarpus drouynianus*), *Eucalyptus* and *Banksia* nectars, and *Acacia* seeds and gums. Interviews with European residents of the area, also suggested use of the 'blackfellows bread', (*Polyporus mylittae*), a fungus which appears after burning in the karri forest, and therefore may well have been a summer or autumn food. Several other aquatic herbs (e.g. *Triglochin* sp.), sedges (e.g. *Scirpus* sp.), lily-like plants (e.g. *Anigozanthus flavida*) and fruits or berries (e.g. *Leucopogon* sp., *Persoonia* sp.) are also considered possible resources.

The paucity of larger game mentioned by Bussell is interesting, and may be a result of Augusta's location adjacent to a major forest area. However, as other comments suggest, these animals were not so scarce that they did not form a part of the diet. Whether this scarcity applied on the other side of the Blackwood is an interesting question, and may have bearing on the density of Aboriginal occupation in other forest regions. Larger marsupials (kangaroo and wallaby) were generally hunted in open forest and woodlands, using spears, pits and fences as a means of capture. Smaller game (possum, quokka and bandicoot) was chased or driven out of trees, scrub and thickets to be clubbed or speared. As noted above, reptiles (including snakes) were also caught for consumption.

Fire was regularly used in animal drives during hunting, or to promote herbage and thus attract animals for hunting, or to open heavily vegetated areas. (Hallam 1975). The settlement at Augusta was threatened several times by Aboriginal burning patterns (Hasluck 1955, Turner 1969), demonstrating that the regime practised in other areas probably extended to the Scott River area as well.

The main foci of economic life about the Lower Blackwood and Scott Rivers were probably the river systems, swamps and wetlands. These areas would have been the seasonal homes of thousands of aquatic birds (in late summer and winter) and provided Aboriginal groups with young birds and eggs during breeding seasons. Freshwater tortoises, frogs, crustacea, and reptiles were also exploited, although shellfish were the subject of a cultural prohibition and not consumed, although they were probably used as berley to attract fish. The Nyungar did not systematically exploit the littoral zone, although for some areas of the south coast there is evidence that fish were speared from rocks overlooking deep pools or holes. Whales, seals and other sea-mammals were enthusiastically consumed if found washed up on the beaches or in otherwise vulnerable circumstances (Bates 1985, Shann 1926), but they were not actively hunted.

Fish were a staple for coastal Nyungar, with both freshwater and marine species being caught by a variety of means in the rivers, estuaries and lakes. Although the fish spear (gidji) was used most frequently by individuals, larger groups of people used organised fish drives, artificial tidal pools, brush fences, gates and fishweirs to trap large quantities of fish, often for the purposes of feeding large ceremonial gatherings. These techniques have been researched for sections of the west and south coast adjacent to the survey region (Dix and Meagher 1976, Gibbs 1987). The conditions in the Hardy Inlet and on the Scott River are similar to the other river and estuarine systems where these methods were used, and probably also witnessed their use. A wooden structure, almost certainly a fishtrap, was located on Blackadder Creek near Northcliffe, within the boundaries of the Pibelmen area (Dortch and Gardner 1976). However, wooden artefacts and structures of this nature usually do not survive, unlike those made of stone, such as the ones at Oyster Harbour and Broke Inlet (Dix and Meagher 1976).

The Nyungar strictly managed their floral and faunal resources by various means, such as controlling or limiting access to or use of certain easily obtained species to prevent their over-exploitation. The Nyungar scheme of management included maintaining a cycle of ritual observances to ensure the renewal of the various plant and animal species, and to reconfirm their responsibilities and links to the land and the spirits who inhabited it.

1.3.6 Summary

The archival research for this report discovered disappointingly little material relevant to the survey area, although, as suggested, intensive study of unpublished journals and correspondence may result in a reasonable view of Aboriginal life about Augusta at the time of contact. As discussed, the European inhabitants of Augusta took little active interest in the Aboriginal population, and were so well employed around the settlement that their explorations were limited to locating the nearest boundaries of their land grants, and establishing land routes to the Vasse.

Several sources agree that the name of the community inhabiting the Scott River area in early historic time was 'Pibelman', or some variant, although their exact territory is uncertain. Historical evidence suggests that the Aboriginal group inhabiting Augusta could have claimed the territory to the east of the Blackwood, including the Scott River. This would therefore place the Pibelman on both sides of the Blackwood.

The river mouth at Augusta was almost certainly a fordable point for at least part of the year, and was therefore probably an intersection point for several trackways. Such major trackways were known as easements for travelling groups, and could therefore explain the mobility on both sides of the Blackwood. Using Ferguson's (1985) model, the area around the ford would probably have been the site of an Aboriginal camp, even prior to settlement. To extend this model further, the Brennan Ford site (S0372) may have played the same role.

The general occupation pattern for the east of the Blackwood was probably similar to that previously suggested by Dortch (N.D., also Dortch and Gardner 1976). Occupation of the southern coastal plain (Scott Plain) was probably not intensive, and generally limited to summer, when environmental conditions closer to the coast were equable. The swamps and pools of this area would also have provided a range of vegetable, amphibian and invertebrate resources in and around their margins, although Dortch (n.d.) suggests that closer to the coast there was little free-flowing fresh water. During summer the most abundant resources would have been marine and estuarine fish in the Hardy Inlet and Scott River. A variety of trapping methods, either using groups of people to herd the fish into shallows, or forcing them into weirs, would have provided major food supplies for this season.

Cold weather, winds and flooding would have made the coastal plain unpleasant during winter, reinforcing the possibility that, as in other southern areas, winters were a period of dispersal into the woodlands for the purposes of hunting larger game.

Tindale (1940, 1974:255) notes that the occupation of the Pibelmen was "chiefly on the hills", although this is ambiguous and difficult to interpret. The relative availability of resources in the forests and woodlands is difficult to assess, although in other forest regions neither floral or faunal food resources were particularly abundant. Further information on the botany and zoology of the Lower Blackwood area would be required if further speculations are to be made. It is possible that the inland movement might have been towards the grassed flats and river valleys along the Blackwood and tributaries. These areas would have attracted the sorts of grazing animals that the Nyungar are known to have exploited. The inland swamps and lakes would also have provided various other sources of flora and fauna throughout the year.

1.4 PREVIOUS ARCHAEOLOGICAL RESEARCH

1.4.1 Regional excavations

Only two small excavations have been previously carried out at the Hardy Inlet-Scott River District (cf. Dortch n.d.). The first of these, Hardy Inlet Trench 1 (S0365, see Figure IX-1) is located on the east bank of Hardy Inlet, 1.5 km east of Thomas Island. An open camp located on a leached sand dune, some 2 m above the waters of the Inlet, the site is adjacent to a swamp and small, freshwater spring. A 1 m² test excavation retrieved quartz and glass artefacts to a depth of 25 cm below surface. No organic remains were recovered and so the shallow deposit is undated.

The second site, Scott River Trench 1 (S0371, see Figure IX-1) is a scatter of quartz and silcrete artefacts on a podsolised sand deposit overlooking a small creek and paperbark swamp. A 1² test pit and two smaller pits revealed numerous stone artefacts in an upper leached zone which had been bulldozed. A lower iron-rich soil, extending to a depth of 10-15 cm below the disturbed surface, contained no cultural material. No dateable material was recovered.

While early occupation of the south-west is well demonstrated in the Leeuwin-Naturaliste Bloc and the western littoral (cf. Ferguson 1985), there are no known well-stratified sites from the Hardy Inlet - Scott River District.

1.4.2 Regional site patterning

Seven archaeological sites, including the two discussed in Section 1.4, have been previously recorded within a 10 km radius of the survey area (see Figure IX-1). These are summarised in Table IX-1.

All of the sites, except possibly S1786, are recent and represent somewhat ephemeral occupation. It is interesting that all the stone artefact scatters are in disturbed contexts where the humic (A₁) and leached (A₂) horizons have been at least partially exposed. Significantly, all the sites occur adjacent either major drainage lines or swamps with known springs. All of the larger and well stratified sites in the region occur at, or close to adjacent portions of the coast. As Dortch (n.d.:6) notes,

The near absence of archaeological material in coastal dunes south of the Scott River suggests that this part of the coast was not occupied intensively during prehistoric times... All of the coastal sites...from neighbouring districts are found on fully or partly sheltered embayments and at places where freshwater streams enter the sea.

1.4.3 Relevant research questions

Although archaeological excavations have not been intensive in the Scott River District, a consistent theme in both the site reports and Dortch's (n.d.) study is the relative paucity of cultural material on the coastal plain and in the adjoining woodlands. The only sites noted appear to be strongly correlated to drainage features, both on the littoral and in the hinterland. At this stage, timely research questions might include:

- 1) Were the woodland and coastal plains surrounding the Scott River occupied on a permanent basis or did they simply express a seasonal (summer) extension of groups otherwise focussed on rich estuarine ecosystems?
- 2) Is the lack of stratified sites in the locality a result of low intensity occupation or destruction by geomorphic processes?
- 3) Given the clear evidence for late Pleistocene occupation in the south-west from the littoral and near littoral zone, is the lack of such sites in the hinterland woodlands a result of their later occupation and use (on a permanent basis) or simply due to a lack of suitable depositional environments, such as rockshelters?

TABLE IX-1

Summary of regional archaeological sites
(locations shown in Figure IX-1).

Site no.	Site type	Context	Comments
S0365	Reworked surface scatter	Dune next to swamp	Hardy Inlet Trench 1 (see above)
S0367	Reworked surface scatter	Humic lens of sand quarry	next to West Bay Creek
S0368	Reworked surface scatter	Sandy slopes above McCleod Creek	Scrapers and geometric microliths from chert, silicified sandstone, meta-dolerite and quartz
S0369	Surface artefact scatter	Quartz sand on laterite surface adjacent Blackwood River	Small scatters containing both quartz and Eocene chert
S0371	Reworked surface scatter	A ₂ soil horizon adjacent river	Scott River Trench 1 (see above)
S0372	Reworked surface scatter	A ₂ soil horizon adjacent river	Large number of silicified sandstone artefacts with geometric microliths
S1786	Engravings	Flat limestone outcrops	Simple figurative and geometric

1.5 SURVEY METHODS

The properties shown in Figure IX-2 were grouped into disturbed and undisturbed land surfaces. Pockets of relict woodland, especially around minor depressions, represent the original ground. Unfortunately, the humic cover and leaf litter is very dense in these areas, which appear not to have been burnt-off for a considerable period of time. Therefore surface visibility is less than 5% for these woodlands, which comprise approximately 10% of the 15 km² survey area. It is generally only on the periphery of these tree stands that deflation and cattle activity has exposed patches of the white underlying sands. All of the pasture land is covered by dense clover, rendering surface visibility less than 2%. Only extant tracks, firebreaks, drainage ditches and dam margins made good surface visibility. It is estimated that these features comprise around 5% of the pasture surface area.

To check for archaeological features, such as stone arrangements, all pasture land was surveyed using traverses spaced at 200 m intervals. All soil exposures, such as tracks and firebreaks, received total coverage, i.e. traverses at no more than 2 m intervals. The peripheries of pocket woodlands also received total coverage. Although the thickly wooded pockets were almost impenetrable, traverses were made through them at approximately 50 m intervals.

All exposed surface soils and sediments in the survey area were totally surveyed. It is estimated that approximately 5% of the pasture and woodland was inspected. Therefore, over 15% of the survey area was actually inspected.

1.6 DESCRIPTION OF CULTURAL MATERIAL

Despite 10 person-days of survey no cultural material was located. The complete absence of even isolated finds was surprising. It is possible that, where these may have been discarded, the cumulative effects of ploughing, vehicular traffic and other soil disturbance caused downward displacement through the medium quartz sands.

1.7 DISCUSSION OF RESULTS OF SURVEY

It was suggested in Section 1.3 that the main foci of economic life about the Lower Blackwood and Scott Rivers district were probably river systems, swamps and wetlands. These would have provided a range of vegetable, amphibian and invertebrate resources in, and around, their margins. In contrast, the productivity of the woodlands, although presently little studied, is likely to have been of lower (cf. Ferguson 1985). The use of the wooded plains was probably intermittent, generally occurring in summer.

The survey area lacks any of the drainage features identified as significant to local settlement/subsistence patterns. Given the relatively low site density for the region (cf. Dortch n.d.) the absence of occupation sites in the survey area is not unexpected. The total absence of isolated pieces is curious, however, and it can only be assumed that they have been vertically displaced in the quartz sands of the A horizon.

1.8 SIGNIFICANCE OF CULTURAL MATERIAL AND RECOMMENDATIONS

Given the lack of any archaeological sites within the boundaries of the proposed project area, the issue of significance does not arise.

Should the developer uncover archaeological material during the process of earthmoving it should notify the Department of Aboriginal Sites of the Western Australian Museum, as outlined in Section 17 of the Western Australian *Aboriginal Heritage Act 1972-80*.

It is recommended that adequate archaeological investigations have been carried out at the Beenup Project and that the development be allowed to proceed.

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2.0 ETHNOGRAPHIC SURVEY

2.1 INTRODUCTION

This section of the report presents details of an ethnographic survey carried out in the vicinity of the proposed mineral sands development at Beenup, approximately 17 km north-east of Augusta, W.A. The survey area is approximately 15 km² and is located in farming country just north of Scott National Park. Research for this report was carried out through the Centre for Prehistory, The University of Western Australia for Lewis Environmental Consultants, acting for their client B.H.P. Exploration.

The purpose of this survey was to locate any sites within the survey area (see Figure IX-1) which have significance for living Aboriginal people and to make an assessment of any such sites in terms of Western Australia's *Aboriginal Heritage Act* 1972-1980. This survey involved examining site documentation for the area and previous historical and ethnographic accounts of the region as well as a visit to the proposed development in the company of Aboriginal spokespeople for the area.

A review of the site files of the Department of Aboriginal Sites, Western Australian Museum, carried out by the Centre for Prehistory, The University of Western Australia, indicated that no sites of significance to Aboriginal people have been registered in the vicinity of the survey area. An ethnohistorical review of the region, also carried out by the Centre for Prehistory, indicated no known sites of significance to Aboriginal people in the area. The Aboriginal people consulted during this survey located no sites of significance within the boundaries of the survey area.

The account of the present survey is presented here in narrative form in order to stress both the results of the survey and the process by which the results were produced. In this way I believe the veracity of the results is more easily evaluated.

2.2 HISTORICAL AND CULTURAL BACKGROUND

An account of the historical and cultural background concerning the particular Nyungar adaptations in the region surrounding the survey area is located above, in the Ethnohistorical section of this report. While many have identified a tendency towards matrilineal forms in the early reports, the reconstructions of the social organisation and culture of this area have been problematic (Berndt 1979; Crawford 1981; Howard 1981:1-37). The ethnohistorical account is important in identifying the survey area as being in perhaps the ethnographically least known region of the south-west of Western Australia. For the purposes

of this survey I concentrated on locating individuals who have ties to the region surrounding the proposed mineral sands development, who are identified by local Aboriginal organisations as having the right to speak for the area and who identify themselves as having this right.

2.3 ORGANISING THE SURVEY

Before conducting the survey of the proposed mineral sands development it was necessary to locate the relevant Aboriginal spokespeople for the area. In order to do this I first discussed the survey with Mr Philip Fry of the Aboriginal Affairs Planning Authority (AAPA), who deals with Aboriginal organisations in the south-west on a regular basis. From Mr Fry I received a list of several Aboriginal organisations located in Bunbury, Collie and Albany, and telephone numbers or addresses where they could be reached.

I first contacted the Southern Aboriginal Corporation office in Albany and, after briefly outlining the survey and the area to be considered, was advised to contact Ms Rose Whitehurst of their Bunbury office. I then contacted Ms Karen Calgaret of the Bunbury Aboriginal Progress Association and arranged a meeting to discuss the survey. As the Southern Aboriginal Corporation and the Bunbury Aboriginal Progress Association share office space in Bunbury it was possible to meet personally with Ms Whitehurst and Ms Calgaret at the same time. The Aboriginal organisation in Collie is not on the telephone so arrangements were made to visit Collie in person.

In the meeting in Bunbury, Ms Whitehurst and Ms Calgaret were most helpful. Without their help the task of conducting this survey would have been much more difficult to organise. After sorting through a long list of potential spokespeople for the survey area, a "short list" of three names was decided upon. I was advised that if they were not the relevant people, these individuals would be able to direct me to the particular spokespeople for the survey area. I was then provided with a list of their names, addresses, and phone numbers where applicable, and a set of maps indicating how they could be found. One of these individuals resided in Bunbury, one in Busselton, and the last in Collie. The names of these individuals are not given in this report but they have been lodged with the Department of Aboriginal Sites for future reference.

Unable to contact these three individuals that day, I went to Augusta and was shown over the survey area by Peter Veth, who had already begun the archaeological survey. This reconnaissance provided me with a detailed knowledge of the boundaries of the survey area and the best routes through it.

The following morning I set out to locate the nominated Aboriginal consultants. I stopped first in Busselton and, finding no-one home, went to Bunbury.

Finding no-one home at the Bunbury address, I left for Collie. At Collie I located the man whose name I had been given and discussed the survey with him. He had been involved with several previous surveys in the south-west and knew the type of information that was sought. However, he explained that his country included the area between Collie, Boyup Brook and Narrogin and that his cultural knowledge did not extend to the present survey area. With no prompting from me, he indicated that the people I needed to talk to concerning the survey area were the other two individuals on my list. I asked if there were any other people I should talk to and he said no, the two mentioned would be enough.

Arriving back in Bunbury late that afternoon I made contact with one of these individuals and discussed the proposed survey. This man, in his early fifties, had grown up in the south-west and knew the area of the proposed development. He had previously worked for some time with an anthropologist, a PhD student from the University of Western Australia, and indicated that he was indeed interested in taking part in the survey. Furthermore, of his own accord he insisted that the third man on my list, living in Busselton, must also be consulted as he was the most senior Aboriginal person with cultural knowledge of the area. We made arrangements to locate the other spokesperson, who is not on the telephone, and if possible to conduct the survey on the following day.

The following morning we arrived in Busselton to try to locate the other Aboriginal consultant. He was at home and once the project had been explained to him he was very interested in taking part. He was a man in about his mid-sixties who was born in Augusta and raised in the south-west. He identified both his parents and himself as being unquestionably Pibelman, a dialectal group within the Nyungar people (see Figure 3 for maps indicating two reconstructions of the dialectal distribution in this area of the south-west). Before leaving to conduct the survey we discussed a number of places in the south-west where Aboriginal people had significant interests and some ways Nyungar people had traditionally used the country we were to visit. He noted that the Blackwood and Scott Rivers, near the survey area, had been very important to the Aboriginal people living in this region, as they moved up them in summer, foraging in the areas surrounding them before returning to the coast for winter. This pattern of moving inland from the coast for summer and back to the coast for winter is also reported for the Nyungar people living further east along the south coast, near Esperance (Haebich 1988: Chapter 1). While this information appears to contradict the movement pattern suggested in the Ethnohistorical section of this report, there is no necessary contradiction. The existence of the Blackwood and Scott Rivers providing permanent water supplies, would allow people to move inland in summer whereas in country with less reliable water supplies this would have been impracticable. However at the moment it is not possible to resolve this anomaly due to the lack of empirical

data. The older of the two Aboriginal consultants also told several stories which he identified as "Nyungar history" concerning the creation and destruction of some past and present landforms in the region.

As I described the location of the proposed development to the two Aboriginal consultants they quickly identified other surrounding landmarks: Brennan Ford, Molloy Island and Scott National Park. Neither Aboriginal consultant had any recollection of any sites of significance in the survey area before the survey was conducted but both expressed the need to visit the area and see the country before any absolute answer concerning the local existence of such sites could be given.

In summary, in organising the ethnographic survey of the proposed development the main Aboriginal organisations representing a large area of the south-west were contacted and consulted. Following this consultation the Aboriginal organisations themselves narrowed down my search for the relevant Aboriginal spokespeople. Having located the three individuals identified as potential Aboriginal consultants by these organisations I discussed the survey with them and asked them to nominate any other Aboriginal people who might act as spokespeople for the area. There was agreement among them that they were the two senior people who had the right to speak for the area and that it was not necessary to consult anyone else.

2.4 CONDUCTING THE SURVEY

Driving from Busselton to the survey area the Aboriginal consultants both told stories of their past involvements in the south-west. Both had worked clearing land and on farms in the area and retained considerable knowledge of past landowners and developments that had taken place.

On arriving at the survey area we drove slowly down Scott River Road heading south from the Brockman Highway down to Governor Broome Road. Scott River Road runs virtually through the centre of the survey area and from it we were able to identify all the properties of interest. The consultant who had been born in Augusta and raised in this area indicated that he knew almost half the property owners as, using the company maps, I identified the owners of particular paddocks. On reaching Governor Broome Road we drove eastwards along it until we reached the end of the survey area. In this way we identified the boundaries of the survey area and gained a sense of the country it contained. We also examined air photographs provided by the company to establish whether any known sites could be identified from this source. During this reconnaissance of the survey area the Aboriginal consultants indicated that they knew of no sites of interest or significance to Aboriginal people within the boundaries we had identified.

Following this drive through the survey area we retraced our path so we could get out of the car and inspect some parts of the survey area in greater detail. To accomplish this I identified a couple of areas from the air photographs where the physical features suggested something other than farmland. I also indicated a willingness to stop the car wherever the Aboriginal consultants wished and examine any place they considered worth looking at. In this more intensive inspection of the survey area no sites of significance or importance to the Aboriginal consultants were located.

Having examined the survey area extensively and intensively the Aboriginal consultants were in complete agreement that there were no known Aboriginal sites under threat from the proposed development of the mineral sands project.

On completing the visit to the survey area the Aboriginal consultants expressed an interest in visiting a couple of other areas that were accessible that afternoon. We drove further south along Scott River Road to Brennan Bridge and looked at the Scott River, again discussing the way Aboriginal people had used the rivers as roadways in the past. As we finished up at the Scott River, the Aboriginal consultants decided that they would like to visit Devil's Lair, so with the Aboriginal consultants directing us we travelled back along the Brockman Highway, the way we had come in, past the Bussell Highway, and on up to Devil's Lair. While we could not get into the cave itself, the Aboriginal consultants expressed considerable pleasure on visiting the site. Having completed the survey we left the extreme south-west of the state to return to Busselton, Bunbury and Perth.

2.5 RESULTS AND RECOMMENDATIONS

Prior to the present survey no sites of importance or significance to Aboriginal people were recorded as being near to or within the boundaries of the survey area. During the present survey the Aboriginal spokespeople consulted identified no sites of importance or significance within the survey area. Having visited the survey area and examined the country in detail, they pronounced the area to be clear of any Aboriginal sites.

Therefore, it is recommended that the proposed mineral sands development be permitted to proceed as there are no grounds within the terms of the *Aboriginal Heritage Act 1972-1980* (WA) for preventing such a development.

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ANNEX 1

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 traditional life of 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 of 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 source 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 are 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.

Burials

In the north of the state it was formerly the custom to place the bones of the dead on a ledge in a cave after certain rituals were completed. The bones were wrapped in sheets of bark and the skull placed beside this. In other parts of Western Australia the dead were buried, the burial position varying according to the customs of the particular area and time. Natural erosion, or mechanical earthmoving equipment occasionally exposes these burial sites.

Stone Structures

If one or more stones are found partly buried or wedged into a position which is not likely to be the result of natural forces, then it is probable that the place is an Aboriginal site and that possibly there are other important areas nearby. There are several different types of stone arrangements ranging from simple cairns or piles of stones to more elaborate designs. Some were constructed in connection with food gathering. Low weirs which detain fish when tides fall are found in coastal areas. Some rivers contain similar structures that trap fish against the current. It seems likely that low stone slab structures in the south-west jarrah forests were built to provide suitable environments in which to trap small animals. Low walls or pits were sometimes made to provide a hide or shelter for a hunter.

Elongated rock fragments are occasionally erected as a sign or warning that a special area is being approached. Heaps or alignments of stones may be naturalistic or symbolic representations of animals, people or mythical figures.

Paintings

These usually occur in rock shelters, caves or other sheltered situations which offer a certain degree of protection from the weather. The best known examples in Western Australia occur in the Kimberley region but paintings are also found through most of the state. One or several coloured ochres as well as other

coloured pigments may have been used at a site. Stencilling was a common painting technique used throughout the state. The negative image of an object was created by spraying pigment over the object which was held against the wall.

Engravings

This term describes designs which have been carved, pecked or pounded into a rock surface. They form the predominant art form of the Pilbara region but are known to occur from the Kimberleys in the north to about Toodyay in the south. Most engravings occur in the open, but some are situated in rock shelters.

Caches

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 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.

ANNEX 2

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 other place or thing to which this Act applied 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 excavating of an Aboriginal site and the examination or removal of any thing on or under the site in such 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 the 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 he may, within the time and in the manner prescribed by rules of court, appeal from 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 and land for a particular purpose nothing done by or on behalf of that person pursuant to, and in accordance with any conditions attached to, the consent constitutes an offence against this Act."

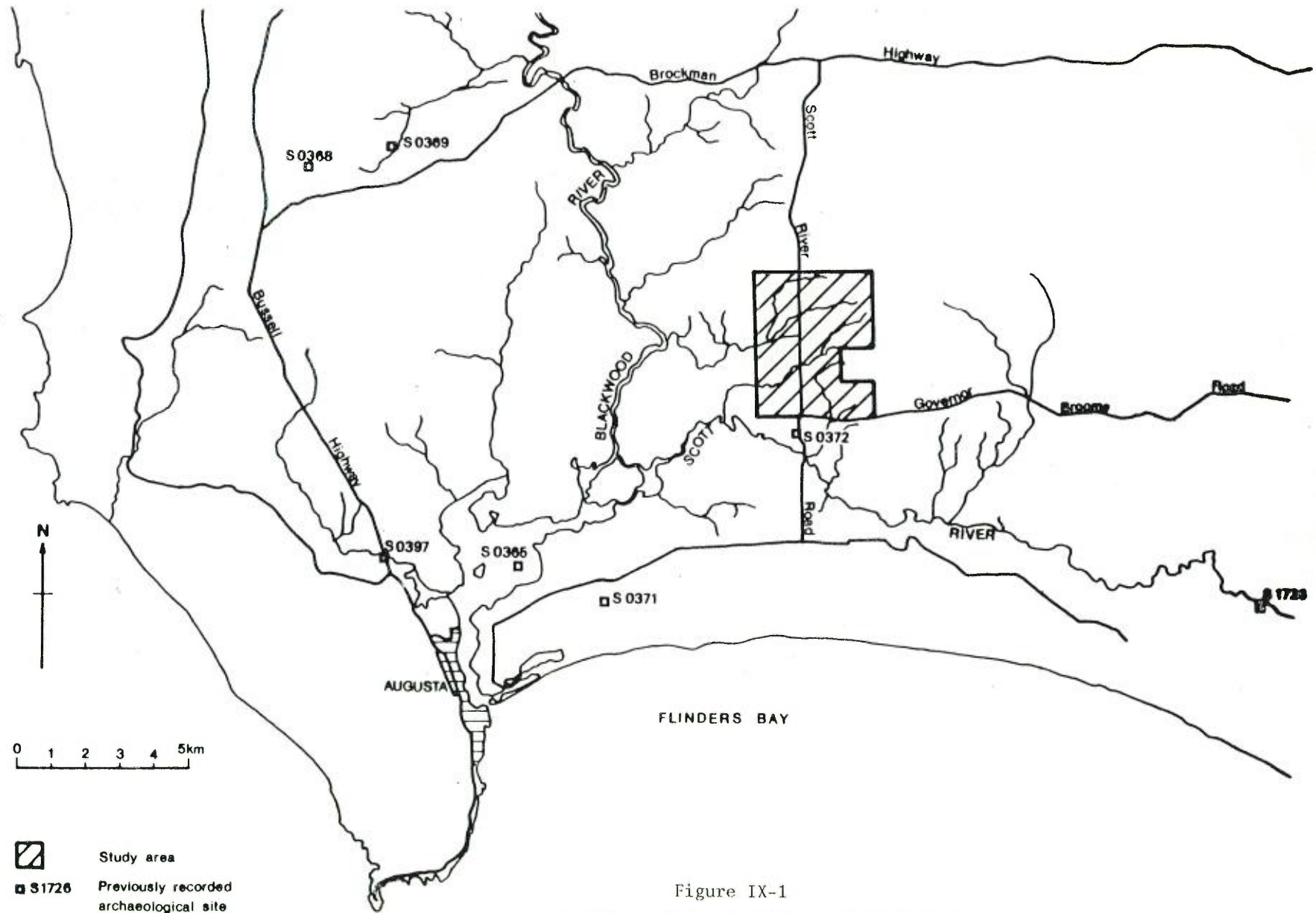


Figure IX-1

Location of survey area and previously recorded archaeological sites

Figure IX-2

Local features of survey area

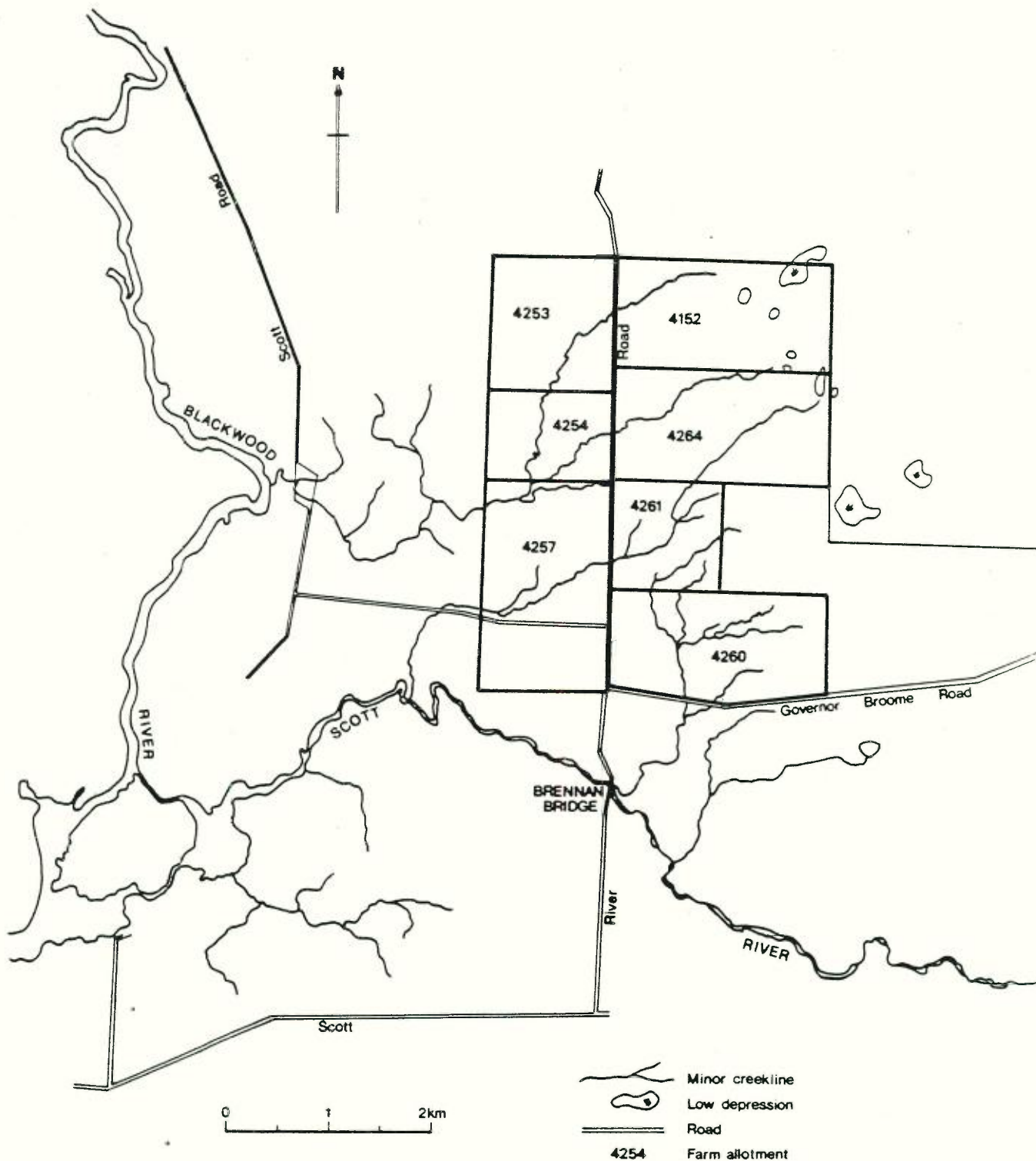
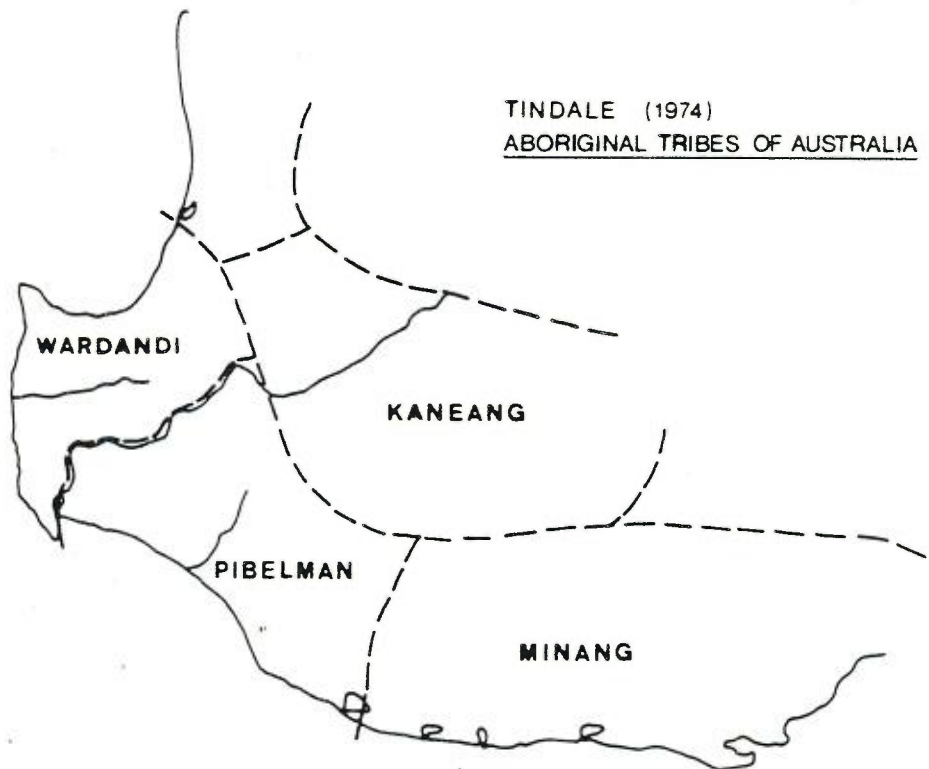
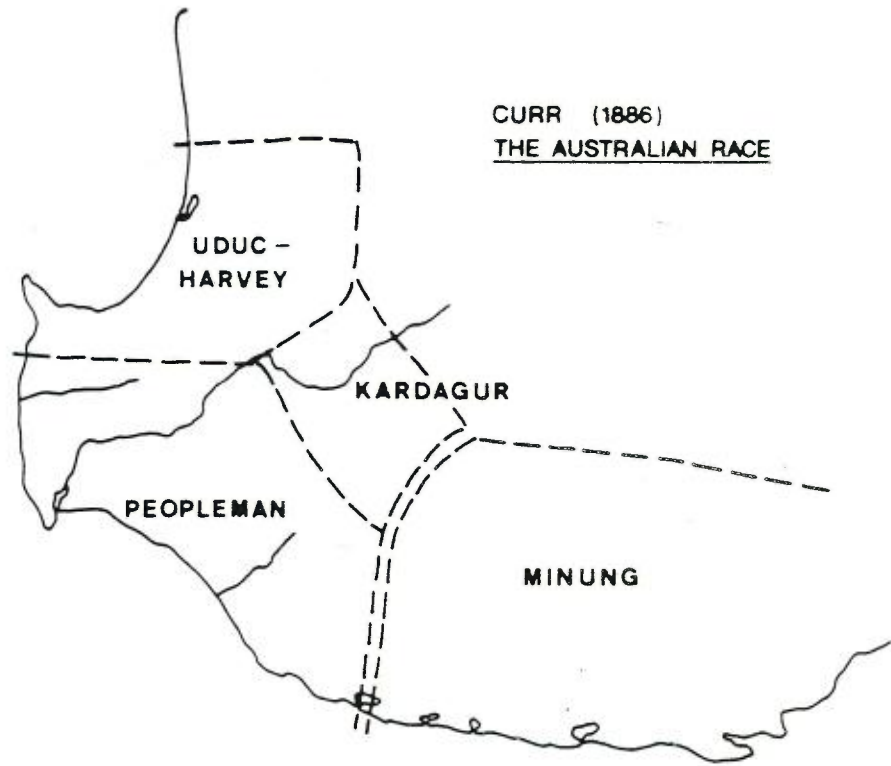
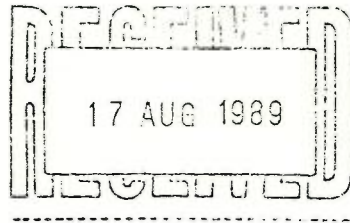


Figure IX-3

Dialectal boundaries after Curr (1886)
and Tindale (1974)



ANNEX 3



Francis Street Perth
Western Australia 6000
Telephone (09) 328 4411
Facsimile (09) 328 8686

Date: 11 August 1989

Your Ref:

Our Ref: 77262
RR:CS

Lewis Environmental Consultants,
P.O. Box 238,
Toowong,
Qld. 4066.

Dear Sirs,

**REPORT OF AN ARCHAEOLOGICAL AND ETHNOGRAPHIC SURVEY NEAR
BEENUP, AUGUST, WESTERN AUSTRALIA**

We have received and assessed the above report.

Although the consultants did not locate any sites within the survey area the *Aboriginal Heritage Act 1972-80* affords protection to sites whether or not they have been previously recorded. Should any sites be uncovered in the course of development the Department of Aboriginal Sites should be advised immediately.

Thank you for your co-operation.

Yours sincerely,

Robert Reynolds
Acting Assistant Registrar
DEPARTMENT OF ABORIGINAL SITES

Branches:
Fremantle Museum
Finnerty Street, Fremantle
Western Australia, 6160
Telephone (09) 335 8211

Western Australian
Maritime Museum
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Western Australia, 6160
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Geraldton Museum
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Appendix X

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SOCIO-ECONOMIC ASPECTS

by

John Mercer & Associates

1.0 INTRODUCTION

This report presents an assessment of the socio-economic effects likely to result from the development of a mineral sands mining and treatment operation situated at Scott River Road in the Augusta-Margaret River Shire, Western Australia.

It is based on ERMP Guidelines issued by the EPA, and on project information available at the end of October, 1989. While this project information may change in its precise detail as project planning progresses, the examination of impacts presented in this report are not expected to vary to any substantial degree. The one major variance which may occur, and which may require reassessment, relates to the transport option finally chosen. At the time of writing this report the method of transport and, more particularly, the actual preferred route for road transport of the project, had not been determined. The project parameters on which this report is based, are outlined in Section 2.

The discussion in this report centres on the Augusta-Margaret River Shire as most, if not all, of the project's social impacts will fall in this geographic area. The economic impacts, on the other hand, will be felt at the local, state and national levels. Given the location of the proposed mine site, and the travel distances involved, it is expected that both Augusta and Margaret River will act as the main dormitory centres for the newcomer population generated by the proposed project. Whilst Nannup is within a reasonable commuting distance, it is unlikely to attract any of this incoming workforce, as the other centres offer a greater range of lifestyle opportunities and facilities. Hence, where matters relating to the ability of the urban locations to accept growth are discussed, the discussion is generally confined to the two main centres of Augusta and Margaret River.

The sources of data used in this Report are referred to in the Bibliography.

2.0 PROJECT DESCRIPTION

The project understanding on which the report is based is outlined in this section. The description put forward here is limited to those items of relevance to the assessment of potential socio-economic impacts.

2.1 PROJECT OVERVIEW

The Beenup mineral sands deposit is situated on Scott River Road approximately 17 km north-east of Augusta.

The project site is located on freehold land, all of which the company has purchased or intends to purchase if the project proceeds. Figure 1-1 shows the project location (refer Figures section in the ERMP).

The Beenup deposit comprises in excess of 500 million tonnes of probable ore. The major mineral contained in the deposit is ilmenite. Other minerals include zircon and rutile. There is an absence of monazite.

The ore is intended to be extracted by an electrically-powered dredge, with the heavy mineral portion being extracted by a wet plant floating in the same pond as the dredge. Waste material is to be returned to the area behind the wet plant, and the heavy mineral concentrate transported to a dry plant for separation into different mineral fractions. It is proposed to site the dry plant in an industrial area to the immediate north of the mining area (Figure 3.2 in Figures section of the ERMP).

Various alternative methods for the transport of the mineral product to market have been being considered. A full discussion of these can be found in Section 3.4 of the main report. The two potentially viable options which have been identified to date are:

- (1) Transportation of the dry product via Scott River Road south to a stockpile located on the shores of Flinders Bay approximately 5 km east of the mouth of the Blackwood River. The mineral will then be loaded via conveyor on a 2 km jetty, directly onto vessels for export.
- (2) Transportation of the dry product via Sues Road north to Bunbury. The mineral would then be exported from Bunbury.

It is understood that Option (2) is the preferred option, and this is the option examined in this report.

It is planned, as part of the normal course of the mining operation, to progressively rehabilitate the mined area. The rehabilitation programme is discussed in Section 3.1.10.

The main project infrastructural requirement relates to the provision of a power supply to the site capable of providing some 7.5 to 9.5 MW of power. It is probable that this supply line (132 kVa) will come from the east, rather than from Margaret River, although this matter is currently subject to negotiation. It is understood that the impacts associated with the provision of this supply are to be separately assessed and hence are not examined here.

At some stage of the project it will be necessary to close a section of Scott River Road, as it is on the proposed mining area. Whilst an alternative access will be provided, the location of this has yet to be determined.

The proposed site contains groundwater of good quality from an extensive aquifer system in the area. The quality and quantity of water available is considered adequate to meet operational requirements.

2.2 PROJECT WORKFORCE

The project consists of two phases - a construction phase and an operational phase. The characteristics of each are outlined below.

2.2.1 Construction phase

The construction phase of the project is expected to take approximately 18 months and will involve a peak construction workforce of some 200 persons. Construction is expected to commence in September 1990 and be completed by March, 1992. The expected buildup on a bimonthly basis is as follows:

<u>Period</u>	<u>Workforce</u>
1	5
2	25
3	60
4	120
5	180
6	200
7	200
8	150
9	50

The skill distribution of this workforce, which will be made up of approximately 5% company personnel and 95% contractors and their staff, is given in Table X-1.

TABLE X-1
Construction Workforce Skill Profile -
Beenup Project

Skill Group	%
Staff	11
Mechanical Trades	33
Electrical Trades	10
Materials Handling	12
Painters	4
Labourers	18
Administrative/Clerical	12

(Source: MDL)

No shift work, apart from site security operations, will be undertaken during this phase.

It is proposed to house all the single construction workforce at the project site in a construction camp complex. Married construction personnel will either use a proposed caravan park to be constructed adjacent to the Blackwood River, near the Alexandra Bridge on existing or existing rental accommodation.

2.2.2 Operational phase

2.2.2.1 Mine and plant

The operational phase of the project is scheduled to commence early in 1992 following plant commissioning. The operational workforce is expected to number 115 persons of whom 96% will be company employees and 4% contract personnel. This workforce will be utilized on a 3 x 8 hr shifts per day basis, seven days a week. Table X-2 gives the expected skills profile of the permanent workforce.

TABLE X-2

Operational Workforce Skill Profile -
Beenup Project

Skill Group	%
Management	12
Technical	7
Administration	8
Mechanical Trades	4
Electrical Trades	3
Plant Operators	39
Trades Assistants	5
Apprentices	1
Labourers/General Hands/Drivers	21

(Source: MDL)

It is expected that all workers will be employed under either the Mineral Sands Mining and Processing Industrial Award or the Mineral Sands Mining and Processing (Engineering and Building Trades) Award.

It is understood that the WA Mines Department Acts and Regulations will apply to the site, and that the occupational health and safety measures adopted under the ambit of this legislation will be employed. The mine will employ a safety officer, and accredited first aid workers will be present on all shifts. A fire tender will be available on site.

Mineral Deposits' recruitment programme and training policy will be to recruit and train workers locally where possible. It is anticipated that up to 35% of the workforce may necessarily be recruited outside the Augusta-Margaret River Shire due to the specialist nature of the skills being sought. This figure is based upon the current state of the labour market in the Shire, and assumes that all plant operators will be recruited and trained locally. If appropriate local persons to be trained as plant operators are not forthcoming at the time of recruitment, an additional 24% of the workforce may need to be recruited externally. This latter state of affairs, however, is most unlikely given the company recruitment experience in other rural areas containing good farming skills. The company is an equal opportunity employer.

As the proposed mine is not located in a remote, isolated area, and as a large measure of local recruitment is expected, it is the Company's intention to not provide housing for its employees. It is intended to offer access to the Company's housing scheme for staff transferred into the area.

It is also intended that employees be responsible for their transport to and from work using whatever means they chose. It is envisaged that most work trips will be made by private car, and that a degree of car pooling will take place.

2.2.2.2 Product transport

The transport of product from the mine site's industrial area to the proposed port facilities at Bunbury will be undertaken by an outside contractor.

The contractor's workforce is expected to comprise 35 persons who are expected to be located both in Bunbury and on site. Therefore about half the contractor's workforce is expected to reside in the Shire.

2.3 PROJECT REVENUES AND EXPENDITURES

The project's construction is expected to involve the expenditure of approximately \$104 million over an 18 month period commencing in September, 1990. Operating costs are expected to involve the expenditure of \$20 million annually. During both project phases the following distributions of expenditure is anticipated.

TABLE X-3
Expenditure Distribution, Beenup Project
(%)

Location	Construction Phase	Operational Phase
Overseas	9	Nil
Australi	91	100
Western Australia	48	80
South West Region	38	73
AMR Shire	26	36

The project's production will be exported overseas in its entirety. Revenues are anticipated to average \$50 million per annum based on current prices and exchange rates.

3.0 COMMUNITY ENVIRONMENT

This section contains a description of the principal components of the existing community environment which are likely to be affected by the proposed project. For the most part this discussion is confined to the Augusta-Margaret River Shire area, and the two main settlements of Margaret River and Augusta.

3.1 ECONOMIC PROFILE

3.1.1 Overview

The historical base for economic activity in the Leeuwin-Naturaliste region has been various forms of primary production, namely agriculture, timber production and, to a lesser extent, fishing. Today, the economy is more diverse with a major dependence on agriculture and tourism, and with significant contributions from the mining and service industry sectors. The timber and fishing industries remain important but now play a lesser role in the economy of this area.

It is expected that agriculture and tourism will remain the largest contributors to the economy in terms of employment and local expenditure, but if additional mining projects (coal or mineral sand mining) were to be established in the region, they would be the major industry sector in terms of gross domestic product generation. In agriculture, horticultural pursuits will contribute an increasing proportion of agricultural product with dairy production also increasing at the expense of meat production.

The tourism industry is expected to grow, despite the problems of a high degree of seasonality which is evident at present, and the popularity of the area as a retirement and alternative lifestyle centre should ensure that service industry levels increase.

3.1.2 Augusta-Margaret River Shire Economy

At the Shire level, the local economy is dominated by agricultural and forestry sectors which together with tourism provide the major sources of employment. The Shire also contains several small-scale manufacturing and farming enterprises, and service industries geared both to local and tourist demand.

3.1.2.1 Agriculture

The main pastoral activities are cattle grazing for meat (27,800 head), dairy production (16,400 head) and sheep for meat and wool (77,500 head). These activities utilize 41,800 hectares of land. The Shire supports a substantial viticulture industry with 25 vineyards (1988) producing wine for Australian consumption. The production of fruit and vegetables is not as substantial but nevertheless is

important. This sector involves the production of kiwi fruit, potatoes, and a variety of other vegetables. The horticultural industry in the Shire utilized some 272 ha of land in the 1987-88 season. The total gross value of agricultural production was \$22.721M, which is approximately 1% of the State's total value of agricultural production.

3.1.2.2 Forestry

Forests occupy approximately 25% of the land area of the Shire. The timber industry is significant, mainly producing hardwood for the building industry, and local furniture and craft enterprises. It is expected that the current downward trend in the industry will continue as the resource declines. No production figures are available on a Shire basis. The value of production for the industry in the Vasse Region in 1984/85 was estimated to be \$5.7M.

3.1.2.3 Manufacturing

The manufacturing sector comprises 22 establishments (1986-1987) which produced goods to a value of \$9.9M. The principal activities in this sector include sawmilling, furniture, wood crafts, local construction materials and metal fabrication, and surfing products.

3.1.2.4 Construction

The construction industry is principally involved in residential buildings, farm buildings and tourist facilities. The 1987-88 year saw 125 houses and 39 residential units commenced, while non-residential building to a value of \$612,000 was undertaken.

3.1.2.5 Fishing

Augusta is the main fishing centre, with minor commercial activity at Margaret River, Hamelin Bay and Hardy Inlet. The total recorded catch for the 1985-86 season was 600 tonnes being mainly fish with smaller quantities of lobster, abalone and molluscs. The potential for expansion of this industry is limited by the size of the local resource.

3.1.2.6 Mining

The Shire does not contain any mining for minerals, coal or oil. A local quarry provides lime sand for fertiliser use, and several gravel pits provide material for road base construction.

3.1.2.7 Tourism

Tourism has grown rapidly in the Shire over the past decade, and now constitutes an important sector of the local economy. It provides substantial consumer expenditure for accommodation, retail and personal services establishments.

The Shire principally functions as a holiday and weekender destination for Westralians, and Perth in particular. The Shire has a large variety of tourist attractions and existing infrastructure to service tourism. The coast is characterised by rocky cliffs and sandy bays and offers ideal surfing conditions, swimming beaches, and fishing. Over 25% of the Shire is forested and contains Aeolian limestone cave systems which are open to the public. The area also contains several industries of interest to the tourist - namely viticulture, fishing, timber production, agriculture and marron production. In addition, there are several historic sites which have tourist appeal, and several events which attract visitors such as the Margaret River world surfing championships.

The Western Australian Tourism Commission estimates that approximately 63% of visitors to the Shire come from elsewhere in Western Australia, 36% are interstate visitors and 1% are international visitors. Tourist visitation is very seasonal, with the summer school holidays providing the peak visitation numbers. The busiest months of the year in descending order of importance are January, February, March, April and September.

The following table giving figures for the March quarter, 1989, illustrates the current situation of the industry.

3.1.2.8 Retail sector

No recent Shire-specific data on the retail sector is available. The data which is available relates to the last retail census, undertaken in 1985-86.

This census indicated the Shire contained 73 retail establishments, which provided employment for 227 persons and paid \$1.046M in wages, and which had a combined turnover of \$16.47M.

The Shire contains approximately 7200 m² of retail floorspace. This figure excludes service trade floorspace such as banks, offices, restaurants and showrooms. Most of this space is situated in Margaret River (which accounts for some 5000 m²) comprises "specialty" shops and a 900 m² supermarket. The overall Shire retail provision level is approximately 143m²/100 persons.

TABLE X-4

Augusta-Margaret River Shire
Selected Peak Season Tourist Accommodation Data
(March Qtr. 1989)

Accommodation type	Hotels, Motels & Guest Houses	Caravan Parks	Holiday Flats, Units & Houses
Total Sites/Rooms/Units	178	1004	32
Guest/Site/Unit Nights ('000)	22.12	40.7	1.5
Site/Room/Unit Occupancy Rate (%)	70	45	70
Guest Arrivals/('000) Unit lettings	11.0	34.2	0.3
Accommodation Revenue (\$'000)	na	450	48

(Source: ABS)

No reliable figures are available on the overall contribution of tourism to the Shire economy.

3.1.3 Employment

The Shire's workforce at the time of the 1986 Census comprised 2324 persons of whom 292 were unemployed. It is estimated that the workforce currently numbers some 2600 persons of whom approximately 200 are unemployed. These figures indicate that the unemployment rate has decreased since the census (12.5%) to be in the order of 7.4% at June, 1989. Over the same period the labour force participation rate has increased marginally from 60.47% to an estimated 61.2%.

Historically, the characteristics of the Shire workforce are as follows:

TABLE X-5

Workforce Characteristics,
Augusta-Margaret River Shire

	1976	1981	1986
Workforce	1649	1659	2324
Workforce Participation Rate (%)	75.23	60.86	60.47
Unemployed	53	111	292
Unemployment Rate (%)	3.21	6.73	12.56

(Source: ABS Census Data)

An indication of the areal distribution of the unemployed labour force resource in the Shire may be gained by examining Department of Social Security records for the numbers of persons receiving unemployment benefits. The figures given in Table X-6 relate to postcode districts and the Bunbury Administration Region of the Department of Social Security:

TABLE X-6

Unemployment Benefit Recipients,
Augusta-Margaret River Shire

	June 1986	June 1987	June 1988
Bunbury DSS Region	3023	3241	2608
Post Code District:			
Cowaramup	57	59	41
Margaret River	177	196	172
Witchcliffe	21	25	21
Karridale	22	30	13
Augusta	33	38	28

It should be noted that the unemployment figures quoted here relate to June which is the low season as far as employment is concerned.

Tables X-7, X-8 and X-9 examine labour force status, occupation and industry employment as given by the 1986 ABS Census. These figures indicate the general composition of the Shire's workforce, although the service industry and construction sectors would now be slightly expanded given the growth which has occurred in the tourism industry and the local resident population since 1986. The workforce characteristics presented in these tables reflects the predominance of agriculture and tourism sectors in the Shire economy.

TABLE X-7

Augusta-Margaret River Shire -
Labour Force Status

Census	1976	1981	1986
1. Employed Workforce	1309	1539	2032
Wage/Salary Earner	49.4%	52.9	58.8%
Self-Employed)	34.2%	28.8%	
Employer)	40.1%	9.4%	9.4%
Unpaid Helper	11.5%	3.4%	2.8%
2. Unemployed Workforce	53	111	292
Seeking Full-time work	na	na	77.7%
Seeking Part-time work	na	na	22.3%

(Source: ABS)

TABLE X-8

Augusta-Margaret River Shire -
Labourforce by Occupational Class (%)

Census	1986
Managers/Administrators	29.7
Professionals	16.2
Tradespersons	12.8
Clerks	9.1
Sales & Personal Services	10.2
Plant & Machine Operators	4.9
Labours & Related Workers	15.0
Other	2.1

(Source: ABS)

TABLE X-9

Augusta-Margaret River Shire -
Labourforce by Industry Class (%)

Census	1976	1981	1986
Agriculture/Forestry			
/Fishing	41.2	36.5	25.5
Minin	0.1	0.2	0.5
Manufacturing	8.2	9.9	2.4
Electricity/Gas/Water	2.5	1.6	1.4
Construction	6.3	6.4	8.4
Wholesale/Retail Trade	10.5	10.6	13.1
Transport & Storage	3.1	3.1	2.5
Communications	1.7	1.2	1.1
Finance/Property			
/Business Serv.	1.3	3.2	4.9
Public Administration, etc.	2.6	3.2	3.5
Community Services	9.9	10.3	17.8
Recreation, Personal & Other Services	4.3	4.8	9.6
Other	8.2	9.9	2.4

(Source: ABS)

3.1.4 Minerals Sands Industry

The South West Region of Western Australia is a major producer of mineral sands, with the rich deposits in the vicinity of Capel forming the basis of the industry. The region produces in excess of 14% of the world's ilmenite. The value of mineral sands production totalled \$75.78M in 1986-87, and the industry employed in excess of 350 persons.

Western Australia is now the leading producer in the international mineral sands industry. The State supplies 43% of the world's ilmenite, 21% of the rutile, 40% of the zircon and 54% of the monazite. Mineral sands production in 1987-88 totalled 1.61 million tonnes valued at \$293M.

3.1.5 Augusta-Margaret River Shire Finances

The Shire covers an area of 2370 square kilometres with approximately one third of this area being held in freehold title. Total revenue for the 1987-88 financial year amounted to \$3.283M of which rates revenue accounted for 26.6%, and government grants 28.1%. Total outgoings amounted to \$3.175M and comprised recurrent payments (49.5%), capital payments (44.4%) and debt servicing (6.1%). This spending was apportioned as follows:

TABLE X-10

Shire spending 1987-88

	\$'000	%
General Public Service	426.9	14.3
Public Order & Safety	70.7	2.4
Health	55.5	1.9
Housing & Community Amenities	627.4	21.0
Recreation and Culture		
- Public Halls & Civic Centre	27.7	0.9
- Recreation and Sport	202.8	6.8
- Libraries, other culture	38.7	1.3
Roads and Transport	1174.2	39.4
Other Payments	357.2	12.0
Total Payments for Goods, Services and Land	2981.1	100.0

As the above figures show, trading for the 1987-88 financial year yielded a small surplus. It is Council's current policy to raise a minimum of 50% of its revenue needs from local activities, and to keep rate increases in line with the Consumer Price Index.

The Council's ability to recoup costs arising from development is limited by State Government regulations. At present, the Council is only able to recoup 21% of operating costs in the provision of building services, 2% of planning services costs, and 15% of health services costs.

Council's administration building is at capacity. Any increase in demand for Council services requiring additional staff and facilities will necessitate the need to

physically expand Council's office complex. There may be a possible need in the short term to provide an alternative building to house the Shire Library.

Council is currently concerned that the increasing demand on its resources for tourist related facilities may reduce the availability of funds for meeting the needs of the permanent population. It is investigating ways to recoup some of this tourism-related expenditure from the industry. Council's aim is to ensure that no undue impact is placed on the resident community as a result of this growth.

Council considers that its level of indebtedness is reasonable as few loans have been raised recently for recovery expenditure purposes. It is Council's policy to utilize loan funds for financing capital projects, and to limit annual loan repayments to a maximum of 30% of rate income (long term) and 45% of rate income in the short term (i.e. 5 years).

3.2 DEMOGRAPHIC PROFILE

3.2.1 Population overview

The South West Region of Western Australia is the most densely populated, rural region of the State. In June, 1987 the estimated resident population was 121,763 persons representing 8% of the State's population and 29% of the population living outside the Perth Metropolitan Area.

The Shire of Augusta-Margaret River with a resident population of 4,825 persons in 1986, contained 4.06% of the region's population. This compares with 3.61% in 1981, and 3.5% in 1976.

Over the 10 year period 1976-1986, the South West Region's population grew at an annual average rate of 3.27%, whereas the population of the Augusta-Margaret River Shire grew at a rate of 4.83%. Intercensal period changes are given in Tables X-11 and X-12.

3.2.2 Augusta-Margaret River Shire

3.2.2.1 Resident population

The past decade has seen a substantial change in the Shire's population characteristics. Rapid growth in visitor and resident numbers has taken place, with the resident population increasing 31% between 1981 and 1986. The latest ABS population estimate for the Shire is 5,505 persons (June, 1988). Shire population growth projections, prepared by the Department of Planning and Urban Development, indicate that the Shire can expect a resident population of between 8,700 and 10,600 by the year 2001. Figure X-1 illustrates these projections.

TABLE X-11

Population Growth Characteristics

	1976	1971	1986
1. Augusta-Margaret River Shire			
- Resident Population	3,011	3,680	4,825
- Average Annual Rate of Growth (%)	4.08	5.56	
- Percentage Share of SW Region's growth	4.23	6.79	
2. South West Region			
- Resident Population	86,070	101,898	118,761
- Average Annual Rate of Growth (%)	3.41	3.10	

(Source: ABS, SWDA.)

Population estimates for adjoining Shires are outlined in Table X-12. They relate to total not resident population.

TABLE X-12

Population Estimates

Year (30th June)	% Change				
	1986	1987	1988	86-87	87-88
Shire					
Augusta-Margaret River	5033	5251	5505	4.3	4.8
Busselton	11933	12376	12955	3.7	4.7
Nannup	1132	1157	1185	2.2	2.4

(Source: ABS)

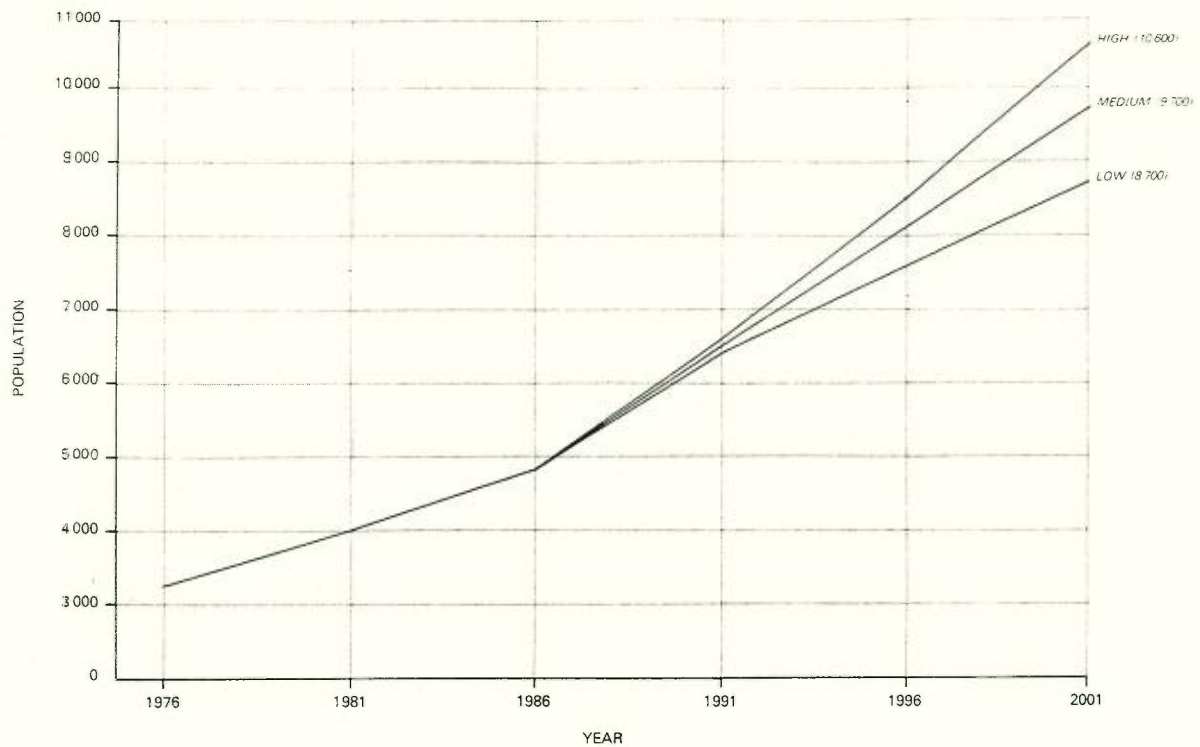


FIGURE X-1

**Augusta-Margaret River Shire -
Project Population**

The most likely outcome is considered to be a doubling of the Shire's resident population by the year 2001. However, should new industries establish in the area and the growth in tourism and recreation continue at present levels, the higher projection would represent the most likely outcome.

It is probable that the advent of the Beenup project will generate population growth in both the Margaret River and Augusta townsites as well as in the surrounding rural localities, as newcomers take advantage of the lifestyle opportunities offered by the Shire. An indication of the present geographical distribution of population within the Shire is given in Table X-13. These estimates are based on 1986 Census collector's district boundaries and figures.

TABLE X-13

Population Distribution -
Augusta-Margaret River Shire, 1986

Locality	Population
1. Augusta Town	933
2. Augusta Rural comprising	954
- Part Forest Grove/Hamelin Bay	250
- East Augusta/Scott River/Warmer Glen	245
- Karridale, Kudardup/Deepdene, Molly Is.	459
3. Margaret River Town	1276
4. Margaret River Rural comprising	2173
- East Witchcliffe/Rosa Brook /Rosa Glen	360
- Witchcliffe/Prevelly/Burnside	413
- Osmington/Upper Margaret River	174
- Gracetown/Ellen Brook	460
- Cowaramup/Treeton	516
- Part Forest Grove/Hamelin Bay	247

(Source: ABS 1986 Census)

The areas currently experiencing the greatest pressure from increases in resident population are the rural fringes of Augusta, the Karridale locality, Molloy Island, and Margaret River West. The most dramatic growth has taken place in the Margaret River West area due to increases in permanent residences in Gracetown and Prevelly, the growth in rural/residential holdings, and growth within the western part of the Margaret River townsite itself.

3.2.2.2 Tourist population

In addition to the Shire's permanent population, the Shire has a floating tourist population. The Department of Planning and Urban Development estimates that peak tourist numbers during the summer season reach some 12,400 persons, with the average throughout the summer being approximately 6,000 persons. These persons are overnight or longer term tourists. If one includes an estimated 3,000 (peak) daytrippers, the population of the Shire can approach 20,000 persons on occasions. This tourist influx places a severe strain on the Shire's facilities and financial resources.

3.2.2.3 Age/Sex structure

The composition of the Shire's population has undergone change as the resident population has grown. The Shire has seen an increase in the 25-40 age group, a decline in the 40-60 group and an increase in 60+ age group over a ten year period. Table X-14 indicates the composition in June, 1986.

From the table it is evident that Margaret River contains a substantial proportion of young to middle families as befits the Shire's main service centre, whereas Augusta is heavily weighted towards an older population profile in keeping with its role as a retirement/holiday location.

3.2.2.4 Ethnicity

The Shire contains a small proportion of persons who were not born in Australia and who do not come from countries where the major language is English. Approximately 1.5% of the population speak another language at home, the principal ones being Italian, German, Dutch, French, Chinese, Polish and Greek. All can speak English sufficiently to carry out day-to-day activities. In birthplace terms, 82% of the population was born in Australia, 9.9% in the U.K., 1.4% in New Zealand, 1.7% in Europe, and the remaining 5% comprises persons from other locations.

3.2.2.5 Family structure

The family structure evident in the Shire reflects the lifestyles being followed, and the groupings in the community. Firstly, the traditional family group and extended family group together comprise 70.9% of the population. Single persons, lone parents, and adult groups comprise the remainder. Table X-15 depicts the relativities between each group.

It is also relevant to examine family structures in terms of family life cycle stage as this is an important indicator of community service needs. As this information is not published by the ABS, the figures in Table X-16 are estimates derived from census data. Estimates are presented for the four commonly-recognised family stages - young, middle, mature and late.

TABLE X-14

Population Age/Sex Structure:
Augusta-Margaret River Shire, 1986

Age Group	SHIRE				MARGARET RIVER (TOWN)				AUGUSTA (TOWN)			
	Males	Females	Persons	%	Males	Females	Persons	%	Males	Females	Persons	%
0 - 4	268	233	501	9.4	59	54	113	8.9	20	31	51	5.5
5 - 9	262	235	497	9.3	58	43	101	7.9	41	37	78	8.4
10 - 14	255	237	493	9.2	58	55	113	8.9	36	38	74	7.9
15 - 19	207	169	376	7.1	51	46	97	7.6	25	34	59	6.3
20 - 24	171	168	339	6.4	49	53	102	8.0	17	18	35	3.8
25 - 29	233	236	479	8.8	69	68	137	10.7	22	28	50	5.4
30 - 39	475	466	941	17.7	110	123	233	18.3	63	60	123	13.2
40 - 49	269	233	502	9.4	72	45	117	9.2	42	46	88	9.5
50 - 54	101	117	218	4.1	18	23	41	3.2	20	22	42	4.5
55 - 59	123	114	237	4.4	26	24	50	3.9	26	27	53	5.7
60 - 64	141	116	257	4.8	26	19	45	3.5	36	45	81	8.7
65 +	245	257	502	9.4	55	72	127	9.9	89	108	197	21.2
TOTAL:	2750	2581	5331	100.0	651	625	1276	100.0	437	494	931	100.0

(Source: ABS Census)

TABLE X-15

Family Structure
Augusta-Margaret River Shire, 1986
(%)

Group	Shire	Marg. River	Augusta
Single persons	17.2	19.8	21.7
Adult group	4.8	5.9	6.5
Lone parent	7.1	7.9	6.8
Couple	27.5	25.4	37.4
Couple + children	32.7	30.1	20.3
Extended family	10.7	10.9	7.3

(Source: ABS Census)

TABLE X-16

Family Life Cycle Stage,
Augusta-Margaret River Shire, 1986.

Group	Shire	Marg.River	Augusta
Young family	325	88	32
Middle family	378	86	46
Mature family	202	43	33
Late family	489	97	140

Source: JMA estimate

Typically, the young family consists of young married couples with no children or pre-school children; the middle family comprises families with children in the 5-15 years age group; the mature family consists of families with children generally 15 years of age or older but still living in the household; and the late family comprises those family units where most children have left the unit to follow their own lives. As Table X-16 demonstrates young and middle families dominate with a substantial number of late families also evident. This reinforces the comments made earlier pertaining to the Shire's age/sex composition - that is, the Shire contains a relatively young population engaged in economic enterprises with a substantial elderly component reflecting persons who have become resident in the Shire seeking a satisfactory retirement lifestyle.

3.2.2.6 Personal income

In general, it would appear from the 1986 Census figures that the bulk (87.6%) of personal annual incomes were below \$26,000 (1986 Dollars). The equivalent income in September, 1989 Dollars is \$33,500, after adjusting for inflation. Table X-17 identifies the income groups within the community, in terms of individual, family and household income levels. It should be noted that the income levels reflect in part a lifestyle choice by a proportion of the population who trade off the earning of income against the opportunity to practice a particular way of life.

TABLE X-17

Annual Incomes
Augusta-Margaret River Shire, 1986
(\$1986)

Income Category	Individuals (%)	Families (%)	Households (%)
NIL	11.2	1.4	1.3
\$1 - \$6000	31.5	4.3	10.7
\$6001 - \$18000	36.1	41.9	40.7
\$18001 - \$32000	11.7	25.3	22.3
\$32001 - \$50000	2.4	9.8	9.1
\$50000+	1.1	4.4	4.6
Not Given	6.1	12.8	11.5

(Source: ABS Census)

By comparison, the West Australian median income level for individuals in June, 1986 was \$17,927. The median Australian family income for married couples for the same period was \$36,115.

An indication of those persons whose incomes can be regarded as "fixed" is given by examining the numbers of persons in receipt of various government pensions. It is estimated that approximately one quarter of the Shire's population receives either pensions or benefits from the Commonwealth Government.

3.2.2.7 Mobility

The growth and change evident in the Shire's population is also demonstrated in terms of population mobility. The 1986 Census indicates that over 35% of the Shire's population had changed residential addresses between June 1985 and June 1986 and that only 40% of the population were still living at the same address they occupied five years earlier at the time of the 1981 Census. This pattern of mobility highlights the influx of new settlers into the area and also the movement of residents within the Shire. Changes of residential address within the shire are precipitated by the summer changeover of many rental properties from a permanent letting status to a holiday, short-term letting status, and the overall shortage of rental accommodation which causes people to accept temporary accommodation until such time as suitable housing becomes available.

3.3 HOUSING

The Shire's housing market is currently very tight with supply and demand very closely balanced. Over the past few years demand for housing has outstripped supply generating a consequential rise in housing and property prices. In Augusta, there is a land and housing shortage whereas in Margaret River there is surplus land for home building available.

3.3.1 House/Land prices

Current residential prices in Augusta vary between \$37,000-\$80,000 for a standard residential allotment, and between \$80,000 and \$350,000 for an established home. Homes with views across the Blackwood River and Flinders Bay command the highest prices. Property prices in East Augusta for a standard residential allotment without town services range between \$37,000 and \$52,000 depending on proximity to the river.

Residential land prices in Margaret River generally vary between \$35,000 and \$50,000 for a standard serviced allotment, and between \$50,000 and \$75,000 for a small acreage block. Established house prices vary between \$85,000-\$150,000 (standard allotment) whereas prices for homes on small acreage properties vary between \$120,000 and \$315,000. Residential land at Prevelly Park ranges between \$50,000 and \$86,000 with the average established home selling in the \$120,000-\$140,000 range.

3.3.2 Land availability

An indication of the current rate of land development for residential purposes is given in the following Table X-18. The table also indicates the potential which exists under the current Town Plan for the creation of additional residential allotments in the two townsite areas.

TABLE X-18

Residential Allotment Supply and Housing Demand

Parameter	Marg. River	Augusta
1. Townsite Lot Approvals		
- 1980/81	20	10
- 1985/86	20	10
- 1987/88	85	20
2. Residential Building Approvals		
- 1980/81	30	15
- 1985/86	45	15
- 1987/88	50	35
3. Potential Residential Allotments	295	270

(Source: AMR Shire)

The Margaret River allotments can be released as demand dictates as they have already been subdivided. The creation of allotments in Augusta is dependent upon the provision of deep sewerage for the 70 allotments which have been subdivided. The remainder of the land which is government-owned requires rezoning. It is envisaged that such land could be released within 2-3 years.

The two smaller settlements of Karridale and Witchcliffe have little or no capacity to provide additional allotments for residential purposes. Karridale has no vacant residential lots whereas Witchcliffe has approximately 20. These blocks are not serviced by reticulated water or sewerage systems although they have access to power and telephone.

In addition to residential allotments provided within the townsite areas, the Shire provides for the creation of rural/residential allotments in its "Policy Area B" rural zone. Lands zoned in this manner are situated to the west of Margaret River centred on Caves Road, and to the west of Augusta. If such lands were to be rezoned to the Special Rural Zone approximately 127 acreage allotments would be created at Augusta and some 124 lots at Margaret River.

Apart from the above lands designated for subdivision for residential purposes, it is the Shire's policy not to permit the further subdivision of rural land. This policy is supported by the Department of Planning and Urban Development. There exists, however, a limited potential for dual occupancy on existing rural allotments greater than 5 hectares in area.

In addition to land used for the erection of single residences in Margaret River, Council intends to introduce town planning scheme designations which will allow unit development. Such lands, situated in Town View Terrace and Station Road, could yield in the order of 255 dwelling units. At present, there is no intention of allowing unit development to occur in Augusta.

3.3.3 Existing housing stock

The existing housing stock consists primarily of single detached dwellings with a limited number of other housing types as described in Table X-19. A significant feature of this housing is that approximately 13% of private homes are unoccupied for a major part of the year as they are used for holiday purposes only, and approximately 12% are available for private rental.

The figures apply to June 1986. More recent ABS estimates suggest the Shire contained a total of 2675 private dwellings (June 1988) of which 2327 were separate dwellings, 146 duplex or unit accommodation, 145 caravans and 57 other types of accommodation.

3.3.4 Temporary accommodation facilities

The Shire, being a tourist destination, has a substantial range of temporary accommodation facilities ranging from serviced hotel/motel accommodation to camping/caravan sites. The reader is referred to Table X-4 for numbers of rooms/site/units currently available.

Details on temporary accommodation facilities in and around Augusta follow as they are mostly likely to be utilised during the project's construction phase.

TABLE X-19

Housing Characteristics,
Augusta-Margaret River Shire (1986)

Characteristic	Shire	Marg. River	Augusta
1. Occupied Private Dwellings			
No.	1729	412	328
Type of Dwellings (%)			
- Separate House	84.8	79.1	79.9
- Semi detached	1.2	2.7	-
- Flats, etc.	1.9	5.8	1.8
- Caravans, house-boats, etc.	6.4	7.5	8.3
- Impoverished dwelling	1.0	-	-
- Shoptop dwelling	1.4	3.2	2.1
- Other	3.3	1.7	7.9
2. Unoccupied Private Dwellings			
No.	677	66	237
Reason Unoccupied (%)			
- For Sale/Let/Repair, etc.	8.4	6.1	6.3
- Holiday Home	44.2	10.5	53.6
- Resident absent	41.9	77.3	38.4
- Other	5.5	6.1	1.7
3. Non-Private Dwgs.	15	6	7
4. Total Dwellings	2421	483	572
5. Rental Dwellings	333	111	37
- Government Agency (%)	14.1	35.1	-
- Private (%)	85.9	64.9	100

(Source: ABS Census)

The Molloy Caravan Park on Fisher Road contains 30 powered sites, 19 park homes, and is full for 3-4 months of the year over the summer school holidays. The Riverside Cottages in Augusta offer 12 fully self-contained units. Doonbanks Caravan Park contains 120 powered sites, 6 cottages, 10 mobile homes and 5 on-site vans. It is also fully utilised over the school holiday period. The Augusta Hotel/Motel offers fully serviced accommodation and contains 51 motel units, 4 hotel rooms and a guest home (6 rooms). The Turner Caravan Park contains 225 caravan sites (of which two thirds are powered), 4 self contained cabins, and a large camp site area. It is also heavily utilised over the summer period.

3.4 LAND USE AND DEVELOPMENT

3.4.1 Land use

Lands comprising the proposed mining site are currently used for agricultural purposes - namely the grazing of cattle and sheep on improved pastures. Lands around the proposed mine site are used for similar purposes, with the exception of lands to the south and west which are reserved for nature conservation purposes under a National Park designation.

The Scott National Park protects about 3300 ha of open jarrah and marri woodland, swamps and riverine vegetation. It features pristine bushland, and provides habitats for many different animals and birds common to the South West. Only one area in the park is used for recreational pursuits. Twinems Bend, accessible by boat only, is a water ski area.

3.4.2 Town Planning requirements

The proposed mine site is zoned "Rural" under the Augusta-Margaret River Shire's town planning scheme. Under the Leeuwin-Naturaliste Region Plan (Stage Two) the area forms part of the South Coast Planning Area (Area No. 7). This regional plan recognises the value of these grazing lands (which have a higher rainfall and longer growing season than other sectors of the region), and is committed to ensure the continued use of agricultural land for extensive grazing purposes. The Plan also recognises the value of the fragile coastal dunes and wetlands between the Scott River and Flinders Bay, immediately to the south of the proposed mine site. In this regard, it announces an intention to declare the coastal dune systems and environs a "Soil Conservation District" and the foreshore area a "Soil Conservation Reserve" pursuant to the provisions of the Soil and Land Conservation Act. The occurrence and potential for the development of heavy mineral sands mining in the area is noted in the Plan. It stipulates that any proposals to mine should have due regard to the water quality of the Scott River and the management of coastal wetlands and dunes.

With respect to the establishment and/or expansion of settlements within the Shire, it is the planning intention to centre all new development in or adjacent to existing urban centres. It is intended that the further expansion of East Augusta be restricted to holiday-retreat type uses, and that Augusta may be promoted as the major tourist and retirement destination. A bridge linking Augusta with East Augusta is not seen as desirable at this point in time.

When examining proposals for mining, the Plan stipulates that the value of the mineral resource should be weighed against the values assigned to other uses, and that the special environmental values of the Shire should be recognised in the decision-making process in respect to all development proposals.

3.4.3 **Infrastructure**

3.4.3.1 Road access

The proposed mine site is readily accessible by means of the existing Shire road system. The site, located on Scott River Road, has access to Augusta via Payne and Courtney Roads, and the Brockman and Bussel Highways; and to Margaret River via the same road system or an alternative route using Warner Glen Road. With the exception of Payne and Scott River Roads, all roads are sealed, with the two highways constructed to two lane, highway standard and Courtney and Warner Glen Roads being rural standard, single lane seal. Payne and Scott River Roads are of rural standard, gravel construction, with the northern section of Scott River Road (between Payne Road and the Brockman Highway) being in poor condition and not capable of being used for mine workforce access without substantial upgrading.

Scott River Road, Payne Road, and Courtney Road currently provide the only means of road access to the settlement of East Augusta, and properties to the south of Brennan Bridge. Whilst private boats are used by local East Augusta residents to access Augusta, there is no means of public access via a ferry or bridge.

3.4.3.2 Water supply and sewerage

(a) Augusta

The town of Augusta has a town water reticulation system which is based on a spring located near Cape Leeuwin. It currently provides water to 600 premises, but during the summer tourist season the system is reaching the point where it is overloaded.

The supply volume from the spring has been dropping over recent years and now the system can only supply approximately 2000m³ of water per day. The water requires treatment to render it suitable for domestic consumption. The Water

Authority is currently investigating a new water source in the Fisher Road locality. This new groundwater source would require treatment and cost in excess of \$1 million to implement. Further growth in population numbers in the town would accelerate the need for this alternative supply to be developed.

The township is not seweraged at present. It is planned to commence construction of a limited deep sewerage system in 1990 to service the commercial area and a new subdivision being constructed by the Shire Council. This new system will initially service 500 persons, but will have a treatment plant capacity of 2000 persons. It is planned to extend the sewerage system as needs are identified and funds become available. The lack of a sewerage system in Augusta is a primary factor limiting the development of unit accommodation in the town.

East Augusta does not have a reticulated water supply or sewerage system. It is government policy not to allow any new urban development in this locality unless it is provided with both reticulated water and a sewerage system.

(b) Margaret River

Margaret River's water supply is considered to be marginal both in terms of quantity and quality. At present, 750 services are provided with the system's storage capacity only sufficient to handle a 1 in 50 year drought. To overcome the situation a new dam is proposed to be constructed on 10 Mile Brook and be operational in the summer of 1992/93.

The town is currently partly seweraged, and a programme is currently being undertaken to catch up the backlog of existing properties. All new subdivisions and developments are now required to be seweraged. The town's treatment plant's capacity is tight, but capacity can be readily increased by the addition of new ponds.

(c) Other settlements

The smaller townships such as Witchcliffe and Karridale have no reticulated water supply or sewerage services.

3.4.3.3 Telephone and electricity

The Shire is well served by telephone (Telecom) and electricity supply with most residents having access to such services if they desire to do so. Problems are, however, experienced with the quality of the electricity supply as voltage drop is common, especially in Augusta. This causes problems with sensitive electronic devices such as business computers and the like.

A 64 KVA transmission line brings power from the State grid to a substation at Margaret River from whence it is distributed around the Shire. A problem exists

with the location of the existing substation as it is located in what will become the centre of a residential area in Margaret River.

The Shire Council foresees an opportunity to relocate the substation, to a more suitable location, if a substantial increase in its size is contemplated.

3.4.3.4 Air transport

The Shire is not serviced by a regular air service, although airstrips exist at both Augusta and Margaret River. The Augusta strip is capable of handling small commuter aircraft and can operate both day and night. It is regularly used by small planes and emergency services aircraft.

3.5 SOCIAL INFRASTRUCTURE

3.5.1 Educational facilities

The Augusta-Margaret River Shire contains 4 primary, 1 secondary and 1 non-government school. In addition to these facilities, the South West College of Technical and Further Education is located in Bunbury and this facility provides both in-house and external teaching facilities. The Bunbury Institute of Advanced Education provides tertiary courses in business, nursing, education, computers, arts and fine arts.

The schools and facilities of relevance in providing services to the proposed mine's workforce and their families are discussed below.

3.5.1.1 Margaret River High School

This high school caters for Years 8, 9 and 10 only, with students in Years 11 and 12 being bused daily through to the Busselton Secondary School. The school, which can cater for a maximum of 230 students, currently has an enrolment of 217 students. In addition, some 85 students travel to Busselton. To expand its capacity above 230 students the school would require new buildings to provide classroom space, teacher work areas, library and administration facilities.

Student enrolment projections, based on present growth patterns suggest the school will need to cater for 280 students by 1995. Plans are currently being put in place to upgrade the school to cater for Years 11 and 12 in 1991-2. If these plans are proceeded with, the school's student numbers would increase by approximately 50 students, and a new Library/Resource Centre would be required.

The school operates a unit curriculum programme (180 units) covering such subjects as agriculture (school farm), manual arts, business studies, home economics, photography, outdoor education, dance, arts and crafts in addition to

the core subjects of English, maths, science, social studies, physical and health education.

3.5.1.2 Margaret River Primary School

This primary school caters for 386 students at present and is at capacity in terms of building space. Enrolments for next year are projected to be 404 students. Over the last few years enrolment growth has averaged approximately 20 children per year. The present school site is of sufficient size to accommodate expansion up to the desirable maximum size of 500 students.

The school also operates a pre-primary school catering for 38 children on-site.

3.5.1.3 Margaret River Community Kindergarten and Pre-School

This facility is privately run and caters for approximately 25 children in the kindergarten section and 20 in the pre-primary section.

3.5.1.4 Nyindamurra Family School

This school is a private primary school owned by the Parents Association. It provides schooling for Years 1-7 and is alternative lifestyle in emphasis both in terms of teaching the State curriculum and in elective activities. It can cater for 50-60 students, but cannot meet the demand for such schooling. A need for a second school of a similar type exists in the community.

3.5.1.5 Augusta Primary School

The Augusta Primary School caters for Years 1-7 and is almost at capacity being full at both the middle and upper primary levels. It currently caters for 94 students and needs more built space to accommodate any further expansion in student numbers. Teacher work and administrative space is severely lacking, and there is an immediate need for a new administration block to allow for satisfactory school operation. The school has its own sports facilities and has access to Shire facilities when required.

3.5.1.6 Kudardup Pre-School

This school, some 6 km to the north of Augusta, provides the kindergarten and pre-school function for the Augusta Primary School. Its two teachers cater for 19 pre-school students and 22 kindergarten students.

3.5.1.7 Karridale Primary School

This rural primary school currently caters for 71 students but has the classroom capacity to handle 100 students. To reach this capacity, however, an extra teacher would be required.

3.5.2 **Medical facilities**

The Shire contains two hospitals, one situated in Margaret River and one in Augusta. They, in conjunction with regular visits from specialists, the more extensive medical facilities of Busselton and Bunbury, and local doctors, provide for the population's health care.

3.5.2.1 Augusta

The Augusta Hospital contains 18 beds, 8 of which are for elderly persons and the remainder for general patients. It has an operating theatre for minor operations, and provides an outpatients service and child health clinic. Seriously-ill patients are referred to the Bunbury regional hospital.

The town supports two general practitioners, an ambulance service, a meals-on-wheels service, and the Silver Chain nursing service. A physiotherapy service visits twice weekly and a podiatrist once a fortnight. A Frail Aged Lodge is available for elderly people unable to look after themselves, as well as various senior citizens homes.

3.5.2.2 Margaret River

The Margaret River hospital contains 26 beds, of which 12 are for general patients, 6 for permanent care patients, 4 for maternity patients, and 4 for pediatric patients. It has a cardiac unit, an X-ray unit, a labour ward and an operating theatre for minor surgery. It provides an outpatient service.

The town supports 6 general practitioners and one anaesthetist, a Silver Chain nursing service, a pathology service, two dentists and one chemist, and an ambulance service. A physiotherapist visits on a regular basis, as does a child health clinic and an immunization clinic.

A modern hospital facility containing 20 beds is currently under construction, adjacent to the existing facility. It is due to open in 1990, and will provide a similar service to the present hospital.

3.5.3 Community facilities

The range of facilities provided in the Shire is quite substantial given the relatively small population base and the need to spread resources to provide similar facilities in both Augusta and Margaret River. A basic need identified in both communities is for a swimming pool as this facility is not available in the Shire.

Margaret River, as it has the larger population and is the Shire's administrative and commercial centre, has a greater range of facilities, although given the travel time involved in moving between the two communities, most facilities are within easy reach of the vast majority of the Shire's population.

3.5.3.1 Recreational facilities

One of the major attractions of living in the Augusta-Margaret River Shire is the natural recreational opportunities which the Shire has to offer. Fishing, bushwalking, boating, canoeing, surfing, swimming, and caving are all available. The Shire's formal recreational facilities are principally located at Civic Park in Augusta and the Gloucester Park Recreation Area in Margaret River.

The Civic Park complex in Augusta provides for tennis, aerobics, squash, basketball, badminton, indoor cricket, indoor tennis, Australian Rules football, a 9-hole golf course, and lawn bowls. In addition, there is an 18-hole golf course 5 kms from town, a basketball court, and a croquet green.

Gloucester Park in Margaret River provides facilities for tennis, squash, Australian Rules football, hockey, netball, bowling, cricket, badminton, basketball, karate, aerobics, and gym. Other facilities in the town include a golf course, speedway, Japanese garden, drive-in theatre and bowling green. Witchcliffe contains tennis courts and a polocrosse ground.

Both centres have several parks and reserves devoted to passive recreation and children's play pursuits.

Annexure B provides a list of recreational clubs present in the Shire.

3.5.3.2 Civic facilities

Margaret River being the Shire's administrative centre, contains the bulk of the Shire's civic facilities. The Shire Council chambers and main works depot is located here, as are police, Telecom, post office, Water Authority, judicial, SEC, and fire services. The Shire library, cultural centre, community hall and Agricultural Society show facilities are also located in Margaret River. The Shire Council provides senior citizens housing, child care and child health centres, and a venue for the Margaret River Community Centre (privately run).

Augusta's civic facilities include a library, the Shire museum, fire station, post office, Telecom, Shire office, and community meeting rooms, police station, and sea search and rescue facilities. Senior citizens housing is provided by private organizations. The provision of a community hall is currently being pursued by the Shire Council.

In both centres, the CWA provides meeting rooms and these are available for public use.

3.5.3.3 Clubs and Organizations

The Shire contains a variety of sporting, arts and crafts and special interest clubs and organizations. A list of these is provided in Annexure B. In many instances they use the facilities described above as venues for their activities. Churches representing the Catholic, Baptist, Anglican and Uniting Church faiths are established in both Margaret River and Augusta.

3.5.3.4 Social support facilities and services

Apart from the services and facilities discussed earlier in this section, the Shire contains several social support services, which require special mention.

The Margaret River Community Centre is a privately-run centre whose functions include the provision of counselling, welfare and charitable facilities; the promotion of the health, welfare and care of families; and the provision of a venue for classes and the dissemination of information.

The centre is an affiliated Learning Centre link and is involved in Skill Share courses. It arranges courses to support local business and community needs. Examples of these courses are microwave cookery, bookkeeping, typing, stress management, computer skills, chess, handicrafts, parenting skills, etc. Information dissemination is oriented to providing information regarding access to State and Commonwealth government social support programmes.

A private mobile counselling service is also established in Margaret River. Although it is privately run, it is largely funded by the government and is run in manner acceptable to the Department of Community Services. The service provides free professional counselling by trained social workers in the areas of family, youth, and marriage guidance, alcohol and drug rehabilitation, grief management, economic and housing matters and some legal matters.

Various churches, service clubs, the Pensioners League, the Red Cross Society and the Country Womens Association also provide support to needy persons.

Although the Department of Social Security visits Margaret River on a regular basis, there is an identified need for a permanent service directly related to the aged, retirement and the unemployed sectors of the population.

3.5.3.5 Commercial facilities

The retail, commercial offices and service and light industrial facilities operating in the Shire are reasonably comprehensive, given the size and nature of the local community. The influence of the area's tourist industry and the demands of the in-migrating population are largely responsible for this. The range of facilities is sufficient to cater for all day-to-day convenience needs and basic comparison shopping. The range and number of tourist shopping outlets and restaurants provide a level of service which would not normally be supported given the local population base. The centres of Busselton and Bunbury provide for virtually all other needs. One complaint common to both Margaret River and Augusta is the lack of competition and the 'monopoly' status of several businesses (especially the supermarkets) which results in little price competition in the two towns.

3.6 COMMUNITY ORGANIZATION

The Augusta-Margaret River community consists of a number of subgroups - the farming/fishing community, persons who live in the Shire so that they can pursue particular alternative lifestyles (e.g. the surfing fraternity, conservationists, etc.), the business community, and the retirement population. These groups, whilst they may be categorised in the above manner, interact closely in their day-to-day business, social, sporting, and civic administration activities. The community is considered to be better for this interaction, and for the more interesting and varied community life such interaction generates. This does not mean that particular issues may not generate different views or the polarisation of views within the community.

In essence, the Margaret River community is relatively young in comparison to the rural population and the Augusta community. Whilst it is commercially-oriented, the population is also keenly aware of the local lifestyle values. The farming community is the original community group in the Shire, and while it is sometimes more conservative in its views, it is pragmatic in attitude. This group also values the Shire's natural attributes. The Augusta community is basically a mixture of retirees, local business people, and fishermen. As a group there is strong feeling regarding change, and change to the natural attributes of the locality. A fourth group comprises the rural lifestylers/ hobby farmers who are seeking rural lifestyle alternatives and to whom the earning of income is often placed second to quality-of-life matters. The attitudes of the various sectors of the community are well represented on the Augusta-Margaret River Shire Council.

It is this local government institution above all others whose decisions reflect the overall community opinion.

In comparison to other rurally-based Shires, the population consists of a comparatively large number of persons who are on fixed incomes, of whom pensioners, single supporting parents and the unemployed (by choice) are significant.

The Shire is considered to be at a point where a combination of newcomers and a larger tourist population is beginning to see an increase in crime and other social problems in this community. For example, people now have to lock their cars and doors whereas five to ten years ago this was unheard of. The Shire has a very small alcohol problem compared to some other centres in the South West, but has a larger group of the population who utilize cannabis. The Shire has very little poverty, but exhibits a substantial number of marital problems occasioned by difficulties in adjusting to changing circumstances. Some disciplinary problems in schools arise from new pupils with new ideas and school habits coming into the school community.

3.6.1 **Community attitudes**

In order to appreciate the concerns a community may have in respect to major projects bringing change to the community, it is pertinent to examine why people chose to live where they live.

In Augusta-Margaret River's case, apart from those persons who live in the Shire for purely livelihood (business) reasons and family reasons (family ties, birthplace, etc.), a large proportion of the population live there for lifestyle reasons first and foremost. The lifestyle attributes of the Shire maybe summarised as follows:

- Ready access to quality outdoor recreational pursuits.
- Temperate climate.
- Country atmosphere/unsophisticated lifestyle.
- Ability to practice a rural lifestyle/non-materialistic lifestyle.
- Good community spirit/relationships/social structure.
- Good place to bring up children.
- Lack of pollution/clean environment.
- Adequate facilities and services.

- Diverse community.
- Small community/not overcrowded or overly commercialised.

By comparison, the Shire is perceived to harbour some lifestyle disadvantages which are mainly due to the inability of a small population base to economically support various facilities and activities. These are outlined below:

- Distance from specialist medical care.
- Distance from cultural events/theatre/entertainment.
- Distance from information sources.
- Lack of schooling options/higher educational opportunities/special education.
- Higher cost of living (to Perth).
- Limited job opportunities for school leavers.
- Business isolation.
- Land prices too high in relation to land's production value.

3.6.2 **Project-related issues**

An essential part of the assessment of the proposed project's impact on the community environment involves the identification of concerns which the community may have about the project. To this end a survey of relevant community leaders and groups was undertaken. A list of the groups and organizations consulted is given in Annexure A. It should be noted that no attempt was made to canvass the views of the population of the Shire at large as part of this study, as such an opinion survey is to be undertaken as a joint Shire/State/Company exercise at some future time. During the survey, the level of project knowledge was found to be quite variable, ranging from good for the members of the Beenup Consultative Committee to poor for those groups not having a direct involvement in the project to date.

The issues identified by this survey have been categorised for convenience into six groups. These are listed below:

3.6.2.1 Quality-of-Life issues

The quality-of-life issues relate principally to people's perception of why they live in the Augusta-Margaret River Shire, and why they have invested money in buying properties in the area. The overall concern is that the project will be the catalyst which leads to the eventual industrialization of part of the Shire, and that this, coupled with the increase in population which this will bring, will lead to the destruction of the lifestyles which the community currently enjoys. Fears have been expressed that crime and social problems will result, and that the existing, relatively unspoilt environment will be severely downgraded.

There is concern that the project will produce a mining-oriented community similar to that at Collie and this is seen as an undesirable outcome of the development.

Other concerns expressed relative to the quality-of-life question are listed below:

- ° The project will create pollution (water, noise, dust, visual) and this will impact negatively upon Augusta and the lifestyles practised by its population.
- ° The project will introduce a radiation danger to the Shire.
- ° The project will result in a dilution of local culture and identity.
- ° The project, through its large electricity demand, will increase coal-fired power generation in the South West, and that this in turn will add to the current global greenhouse problem. The view is put that if the greenhouse problem is to be addressed, each reduction in the emission of greenhouse gases that can be achieved is of value.
- ° The project will bring people into the Shire who have a different set of values, and who will not appreciate or value the Shire's natural attributes or lifestyle practices. This will lead to the downgrading of the Shire's cultural identity, and will generate more division within the community to the detriment of the Shire's existing population.

3.6.2.2 Mining/Mine site issues

These concerns basically relate to the mine's operation and the lack of project information. A common concern, outside of the Beenup Consultative Committee members and their individual organizations, is the availability of sufficient information on the project to enable a reasonable understanding of the project to be gained by the population at large. Mining and mine-site concerns noted were as follows:

- ° The impact on local groundwater aquifers and farm water supplies.
- ° The creation of water, dust, noise and visual pollution as a result of the project's construction and operation.
- ° The impact of the project on adjoining farms and the Scott National Park in particular.
- ° The effect on the water quality in the Scott and Blackwood Rivers.
- ° Doubts about the project's ability to rehabilitate land to a productive agriculture use. Various views have been expressed as to the preferred end land use ranging from improved pasture, a return to native bush, to the creation of a recreational lake system.
- ° Impact of mining on rare flora and fauna located adjacent to the proposed mining area.
- ° The need for an all-weather road access to be maintained for East Augusta residents to gain access to their properties.
- ° The need to protect the nearby fragile dune systems from damage by the mine's workforce and contractors.

3.6.2.3 Product transport (Road) issues

Road transport issues identified primarily related to the potential conflict between mining trucks, and local residents' and tourists' vehicles. Local roads and highways are considered to be inadequate to carry the volumes of traffic likely to be generated by the project. In addition, many persons fear the fact that as such roads will be constantly used by mining vehicles, it will have the effect of deterring tourists from coming to the Shire. It is perceived that tourist traffic and heavy industrial traffic do not mix.

Other concerns expressed relate to the impact heavy construction traffic will have on the Bussel and Brockman Highways, the heightened pollution levels created by more traffic, and the increasing hazards for road users.

3.6.2.4 Product transport (Sea) issues

The concerns of the Augusta community relate primarily to the sea transport options proposed by the Company. Dust from the onshore stockpiles reaching Augusta is a major concern, as is the potential impact of the stockpile area and

loading facilities upon Vicki Hart's property, Swan Lake, and fragile foredune system. The proposed jetty and its visual impact is the major concern of Augusta residents as it is believed this facility will strongly detract from the aesthetic appeal of Flinders Bay, and lead to depression in property values. The proposed jetty has also raised concerns regarding its impact on local fisheries, and the pollution risks associated with ships using the facility.

3.6.2.5 Community issues

Apart from the lifestyle questions outlined above, other community concerns relate to:

- ° The possible overcrowding of community facilities (in particular, schools and hospitals).
- ° Possible law and order problems.
- ° The exacerbation of the existing housing problem and the rise in house/land prices and rentals this will inevitably produce.
- ° The possibility of unionism being introduced to the Shire.
- ° The impact on Shire rates, and
- ° Journey to work issues such as the need or otherwise for a ferry service linking Augusta and East Augusta and a general increase in traffic and parking problems.

3.6.2.6 Economic issues

A principal concern relates to the question of who will bear the costs associated with the establishment of the project's infrastructure. This issue centres around the need, in the community's eyes, for all government outlays to be recouped in a manner which does not place any burden on the local Shire Council, or the State as a whole. A second major concern relates to the question as to what net benefits will flow to the local community if the project proceeds. The other major economic issue noted relates to the potential conflict between the tourist industry and the mining industry. Concerns have been expressed here relating to the possible financial ramifications of this conflict. The local fishermen are also concerned that increasing numbers of recreational fishermen will put added pressure on an already heavily utilised resource and this could affect the financial viability of local fishing enterprises.

4.0 ECONOMIC IMPACT ASSESSMENT

The economic impact of the development of the Beenup mineral sands project has been examined in terms of contribution to the South-West regional economy and to the Augusta-Margaret River Shire economy in those cases where meaningful information has been available.

This analysis has been based on input-output multipliers developed by the W.A. Department of Resources Development in conjunction with the University of Western Australia, and which are specifically applicable to the mineral sands mining industry. It should be understood that the figures which are derived in this manner are not a precise forecast, but rather provide a reasonable indication of the likely economic effects. It should also be noted that the analysis takes no account of likely lead times or lags involved in the multiplier effects working through the economy. In some cases it may be 1-2 years before the full effects become established.

Thus, the multipliers provide order-of-magnitude estimates only. They take no account of slack capacity, and where induced effects are concerned, they tend towards over-estimation rather than underestimation. Consequently, they indicate the maximum level of impact likely due to flow-on effects.

4.1. EMPLOYMENT EFFECTS

4.1.1 Construction phase employment generation

Subject to project approval, the construction of the project is to be conducted over an 18-month period commencing in September, 1990. Workforce numbers are expected to peak at 200 workers over the four month period July-October, 1991, with the main bulk of the workforce being on-site during the period May-December, 1991. The buildup and drop-off in workforce numbers during this Phase will give rise to abrupt changes in local employment levels.

The level of local employment opportunities generated by this phase will depend the availability of the required skills in the Shire labour pool. The Company will encourage contractors to hire local labour. It is estimated that between 35% and 50% of the construction workforce skills needs could be obtained from the Shire labour pool. The demand for labour during the construction phase could help ameliorate unemployment in the area.

Table X-20 outlines the direct employment and flow-on employment expected to be generated by construction phase expenditure within the South West Region. The table also outlines a probable distribution of the employment opportunities between the Augusta-Margaret River Shire and the rest of the South-West Region. The distribution is indicative only being based on expenditure locational assumptions.

TABLE X-20
Construction Phase - Employment Generation Estimates
- South West Region

Year Month	90 S,O,N	90 N,D	91 J,F	91 M,A	91 J,J	91 J,A	91 S,O	91 N,D	92 J,F
Period	1	2	3	4	5	6	7	8	9
1. Direct Employment	5	25	60	120	180	200	200	150	50
2. Flow-On Effects:									
i. Production- Induced	6	29	70	140	211	234	234	175	58
ii. Consumption- Induced	7	26	77	154	230	256	256	192	64
iii. Total Flow-On	13	55	147	294	441	490	490	367	122
3. Total Employment Effect	18	80	207	414	621	690	690	517	172
4. Flow-On Employment Distribution									
i. Augusta-Margaret River Shire	9	37	99	199	298	331	331	248	82
ii. Other South-West Region	4	18	48	95	143	159	159	119	40
5. Total Employment Distribution									
i. AMR	14	62	159	319	478	531	531	398	132
ii. Other S.W.	4	18	48	95	143	159	159	119	40

NOTES: Employment Multipliers supplied W.A. Dept. Resources Development

The flow-on employment effects represent the absolute maximum likely effect. Given the relatively short construction peak and the short overall construction period, it is unlikely that local businesses (especially in the consumption induced area) will employ extra staff to the extent indicated in the table. In addition, a level of underutilised service capacity is likely to exist in many of the businesses.

4.1.2 Operational phase employment generation

The project will directly generate 115 jobs during the operational phase of the project once steady-state production is reached. This is anticipated to occur immediately following plant commissioning in March-April, 1992. As indicated in Section 2, between 40% and 65% of this direct workforce requirement has the potential to be locally recruited given the skills which currently exist in the Shire. However 90% will be available to Shire residents if they have the necessary skills. For those workers forming the unemployed sector of the workforce, and seriously desiring work, the project will provide substantial employment opportunities. It will also provide opportunities for people to move from part to full-time employment, and for people who are "under-employed" to gain full-time employment. It is understood that there is a measure of hidden unemployment in the rural and fishing sectors, and given that persons from such backgrounds usually have the right skills and attitudes to be trained and employed as plant operators, substantial opportunities will be provided for these persons.

Table X-21 outlines the indirect, flow-on employment expected to be generated by the operational phase. Unlike the construction phase, these flow-on jobs are likely to be permanent in nature for the life of the project. As the table indicates the consumption-induced jobs (those related to household spending) dominate, indicating a substantial number of jobs are expected to be created in the retail/wholesale and service sectors of the economy.

TABLE X-21

Operational Phase - Employment Generation Estimates,
South West Region

1. Direct Employment	115
2. Flow-On Effects :	
(i) Production-Induced	109
(ii) Consumption-Induced	200
(iii) Total Flow-On	309
3. Total Employment Effect	424
4. Employment Distribution	
(i) AMR Shire	267
(ii) Other South West Region	157

4.1.3 Related employment effects

The project will have a significant positive effect on the economic base of the Augusta-Margaret River Shire, through the addition of new industrial sector. This should, given the cyclical nature of the main economic sectors, provide an added support to the economy. Given the 20+ year mine life envisaged, the project will provide stable long-term employment opportunities, and add to career opportunities for some sections of the communities.

The wage levels likely to be offered by construction contractors during the construction-phase of the project is likely to be substantially higher than existing wage levels for comparable jobs within the Shire. This may, in spite of the short term nature of the employment offered, induce a level of labour turnover within the community. During the operational phase, wage levels will be only marginally higher than those available within the community, and this may encourage some turnover, although it is not expected to be substantial. In some cases, existing local employers may be placed in a position where they need to increase their own wage levels in order to compete effectively on the labour market.

4.2 OUTPUT AND INCOME EFFECTS

Output effects refer to the changes in the value of output (i.e. the value of goods and services) produced by a firm institution or government, which will be generated as a result of expenditure on project construction, and by the production of mineral sands during the project's operational phase.

The income effects refer to the impact of the project's construction and operation on household income in the economies identified.

4.2.1 Household income effects

The wage bill associated with construction and operation of the project will add to the economic well-being of the Shire and region. Direct wage payments during the construction phase are expected to total \$4.78M; and during the project's operational phase to be \$4.66 million annually (\$1989). In addition to the direct workforce wages payments, the flow-on income effects are expected to total \$12.43M over the construction period, and be \$6.058M annually during the operational phase within the South West Region. Table X-22 below details the expected household income effects.

TABLE X-22

Household Income Generation
South West Region (\$1989)

	Total Construction Phase	Operational Phase (Annual)
Initial Stimulus Production Induced Effects	\$ 4.78M	\$ 4.660M
Consumption-Induced Effects	\$ 6.93M	\$ 2.796M
Total Flow-On Effects	\$ 5.50M	\$ 3.262M
Total Impact	\$12.42M	\$ 6.058M
	\$17.21M	\$10.718M

4.2.2 Production effects

As a result of linkages between the project and other industries during both the construction and operational phases, the project will generate benefits with respect to the value of output in other sectors of the economy.

The construction phase of the project will involve the expenditure of some \$104 million with some 25% of this being spent in the Augusta-Margaret River Shire, and an additional 12% elsewhere in the South West Region. In total, some 48% of project construction expenditure will occur in Western Australia. Annual operating phase value of output is expected to average \$50.0 million (Australian dollars).

Table X-23 details the expected output effects in the South West Region resulting from this regional expenditure.

TABLE X-23

Output Effects, South West Region (\$1989)

	Total Construction Phase	Operational Phase (Annual)
Initial Stimulus	\$ 39.14M	\$ 50.0M
Production-Induced Effects	\$ 24.66M	\$ 19.5M
Consumption-Induced Effects	\$ 16.83M	\$ 23.0M
Total Flow-On Effects	\$ 41.49M	\$ 42.5M
Total Output Effect	\$ 80.63M	\$ 92.5M

4.3 EFFECT ON GOVERNMENT REVENUES

Both the construction and operational project phases will provide revenues for the Federal and State Governments.

Federal Government revenues will be derived principally from company taxes and income taxes. Company tax will be paid at the appropriate level as determined by the Commissioner of Taxation. Income taxes will be paid from wages and salaries of the project's workforce during both project phases. Income taxes are likely to total approximately \$1.86M for the construction phase, and \$1.45M annually for the operational phase.

State Government Revenue will mainly comprise payroll tax payments, royalties, and revenues relating to services provided by semi-Government authorities such as the State Electricity Commission. It is estimated that mining royalties, payroll tax, fuel tax, and other revenues to the State Government will be in the order of \$7.05M per annum.

4.4 EFFECT ON SHIRE FINANCES

4.4.1 Impact assessment

The existing status of the Augusta-Margaret River Shire finances is discussed in Section 3.1.5. The advent of the proposed project and the growth in population which it will generate will place additional demands upon the Shire in terms of the provision or augmentation of facilities to service the needs of incoming population, and the maintenance and upgrading of roads used by the mine workforce and product transport.

Whilst the Shire's accounts are currently showing a small surplus, the growth in population which the Shire is experiencing and the demands beginning to emerge as a result of this growth, will necessitate the Shire undertaking some major investments to accommodate this growth. The ability of the Shire to finance a major increase in spending solely through rates revenue is doubtful.

As discussed in Section 5, it is desirable to have facilities in place prior to the population influx, so that potential social impacts arising from the lack of facilities are negated. This can pose an additional funding problem in that capital expenditures need to be made and debts serviced prior to the time when additional rate revenue to help fund the debt can be collected. A substantial burden is thus placed upon the existing ratepayers to fund the financing gap.

It is understood that the upgrading and ongoing maintenance costs of the roads constituting the product transport route will be borne in part by MDL and in part by other major users, in accordance with an agreement to be negotiated between the parties concerned. The outcome of these negotiations should mean that the Shire is adequately compensated for any costs it may incur.

The mining company will also be required to pay rates to the Shire, in the same manner as other persons living and/or operating a business in the Shire. The rating formula to apply to the mine has yet to be determined. Rates will be paid by the proponent to the Shire at an appropriate level and will be adequate to cover such items as the mine's share of maintenance to local roads used by the mine's workforce.

4.4.2 Management Measures

To ensure that the Shire does not, in effect, end up unduly subsidising the provision of mine-generated infrastructure and services, it is suggested that an infrastructure package be negotiated which ensures additional funding requirements are adequately addressed.

4.5 IMPACT ON TOURISM

As noted in Section 3, tourism is a substantial contributor to both the regional and local economies. Substantial concern has been expressed by residents and tourist operators that the project's operations will impact negatively upon the tourist industry. The principal potential impact is that :

- (a) a general loss of amenity in the Shire will occur due to the introduction of industry to an area which is renowned for its natural attributes and rural-

based lifestyles. It is believed that the attractiveness of the locality for the tourist and holiday maker will be compromised;

- (b) there will be a conflict between tourist traffic and mine traffic, and this will tend to deter tourists and holiday makers from coming to the Shire;
- (c) holidaymakers and tourists will not mix socially with mine workers and that the presence of the miner element in the community will tend to discourage tourist/holiday makers from coming to the Shire to recreate;

and that these three effects will cause a drop in revenue for tourist-based businesses, and the possible closure of some businesses.

There is no known equivalent Australian experience to suggest this will occur. It is difficult to assess whether the introduction of a mining operation will detract sufficiently from the tourist and holiday appeal of the Shire to cause a major downturn in tourist visitation and revenues.

Given the location of the project, in an area of the Augusta-Margaret River Shire which is not part of the normal tourist route, it is unlikely that project site operations will be a problem in this regard. They will be so located as to be hidden from view from major tourist roads, attractions, and tourist centres such as Augusta. The mining operation, however, may be stumbled upon by the recreationalist or fisherman seeking to access the pristine wetlands and coastline of Flinders Bay, or Swan Lake at East Augusta, for example.

It is possible that the mining operation may become a tourist attraction in its own right as has happened elsewhere in Australia, where public interest has been such that mining companies have instigated information tours and the like.

Mineral sand mining operations in Queensland, and New South Wales, currently co-exist with tourist and recreational activities, some prime examples being North Stradbroke Island, and the Myall Lakes area in New South Wales.

The question of tourist traffic conflicting with mine product transport is an area where a negative effect may occur, as no tourist likes to have to contend with heavy vehicle traffic when undertaking scenic driving. The magnitude of this impact and its effect on revenues cannot be quantified. Similarly, the economic effects of social conflicts that may arise between the mining fraternity and the tourist/holiday maker in Margaret River and Augusta cannot be quantified.

It should be noted that the preferred road transport route for the project has been selected in an effort to reduce the potential for conflict between the tourist and product transport vehicles. The application of appropriate road management procedures will be needed to ensure that either tourist vehicles do not utilise the

new road link created, or alternatively that those that do fully recognise the function of the road they choose to travel.

It is unlikely that the miners as a relatively small group in the community, will conflict with tourists and holiday makers any more so than other sectors of the community. During the tourist season, tourists in numerical terms far outweigh the local resident population.

4.6 PRODUCTION TRANSPORT EFFECTS

The use of the Sues Road/Tutunup road transport route for the transport of product to Bunbury has several economic advantages. Whilst data are not available to quantify these benefits in dollar terms, it is believed these benefits will be substantial in the long term.

The establishment of a new, all weather road access into the Augusta-Margaret River Shire using Sues Road as the key link, will enable people to travel more directly between the southern part of the Shire and Capel and centres to the north. This could have product transport cost advantages for all goods and services being moved by road.

The establishment of such a road link also provides an opportunity for the establishment of a specific heavy-haulage route into the Shire. By making it attractive for heavy traffic to use this route, the heavy traffic load on the other main access routes (the Bussell, Vasse and Brockman Highways) could be reduced. As these other main access routes are also important tourist roads, this would serve to lessen conflict with this traffic, as well as local traffic. It should be borne in mind, however, that businesses which currently depend on the existing heavy-haulage traffic on the existing routes for their livelihood, could be disadvantaged by such a move.

In terms of regional road planning and economics, the heavy-haulage route concept has merit in that if the Jangardup mine proceeds the Beenup route could also service that project.

The creation of a specific heavy haulage route, however, will require consideration of peripheral impacts caused by such a move. Such questions as to who will be permitted to use the road, and the need to reduce potential conflicts between heavy haulage traffic and other road users, will need examination by the relevant authorities.

The potential negative economic effects associated with the creation of the proposed road link relate to disruption to agricultural production and other businesses arising from the nuisances generated by heavy traffic. These are discussed in Section 5.4 of this report, as are potential mitigation measures.

4.7 BALANCE OF PAYMENTS EFFECTS

The proposed project's operations will make a positive contribution to the country's export income to the extent of an average of \$50 million (\$1989) per year during the operating phase. No importation of goods is required during this phase. During the project's construction goods to the value of \$20 million will be sourced overseas. Hence the balance of payments effects will be positive, with the initial negative effect being overcome by revenues during the first year of the project's operation.

4.8 AGRICULTURAL PRODUCTION

The development of the mining project is not expected to lead to major changes in livestock numbers carried in the district. MDL has purchased some 937.3 ha of land from the farming community for its mining operation. The land is currently being leased back to the farmers for continuing agricultural production. It is envisaged that a proportion of this land will be available for agricultural use during the mining operation itself. The mine site's productive capacity will be restored progressively as mining proceeds. Section 3.1.10 in the main report discusses proposed rehabilitation options.

5.0 SOCIAL IMPACT ASSESSMENT

This section outlines the principal social impacts likely to arise as an outcome of the project's implementation. The form and magnitude of these effects is directly related to the size of the incoming workforce, the demographic characteristics of this workforce (and their families) and the existing social order within the Shire.

It is important to note when examining these matters that the Augusta-Margaret River Shire is currently undergoing substantial population growth due to the increasing importance of tourism, and the attraction of retirees and alternative lifestyle persons to the Shire. This growth has already initiated substantial change within the community, and if current population growth projections are realised, it will continue to do so well into the future. The advent of the proposed mining project will inject a number of newcomers into the Shire in a relatively short time span (approximately 2 years). It is the timing of this population injection which makes the project generated growth stand apart from the trend population growth evident in the Shire today.

5.1 POPULATION GENERATION ESTIMATES

This section examines the population likely to be generated within the Augusta-Margaret River Shire, where the effects are likely to be most significant. Whilst the project will generate population increases elsewhere in the South West Region, it is not possible within the scope of this study to identify where in the region the growth may take place.

In general terms, the population increase in the South West Region (other than in the Augusta-Margaret River Shire) attributable to the project, could reach a peak of 250 persons during the construction phase, and be a similar figure during the operational phase.

It should be noted that the estimates outlined here are indicative only, as it is not possible to accurately predict the labour market conditions and demographic characteristics of any newcomer population. The estimates contained here are based on characteristics exhibited by similar workforces in other mining projects in Australia.

5.1.1 Peak construction phase population

The discussion here examines the peak construction phase situation as it is when the effects of the workforce buildup are likely to be at their maximum level.

In developing these estimates it has been assumed that local recruitment will be 35% and that the incoming "newcomer" project workforce will total 130 persons. It is also assumed that this level of local recruitment will take up 50% of the

labour available locally, such that most of the flow-on employment opportunities will require persons to come into the Shire to take up the jobs created. It should be noted that this is a conservative approach and hence represents the maximum impact situation. As discussed in Section 3, the slack in local economic capacities and the short time frame, may quite likely lead to a situation where the flow-on employment opportunities do not reach the maximum levels postulated. It may well be that the production-induced workforce flow-on effect may not eventuate in some sectors as some industries will not find it financially viable to add new capacity to meet a short-term extra demand situation.

The estimated newcomer population profile is given below:

(a) Direct Project Workforce Component :	
newcomer workforce	= 130
family units	= 32
single persons	= 98
direct population	= 239
children (kindergarten/ preschool age)	= 9
children (primary school age)	= 32
children (secondary school age)	= 19
(b) Flow-On Workforce Component :	
newcomer workforce	= 281
family units	= 120
single persons	= 99
direct population	= 454
children (kindergarten/ preschool age)	= 21
children (primary school age)	= 73
children (secondary school age)	= 43

5.1.2 Operational phase population

During the operational phase once a steady state production situation is reached, the project will employ 115 workers. This situation will apply from March-April 1992 onwards for the life of the mining operation as currently proposed. As discussed in previous sections, it is probable that between 40% and 65% of the operational workforce could be recruited from the existing Shire labourforce. Taking into account the skills possessed by the unemployed sector of the workforce, and the hidden underemployment in the primary industry sector of the Shire, this local recruitment range should be achievable.

The Company is willing to make over 90% of the jobs available to residents. Positions for suitably aualified employees will be advertised locally before attempting recruitment outside the Shire. MDL has also had many enquiries from non-resident landowners.

The estimated newcomer population profile is given below for two cases - Case A for 65% local recruitment and Case B for 40% local recruitment :

	Case A	Case B
(a) Direct Project Workforce Component		
newcomer workforce	40	60
family units	28	49
single persons	10	17
direct population	98	171
children (kindergarten/ preschool age)	5	9
children (primary school age)	18	31
children (secondary school age)	11	18
(b) Flow-On Workforce Component		
newcomer workforce	80	95
family units	35	41
single persons	28	33
direct population	151	177
children (kindergarten/ preschool age)	6	7
children (primary school age)	22	26
children (secondary school age)	13	16

5.1.3 Baseline population growth

The Shire population growth projections assume an average annual growth rate of 4.76% per annum between 1986 and 2001 for the medium growth scenario (Refer Section 3.2.2). This scenario has been used to illustrate the baseline growth situation and to provide a basis for comparison with the growth estimates associated with the proposed project.

The following table compares the expected baseline population growth with that likely to be generated by the Beenup project.

TABLE X-24

Baseline Shire and Project-Generated Population and Workforce Growth

Year	1986	1989	1990	1991	1992	1993
1. Baseline Resident Population	4825	5547	5811	6088	6478	6681
2. Project Generated Newcomer Population						
- Construction (Peak)	-	-	-	693	-	-
- Operation	-	-	-	-	348	348
3. Expected Shire Population	4825	5547	5811	6781	6726	7029
4. Baseline Workforce	2324	2672	2799	2932	3072	3218
5. Project-Generated Newcomer Workforce						
- Construction (Peak)	-	-	-	411	-	-
- Operation	-	-	-	-	164	164
6. Expected Shire Workforce	2324	2672	2799	3343	3236	3382

The project will thus account for approximately 10% of the Shire population and workforce at the peak of project construction, and approximately 5% at the commencement of the operational phase.

5.2 HOUSING PROVISION

5.2.1 Project-related housing demand - Construction phase

During the construction phase of the project, it is intended that single status persons be accommodated in the on-site construction camp. Hence, no external accommodation requirement will arise for this component. The married direct peak workforce component is expected to comprise 32 family units who will require caravan park accommodation or a rental home. The flow-on peak component will

generate a demand for some 120 caravan park or family accommodation units and accommodation (hostels or rental flats) for approximately 99 single persons.

The Company is willing to construct a new caravan park on the old Bullens mill site adjacent to Alexandra Bridge for the construction phase. Management of this facility would become the responsibility of the Shire after construction.

5.2.2 **Project-related housing demand - Operational phase**

Operational phase direct housing demand is expected to comprise 69 family dwellings and 11 x 2 BR units or flats for the single workers. Flow-on demand is expected to total 41 family dwellings and 22 x 2 BR flats or units.

As it is company policy for all workers to find their own accommodation during this phase, the appropriate housing for both the direct and flow-on workforces will be sought on the local market. It is probable that this demand will be concentrated in the two urban centres of Augusta and Margaret River, although a percentage of the incoming population is expected to seek housing elsewhere in the Shire to satisfy their lifestyle goals.

5.2.3 **Impact assessment**

The demand for accommodation for the married component of the construction workforce and the associated flow-on workforce will take the form of demand for temporary accommodation facilities. It is expected a majority will be seeking caravan park facilities, although rental houses and flats will also be sought especially by the flow-on population. The accommodation required is short-term in nature with the heaviest demand falling over a four month period from July to October, 1991.

Any delay in the proposed construction schedule could see the peak construction phase demand coinciding with the peak summer holiday tourist influx.

Neither Margaret River or Augusta has the ability at present to satisfy the likely demand for rental houses or flats, although both centres would have sufficient caravan park accommodation at that time of year to service likely demands. The demand is likely to be greatest in Augusta as it is the closest urban centre to the project site.

The operational phase demand is for long term, permanent accommodation totalling 110 dwellings and approximately 33 x 2 BR flats or units. This accommodation needs to be available in the first two months of 1992 - i.e. in approximately two years time. It is estimated that the baseline population growth will require the provision of approximately 286 housing/accommodation units during the period 1989 to 1992. Added to this will be the project-related demand for 143 units. In terms

of allotments, this equates to approximately 389 lots of which 15 would be unit sites.

When this demand is compared to the land availability situation as outlined in Section 3.3.2, it would appear that the supply situation in Margaret River should meet the demand but in Augusta there may be a supply problem. From the information, 70 urban allotments could be available in Augusta in the time-frame required. It is expected that a substantial proportion of the project's workforce would wish to locate in Augusta, as it is the closest urban centre to the mine site. In addition, as there currently is no provision for unit accommodation in Augusta, the type of housing preferred by the single component of the incoming workforce, may not be available.

If a tight housing supply/demand situation continues in the Shire and current growth trends suggest this will occur, the added demand of the project could lead to an escalation of house/land prices to the point where the majority of the incoming workforce would not be able to afford to purchase the houses that are available. There is a need to ensure a small oversupply of both housing and land to maintain reasonable price levels.

5.2.4 **Management measures**

The primary means of alleviating any accommodation shortage is to instigate measures which will ensure that adequate serviced land and housing are available to meet the demand when it occurs. In this situation, the timing and magnitude of the demand can be forecast with reasonable certainty. The Company will commence negotiations with the Shire Council to examine ways in which the anticipated housing demand in Augusta can be met within the required time frame. The availability of water and sewerage systems in Augusta will also be an important factor in this examination, given the current supply situation.

5.3 **INFRASTRUCTURE PROVISION**

5.3.1 **Road access**

As outlined in Section 3.4.3, road access to the mine site from both Augusta and Margaret River mainly utilises the Bussell and Brockman Highways. It is desirable that site access be by way of an all-weather road system and to this end some upgrading of Payne and Scott River Roads may be necessary.

The extent of this upgrading is a matter for negotiation between MDL and the Augusta-Margaret River Shire Council.

5.3.2 **Water supply and sewerage**

The water supply and sewerage systems at Augusta will need to be upgraded to cater for the expected growth in population arising from both trend growth and the proposed project. Given the timing of the project, this is a matter which will require immediate attention if local serviced allotment demand is to be met.

Consideration should also be given to extending Margaret River's sewerage system and to bring forward the completion date of the 10 Mile Brook water supply reservoir.

The resolution of the above matters should form part of the role of the housing task force discussed earlier.

5.3.3 **Telephone and Electricity**

These services are currently available in those localities likely to experience growth. As with the other utility services foreknowledge and forward planning will ensure that both services can be provided when required to meet the needs of the incoming population.

5.4 **PRODUCT TRANSPORTATION**

5.4.1 **Impact assessment**

The preferred product transport method is for the product to be transported by road to Bunbury for shipment overseas. The proposed transport route from the mine industrial area is to use Scott River Road, the Brockman Highway, Sues Road and Sabina Road to its intersection with the Vasse Highway.

Several route options are currently being examined by MRD for the Vasse Highway to Capel section. From Capel, it is proposed to use the Bussell Highway with appropriate by-passes to reach the Inner Harbour loading facility at Bunbury.

The principal social effects which can arise from product transport by road (involving some 60 trucks per day) are a result of this increase in traffic, and the type of traffic. They relate to the disruption of day to day residential, farming and business activities; increase in conflict with other local road users; and to the effects of dust, noise and vibration generated by passing heavy haulage vehicles.

The section of the proposed haulage route between the mine industrial area and the end of Sabina Road generally passes through sparsely inhabited rural lands and State Forest. Between Sabina Road and the Bussell Highway/Capel route alternatives pass through a more closely-settled dairy farming area.

(a) Mine Site to Sues Road

Scott River Road between the mine site and the Brockman Highway is to be widened, raised, and sealed. This will improve access to adjoining rural properties by providing an all-weather road. Current access problems during wet weather should be overcome by this action. As no houses are located along this section, no residential nuisance is anticipated.

The Brockman Highway section, between Scott River Road and Sue's Road involves a distance of some 12 km. The existing sealed road is intended to be increased in pavement width from the existing 6m to 7m. This section of the route has 4 houses within 100m of the highway. They are grouped at the western end, whereas the eastern part is in State Forest. No traffic volume figures are available for this section of the highway. It is understood, however, that average daily volumes are relatively light in the range of 200-300 vpd, and that seasonally higher peaks occur. The increase in volumes attributable to the mine is expected to be 60 heavy vehicle trips per day, with haulage 24 hours per day, five days per week.

While this additional load will require some adjustment on the part of residents adjoining the Highway, it is not expected to disrupt their daily operations to an unacceptable degree. As there are no school buses operating on this highway section, no conflict is expected in this area.

(b) Sue's Road - Sabina Road

This section of the route runs through State Forest only. There are no houses here, and only one tourist attraction, this being the Sue's Bridge camping and picnic area on the Blackwood River. No school buses use these roads. The daily traffic count is unknown but believed to be small (i.e. less than 20 vpd.).

Sue's Road is an unsealed 7m wide forestry road, and Sabina Road is a forestry track. The upgrading of both roads will greatly improve access for forestry operations, and fire control. Sealing of the road will eliminate dust nuisance to the Sue's Bridge facility on the one hand, but the increased traffic will generate an increase in traffic noise and the potential for conflict between road users. Neither of these effects are considered to be unacceptable. The provision of a sealed, rural highway standard carriageway will create an opportunity for use by other road users and provide a more direct route into the Augusta-Margaret River Shire for highway transport companies and the public alike. There will be a need to arrive at a tradeoff between the desire to segregate heavy traffic from normal road users (including tourists) and the added convenience and shorter travel distances which the opening up of this road sector will generate.

(c) Sabina Road to Capel

MRD will carry out a study of route options and their respective impacts before a route for this section is decided on. Irrespective of which of the route options selected for this route section, there is potential for disruption of the local residents activities which the MRD is likely to examine. Opinions expressed by local residents suggest that the provision of a heavy transport route through this agricultural area will be intrusive and disruptive to their way of life, and will in some cases threaten their economic viability. Potential effects which the MRD is likely to examine are as follows:

- the loss of the use of roadside verges for stock grazing;
- increased difficulty in moving stock along and across roads;
- increased hazard for school children riding their bikes to reach bus stops;
- conflict between mining trucks, milk tankers, school buses, and other local traffic;
- increased incentive for other traffic to begin utilising the upgraded road system as it will provide a more direct, faster link between the Vasse Highway and Capel;
- where new road is proposed, the separation of one part of a farm from another with the attendant difficulties in working a farm consisting of two distinct segregated units; and the associated loss of agricultural land;
- the loss of the aesthetic appeal of the roads involved through the removal of roadside vegetation and realignment of carriageways. The existing roads are generally narrow and winding with vegetation close to the road and with trees overhanging to form an avenue;
- an increase in road traffic noise as most houses are located close to the road;
- a decrease in safe ingress and egress to property adjoining the route;
- downgrading of land values.

The degree to which these impacts are realised will depend upon the route option selected and how the upgrading and new road works are proposed to be undertaken.

The most obvious measure to eliminate these impacts is to select a route alternative which utilises either the existing highway system (Vasse Highway and Bussell Highway) which carries heavy traffic and where such traffic is accepted by adjoining residents and businesses; or to locate a route which does not pass through a closely settled, intensively farmed agricultural area. This will be done by MRD as a strategic planning exercise.

(d) Capel to Bunbury (Inner Harbour)

This section of the route follows the existing Bussell Highway to Bunbury. Bypasses are intended to be constructed at Capel and Bunbury. The Capel Bypass route location is incorporated in the Leeuwin-Naturaliste Plan (Stage I) and was derived after detailed community consultation. The need for the Capel By-Pass is evident now, with the added traffic generated by the Beenup mine and the proposed Jangardup mine adding weight to the argument. As the social impacts associated with the Capel By-pass are understood to have been considered in determining the bypass, this report does not consider this matter further.

The final section of the route follows the Bussell Highway. This highway already carries a substantial volume of traffic both local, tourist and heavy transport vehicles. Residences and businesses adjacent to the road accept the function of the highway and the perceived disadvantages of living adjacent to such an arterial road. It is understood that the route at the Bunbury end, will utilise the proposed Bunbury By-Pass as identified in the Bunbury Region Plan. The intent of this By-pass is to direct non-essential traffic away from the Bunbury urban area by re-routing it around the urban area and linking with the Australind By-pass. Utilization of this By-pass should alleviate any effects heavy truck traffic from the Beenup mine may have on the urban residential areas of Bunbury.

In essence, the contribution of Beenup-based truck trips to average daily traffic flows along this sector of the Bussell Highway will be small in comparison to current traffic volumes.

The question of land values being depressed by having heavy traffic moving through a rural area is difficult to assess. From a land valuation viewpoint, the creation of an upgraded road adjacent to a property would usually improve land values rather than depress them. This state of affairs would apply up to the point where the disruption experienced as a result of traffic along the road, outweighed the perceived advantage of the good road-surface and the access it provides.

5.4.2 Management measures

The principal potential social impacts identified relate to possible disturbance to the daily operation of farmers located in the Sabina Road to Capel section. Appropriate management measures will be prepared by MRD when their Study is completed.

5.5 CONSTRUCTION MATERIALS TRANSPORTATION

It is understood that the main transport route for the movement of construction materials, plant and equipment to the project site will be via Sue's Road and the Bussell, Vasse, and Brockman Highways.

No information is available on the likely volume or frequency of such traffic at the present time. It is, however, expected that this transportation will not be sufficient to cause any undue disruption to residents and businesses along the transport route. This transport will involve wide and long loads on occasions, but the effects of this would short-lived and minimal, and take the form of minor delays and nuisance.

5.6 SOCIAL INFRASTRUCTURE

The newcomer population generated by the project is expected to comprise a mixture of young single persons and families in the young and middle life cycle stages. Typically, the community services needs for the young single, independent population are sporting and social facilities which cater for the young adult age group. The young family requires access to childhealth centres, family planning services, playgroups, childcare and pre-school centres, and a variety of information services relating to social welfare matters in particular. The middle family also places demands upon the general practitioners and other health and welfare services with a greater, regular use being made of dental facilities. In addition, education services, clinical guidance and counselling are often required, and library services are very much in demand.

The growth in permanent population attributable to the project is expected to account for approximately 42% of the Shire's overall resident population growth in the period 1989-92. After 1992, the project makes no further contribution to the population growth.

This section examines the ability of the Shire's social infrastructure to accommodate growth. Where possible provision shortfalls are identified, it is recommended the Beenup Consultative Group be used as the mechanism through which these shortfalls are addressed. The role of this body would be to firstly, in conjunction with the relevant authorities, make sure the needs are communicated; and, secondly, that appropriate programs are developed to have the facilities in place for when they are

needed. Thirdly, the consultative group could act as the monitoring body to assess progress and to deal with any unforeseen problems which may arise.

5.6.1 Education facilities

Project-related demand for school places is expected to be as follows:

	Construction Phase (Peak)	Operational Phase
Kindergarten/Pre-School	30	16
Primary School	105	57
Secondary School	62	34

This demand, coupled with that originating from trend growth, will necessitate an increase in the capacity of all three levels of educational provision in the Shire. As discussed in Section 3.5.1, all schools have very little spare classroom capacity and most are in need of additional administrative and teacher preparation space at the present time. Measures will need to be put in place to not only cater for the short-term peak occurring in the second half of 1991, but to provide for the ongoing teaching needs of the permanent project population.

5.6.2 Medical facilities

The Shire's medical facilities are considered adequate to cater for the needs of the incoming workforce, although the needs of the retirement population may require additional hospital beds for aged patients to be provided, or alternatively additional nursing home beds.

With respect to the project site, the closest medical facility is located in Augusta. In emergency situations, the fastest route to this hospital would be via Scott River Road and East Augusta. Consideration needs to be given to the possible establishment of emergency procedures using this route.

5.6.3 Recreational and Civic facilities

As discussed in Section 3.5.5, the Shire possesses a substantial range of both civic and recreational facilities, sufficient to cater for most community needs. The three items identified as being needed in the community were a Shire swimming pool, a community hall at Augusta, and a permanent police presence in Augusta. With the advent of the project, weight would be added to the demand for such facilities and services. In particular, the need for a swimming pool facility in which people can learn to swim is considered a necessity in most communities. The need for a

permanent police presence in Augusta will also be a necessity before the commencement of the project's construction phase.

5.6.4 **Social support facilities and services**

The main social support services required for any population are access to legal aid; drug and alcohol rehabilitation; information services; community centres; neighbourhood houses; family financial, youth, marriage, personal and sex counselling; and sex, life skills and pre-marriage education.

As identified in Section 3.5.3.4 the Shire contains the basis on which to build an effective social support system. The services provided, the community centre and the mobile counselling service cover most aspects to varying degrees. It is envisaged that as the Shire's population grows these services will need to be expanded in depth and scope.

5.6.5 **Commercial facilities**

The commercial facilities in the Shire are sufficient to cater for most convenience shopping needs. Comparison shopping opportunities will increase as the population grows and can support such facilities.

5.7 **SOCIAL ADJUSTMENT**

The development of the proposed mine will generate some inevitable social adjustments within the community. The effects occasioned by population influx will tend to alter existing social networks as well as individual attitudes.

5.7.1 **Construction phase**

5.7.1.1 **Impact assessment**

The existing pace and nature of life in Augusta, and to a lesser extent in Margaret River, would undergo some change during the construction phase. The peak construction related population will represent approximately 10% of the Shire's population, whereas the direct component of this population will represent some 240 persons or 130 newcomer workers. A substantial proportion of this population is expected to locate in and around Augusta.

Traditionally, this incoming construction workforce may be categorized into the following groups :

- ° The young or single construction worker.

- ° The unaccompanied construction worker or specialist tradesman who has an established home elsewhere.
- ° The accompanied worker, housed in his own caravan, or rental accommodation. Many of these workers might be permanent construction workers who move from one construction project to the next with well-equipped, large caravans.

From experience in other construction situations, it can be anticipated that some construction workers will spend many of their non-working hours drinking and relaxing in local hotels and clubs. While the level of drinking, in turn, may cause some traffic offences and petty brawling, the incidence of such behaviour is generally low and must be viewed in the context of the annual influx of tourists.

The standard and availability of construction workforce accommodation will be an important factor in helping to minimise or prevent social problems related to this group. For example, experience elsewhere indicates a positive relationship between good standard housing and facilities and a lack of behavioural troubles in this workforce.

It can be expected that a proportion of the newcomer construction workers will have little or no interest in identifying with the Shire's communities, and little understanding of the behavioural standards and attitudes which prevail in the Shire. The incidence of social adjustment effects will also depend upon the attitudes of the local population towards change. Given the local acceptance of the seasonal tourist influx in Augusta and Margaret River, it would be reasonable to expect the local population to accept a degree of change.

Although it is difficult to predict exactly how problems of social adjustment may be manifested, some consideration of the possibilities will assist in recognising and dealing with social situations as they arise.

The beneficial social affects arising from construction will result from an increase in employment opportunities, in business turnover, in opportunities for meeting new people, and in a more optimum use of sporting and other community facilities. However, adverse social effects may arise and may include :

- ° Increased activity in the two towns (more traffic, more strangers in town, more people looking for entertainment, etc.) making them "not what they used to be".
- ° A small increase in incidence of traffic offences, brawling and petty crimes.

- ° A possible tendency for some locals to use the construction workforce as scapegoats for incidents which occur, irrespective of their involvement.
- ° The attraction to the Shire of persons who have neither job, accommodation or money, and who tend to place an increased burden on the Shire's welfare services.

5.7.1.2 Management measures

Some solutions to these above social problems are available. Measures which may assist in lessening problems include :

- ° Provision of sufficient and adequate accommodation (in particular rental accommodation).
- ° Encouragement of interaction between the local population and the construction population through specially arranged social and sporting activities.
- ° Adequate locally-based welfare resources to cope with both emotional and practical problems.

5.7.2 Operational phase

5.7.2.1 Impact assessment

The production phase will require social adjustments similar to those mentioned above for the construction phase situation. It is probably that some persons who come for the project construction will remain and gain employment in the project's operation.

Amongst the newcomer permanent population, it may be expected that non-working women will experience the most difficulties in adjusting to a new life in a new location. Those in the workforce and children have school to provide socializing opportunities, whereas women who do not work may feel isolated and lonely in their new environment. Dislocation from established networks of family, friends and familiar environments is often central to the problem. Other problems faced by newcomers may also include lack of information about community services and support systems such as baby-sitting and the like.

Difficulties which may be faced by the existing Shire population may include difficulty adapting to different values, beliefs and behaviour patterns that newcomers may bring (although given the community's exposure to change over recent years

this should not be a major new problem); a real or apparent loss of the "small town atmosphere" and suspicion or resentment of the abilities and talents of new residents which are apparent through their involvement in community or sporting organizations.

The shift work involved at the mine will generate different work and recreation patterns for those involved, and may place strains on family life.

The benefits which may result from the incoming permanent population will be a more varied community, additional support and membership of community service and recreational clubs, the development of new interest groups, and increased population thresholds which will add justification for the provision of additional community facilities. The increased employment opportunities will benefit school leavers reducing the extent of out-migration amongst certain age groups.

5.7.2.2 Management measures

Some general measures which may assist the social adjustment problems discussed above include :

- ° Timely provision of facilities and services needed by the incoming population (and coordinated by the Beenup Consultative Committee)
- ° The establishment of a new residents information kit providing advice about access to services, etc.
- ° The provision of neighbourhood or community houses in appropriate locations.
- ° Concerted efforts by existing clubs and organisations to attract new members.
- ° Specially-organised activities to encourage social interactions.

As indicated earlier in this report, effective local authority management based on cooperation and coordination with community groups, government departments and services, and the project management, will greatly assist in accommodating and integrating the new population in a manner which is least disruptive to the existing community.

5.8 LIFESTYLE EFFECTS

The discussion in this section examines the generality of lifestyle impact. The more specific quality-of-life items have been examined in the preceding discussion.

As outlined in section 3.6.2 lifestyle issues are of primary concern to the Shire's resident population. The overall concern is that the project will be the forerunner of a number of industrial projects locating in the Shire, and that this coupled with the accompanying increase in population, will lead to the destruction of the lifestyles which the community currently enjoys.

The basic question to be examined here is how will the implementation of the Beelup Project reduce or eliminate the ability of the current Shire population to practice their current lifestyles? Will the project's implementation lead to the transformation of the Shire from a rural/holiday based community to an industrial community?

From the preceding information, it is considered unlikely that the project will lead to a downgrading in lifestyles. The major effects identified which may limit lifestyle opportunities are land/house price increases generated in the short-term by demand exceeding supply.

It is beyond the scope of this study to examine the potential for the industrialisation of the Shire and the way this may impact on existing lifestyle values.

ANNEXURE A:

LIST OF ORGANISATIONS/PERSONS CONSULTED

Augusta Businessmen's Association
Augusta-Margaret River Development Association
Augusta-Margaret River Shire Council
Augusta-Margaret River Tourist Bureau
Augusta Pensioners League
Augusta Ratepayers Association
Australian Bureau of Statistics
Beenup Project Consultative Group
BHP-UTAH Minerals International
Blackwood Protection Group
Business and Professional Women's Club (Margaret River)
Commonwealth Department of Social Security
Commonwealth Employment Service
Cr. D.H.Patmore
Cr. A.L. Colyer
Cr. S. Hohnen
Cr. A. Jaworak
Cr. E. Stephenson
Cr. A. West
Cr. C. Wilcox
Cr. L. Sheppardson
Country Women's Association
Leeuwin Conservation Group
Margaret River Business Association
Margaret River Counselling Service
Mineral Deposits Limited
Mineral Sands Study Group
Nayton Communications
Social Impact Unit, W.A. Deputy Premier's Office
South-West Development Authority
Water Authority of Western Australia
W.A. Department of Conservation and Land Management
W.A. Department of Employment and Training
West Australian Farmers Federation
West Australian Fishing Industry Council
W.A. Department of Planning and Urban Development
W.A. Department of Resource Development

ANNEXURE B:

LIST OF CLUBS AND ORGANISATIONS,
AUGUSTA-MARGARET RIVER SHIRE

1. **Sporting Organisations:**

Mixed Badminton Club, Margaret River
Ladies Badminton Club, Augusta
Mixed Badminton Club, Augusta
Mixed Badminton Club, Cowaramup
Basketball Club, Gloucester Park, Margaret River
Basketball Club, Civic Park, Augusta
Margaret River Bowling Club
Margaret River District Social Bowling Club
Leeuwin League Bowling Association
Pony and Horsemen's Club
Mixed Squash Club, Margaret River
Margaret River Tennis Club
Augusta Tennis Club
Cowaramup Tennis Club
Gracetown Tennis Club
Alexandra Bridge Tennis Club
Busselton/Margaret River Cricket Association
Margaret River Indoor Cricket Association
Augusta/Margaret River and Districts Football Club
Augusta/Margaret River Junior Football Club
Margaret River Golf Club
Augusta Golf Club
Margaret River Mens Hockey Association
Women's Hockey Association
Hot Rod Club
Margaret River Karate Club
Augusta/Margaret River Netball Association
Margaret River Polocrosse Club
Margaret River Softball Association

2. **Recreational Clubs**

Augusta Aero Club
Augusta Square Dancing Association
Moondyne Arts & Crafts Society
Augusta/Margaret River Arts Council
Margaret River Arts Club
Augusta Spinners & Weavers Club
Margaret River Choral Society
AMR Speliological Group
Folk Music Club
Margaret River Ballet Group

Veteran and Vintage Car Club
Augusta Art Club
Weight Watchers Club

3. Service Clubs and Organisations

St. John Ambulance (Augusta and Margaret River Branches)
Volunteer Fire Brigade (Augusta and Margaret River Branches)
Margaret River Pensioners League
Augusta Pensioners League
Red Cross Society (Margaret River and Augusta-Kudardup)
Cowaramup Action Club (ex Jaycees)
Fruit Growers/Market Garden Association
Country Women's Association (Branches at Kudardup, Margaret River,
Augusta, Alexandra Bridge, Karridale, Rosa Brook and Cowaramup)
Business and Professional Women's Association
Margaret River Apex Club
Margaret River Rotary Club
Lions Club of Leeuwin
Margaret River Businessmen's Association
State Emergency Service
Augusta-Margaret River Counter Disaster Committee
Augusta Ratepayers Association
Leeuwin Conservative Group
Augusta-Margaret River Tourist Bureau
Blackwood Protection Group
Augusta Businessmen's Association
Margaret River and Districts Agricultural Society
Augusta Historical Group
Returned Soldiers League
P & C Associations (Margaret River, Augusta and Karridale)
Margaret River Community Centre

ANNEXURE C:

REFERENCES

Augusta-Margaret River Rotary Business Directory (1989)

Leeuwin-Naturaliste Region Plan (Stages 1 & 2), State Planning Commission (1987 and 1988).

Social Impacts of Proposed Mineral Sands Transport Routes, Internal Report (1989), South West Development Authority.

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Augusta-Margaret River Recreation Study (1989), Hocking, Patman, Antill Pty.Ltd.

South West Strategy (Draft Report) (1988), South West Development Authority.

Central Forest Region - Regional Management Plan 1987-1997,(1987), Department of Conservation and Land Management, Western Australia.

Employment and Population in the South West 1981-1990, Department of Resources Development, Western Australia.

Shire of Augusta-Margaret River Corporate Plan, 1988. (Internal Council Report).

South-West: A Regional Profile (1988), South West Development Authority.

Economic Profile of the Leeuwin-Naturaliste Region (1987) ACIL Australia Pty. Ltd.

South-West Region - Tourism Development Plan (1986), Western Australian Tourism Commission.

Community Needs Study, Bunbury and South West Region (1985), Wilson Sayer Core Pty.Ltd.

Appendix XI

REPORT ON THE ACTIVITIES AND RECOMMENDATIONS
OF THE BEENUP FINAL LAND USE WORK PARTY

INTRODUCTION

On 15th May 1989, the Hon Minister for Mines approved the formation of an interdepartmental and community based Work Party to look at the final land use options for the proposed Beenup Heavy Mineral Sands Project east of Augusta. The project proponent is Mineral Deposits Limited (MDL), a subsidiary of BHP-Utah.

Two key issues have been identified during preliminary discussions on the project. The first was transportation, and the second, final land use. The first issue is being addressed by the Department of Resources Development (DRD) chairing a consultative committee to investigate transportation issues in the south-west. The final land use issue was addressed by the Hon Minister for Mines who instigated this Work Party.

MEMBERSHIP

An invitation to participate was extended to the Department of Agriculture, the Department of Mines, Department of Conservation and Land Management (CALM), the Department of Resources Development (DRD), the Environmental Protection Authority (EPA), the South-West Development Authority, the Water Authority of W.A. (WAWA), Augusta-Margaret River Shire Council and the proponent. The DRD and EPA subsequently declined the invitation to participated.

OBJECTIVES OF THE WORK PARTY

1. Collate and review available data.
2. Consider alternate final land use options.
3. Recommend final land use option(s).
4. Advise the Hon Minister for Mines of the recommended option(s).
5. Long term - review operating performance by the proponent on rehabilitation/land use matters on an annual basis

TERMS OF REFERENCE OF THE WORK PARTY

- (a) To assist and advise the proponent on recommended land use option(s) for inclusion in the environmental documentation required for project approval.
- (b) To co-ordinate the development and long term planning of the project rehabilitation and final land use.
- (c) To monitor and co-ordinate progress in rehabilitation on an annual basis.
- (d) To give advice to the Hon Minister for Mines when requested.

MEETINGS

Over the course of the following six months the Work Party met on three occasions: 6 June 1989; 26 July 1989; and 26 October 1989. The first meeting was held in Perth where the objectives of the Work Party were described and the meeting discussed its role and organisational structure. At that meeting, a preliminary list of alternative land uses was developed which included such items as agriculture (pasture), national park, tree farming, intensive agriculture, wetlands, community use (as either recreation land or revenue earning), or as a resource to swap for land of high conservation value. It was recognised at that meeting that the previous and current ownership of the land on which the project was to occur would pre-determine some of the alternative land uses. This arises due to the provision in the Mining Act 1978-87 which enables agreements to be made between the private land owner and the proponent on matters which especially relate to rehabilitation requirements.

The second meeting held on 26 July 1989 included a site visit which enabled the project to be described by representatives from the proponent company. The majority of project components (known at that time) were raised for the Work Party members. At that meeting, members tabled various documents and publications which were found to be useful for consideration of the various options applicable to the site. Also during the meeting, the representatives from the proponent company outlined the current progress of the various environmental studies being undertaken to enable completion of the anticipated environmental review. These studies included soil survey, anthropology, flora and fauna, hydrology and geotechnical drilling.

Prior to the meeting, an invitation had been extended by the Chairman to the Community Consultative Committee (set up at the instigation of the proponent), to comment on the options for final land use. It was reported at the meeting of the Work Party that the proceedings of the Community Consultative Group (CCG) had not resolved the matter of final land use.

It was also resolved by the final land use Work Party that the CCG be advised in writing that the best option for final land use for Beenup would predominantly be agriculture (in its broadest sense). This letter subsequently was forwarded to CCG.

It was agreed also at that meeting that little more could be achieved by the Work Part at that time until the proponent had undertaken further feasibility and planning studies, especially in relation to finalisation of the mining plan.

The third meeting was held on 26 October 1989 at Margaret River. The proponent gave a talk on the proposed mine plan which was then discussed in detail by the Work Party members. The proponent also described the land use limitations which occurred through the agreements made with the various land owners prior to purchase. For instance, one land owner has the first right of refusal for re-purchase of the land following mining and if accepted, requires that the land be returned to its current land use of grazing with pasture. However, the mine plan enabled the Work Party to arrive at the principle recommendations for the final land use.

RECOMMENDATION

It was anticipated that approximately 1,000 ha of land would be disturbed over the currently planned life of the project. Following discussions by the Work Party, it was agreed that the final land use would encompass the following proportions given the knowledge on the deposit available at that time:

- ° 70% could be pasture suitable for agricultural grazing by sheep or cattle
- ° 10 to 15% could be native vegetation to include replanting in suitable locations such as shelter belts and fenced-off shelter belts (protected areas along drainage lines).
- ° 5 to 10% as a buffer zone along the southern boundary of the deposit, i.e. adjacent to Scott National Park, which could extend the area of native vegetation approximately 300 m northward. The piece of land would be a buffer zone and in the long term this land could be excised from freehold land so that it could be included within the boundaries of the National Park.
- ° 10% land for community uses which could be planted down to a commercial tree crop under the Tree Trust run by the CALM.

Emphasis should be placed on the role of the community land proposed to be donated by the proponent. It is anticipated that an area of 100 ha of community

tree planting would be given an annual amortised return to the community of approximately \$170 per ha (\$17,000 total per annum) at the current rate of return. The proponent made it quite clear that any land returned for community use could not be managed in the long term by the proponent. The Augusta-Margaret River Shire Council stated however, that they would be pleased to take on the management of those areas if it was a project from the community would gain a fair return.

FUTURE ACTIVITIES OF THE WORK PARTY

This Work Party has achieved its objectives of giving recommendations to the Government and to the proponent for viable options for final land use at Beenup. It is proposed that this report be appended as an appendix to the Environmental Review and Management Programme prepared for Government by the proponent and would be the corner-stone for the rehabilitation commitments by the proponent.

It is anticipated therefore, that the Work Party will recess for at least the next twelve months until all Government approvals have been obtained and a final decision is made by the proponent to go ahead with the project. When the project commences, it is recommended that the Work Party reconvene to operate as an advisory group to Government and to assist the proponent. At that time the Work Party would be able to delineate, in greater detail, the sites and extent of the various land uses previously recommended.

(signed) K.E. Lindbeck
CHAIRMAN
BEENUP FINAL LAND USE WORK PARTY
DEPARTMENT OF MINES
PERTH
12 December 1989

Appendix XII

COMMUNITY CONSULTATION PROGRAMME

1.0 INTRODUCTION

BHP released details of the promising results of Beenup drilling on April 24, 1989 - more than two months before a decision to go ahead with an application for mining approval. The announcement included a commitment to keep the community supplied with whatever information was available on the project. The early announcement was intended to keep the public well informed. However, the proponent's inability to follow up with immediate detailed information created some frustration among local residents.

In May 1989, the proponent held information talks with Augusta-Margaret River Shire Council representatives. They discussed the formation of a consultative group to provide local input into the early stages of Beenup's planning and review.

On June 7 1989, the proponent sent letters to six community and government organisations, inviting them to nominate representatives for the group. By inviting community group nominations, the proponent hoped to draw opinions from a broad cross section of the district, at the same time working with a group small enough to evaluate the project proposals and, hopefully, make consensus recommendations. In practice, some issues had to be settled by vote to accommodate the disparate views of the group members. The invitations went to the Augusta-Margaret River Shire Council, the WA Farmer's Federation, the Leeuwin Conservation Group, the Augusta Ratepayers Association, the Department of Conservation and Land Management and the South West Development Authority.

The organisations were told that the proponent wanted to provide the community with an opportunity for local input into planning the project. The issues to be considered included:

- ° The transport of mineral sands products.
- ° Planning for rehabilitation.
- ° Land use options.
- ° Workforce requirements.
- ° Environmental studies.

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- ° Social impact.
- ° Regional economic development.

The membership of the Consultative Group is as follows:

Cr. D.H. Patmore	Chairman, Augusta-Margaret River Shire President
Mr. T. Adams	Augusta Businessmen's Association/W.A. Fishermen's Association
Mr. M. Ashford	Social Impact Unit
Mr. L. Calneggia	Shire Clerk, Augusta-Margaret River Shire
Mr. B. Chandler	CALM
Cr. A. Colyer	Augusta-Margaret River Shire
Mr. P. Gleed	Shire Planner, Augusta-Margaret River Shire
Mrs. A. Jaworak	Augusta Ratepayers' Association
Ms. P. Kelly	Consultative Group Secretary
Mr. J. Koeyers	Leeuwin Conservation Group
Ms. A. Lane-Glover	SW Development Authority
Mr. D. Lean	Development Manager, Mineral Deposits Ltd/BHP-Utah
Mr. B. O'Dea	Landowners representative
Ms. L. Serventy	President, Leeuwin Conservation Group
Ms. E. Smyth	Project Co-ordinator, Mineral Deposits Ltd/BHP-Utah
Ms. B. Thomson	Scott River Region Study Group
Mr. J. Thomson	Farmers Federation of WA
Mr. J. Wise	Department of Agriculture

2.0 TRANSPORT

One of the group's major roles was an evaluation of the options for transporting minerals produced at Beenup. The proponent identified three potentially viable export proposals:

- ° Shipping separated minerals from a jetty and conveyor belt at Flinders Bay, five km east of Augusta
- ° A seabed pipeline and pontoon loader for wet mineral concentrate, using the same site in Flinders Bay
- ° Road transport to the port of Bunbury

The proponent had earlier ruled out the cheapest transport option, road haulage on Bussell Highway to the port of Bunbury, because of potential disruption to communities en-route.

The consultative group set up a five member sub-committee (Peter Gleed, Alan Colyer, Terry Adams, Anne Jaworak and Lyn Serventy), to make a detailed analysis of the options from a community viewpoint. The sub-committee made no recommendations but found that the sea transport options were likely to create the greatest social impact problems.

The sub-committee report, which included a notional social cost-benefit analysis of each option, was adopted by the consultative group on October 25, 1989. The proponent's Mining Development Manager, David Lean, agreed to an engineering review to take account of the committee's findings.

Since then, the proponent has selected a transport option - Sues Road with a major by-pass around Ludlow and Capel. The route is the option which the sub-committee identified as having least negative impacts and most advantages to the community.

3.0 SOCIAL IMPACT

The consultative group will help to evaluate the social impacts of the Beenup development. At its meeting on September 20, 1989, the group adopted guidelines for the social impact study.

These guidelines were based on draft proposals by the consultant and WA Government Social Impact Unit Director Anne Vershuer, with some minor modifications by the consultative group. The group is expected to use the social

4.0 SITE VISITS

The consultative group has made two site tours to inspect the mining and rehabilitation of existing operations.

On October 5, 1989, six consultative group members visited mining and rehabilitation operations in the Capel area. The group inspected dredge mining and sand dune rehabilitation at Minninup, pasture rehabilitation at North Capel and the AMC Wetlands Centre wildlife sanctuary at South Capel. The chairman later reported that the group had been impressed by the standard of rehabilitation.

Between November 13 and 16, 1989, twelve consultative group representatives visited New South Wales to inspect Mineral Deposits' existing operations at Hawks Nest, Viney Creek and Stockton. A subsequent report to the Augusta-Margaret River Shire Council said that members of the group were generally impressed by Mineral Deposits' operations in the Great Lake region.

"The proponent appears to be sensitive to local issues and works within the standards of rehabilitation required by Government legislation," the report said.

The local Shire Council and representatives of local community groups support that impression, speaking positively about MDL's presence in the area and the proponent's contribution to community activities and projects.

"The Great Lakes region's major industry is tourism and the local economy is dependent on the tourist dollar. The unanimous opinion was that sand mining did not affect tourism either by the use of roads to transport the product or location of the mines in relation to tourist destinations."

The group listed seven issues of concern with potential relevance to Beenup:¹

- ° Dust levels at the minesite and dry mill.
- ° The origin of the proposed workforce.
- ° The number of plant species in rehabilitation.
- ° The impact of mining on the area's hydrology.

¹ The matters are dealt with in the appropriate sections of the ERMP

- ° The impact of mining on the area's hydrology.
- ° Maintenance of roads.
- ° The number and timing of truck movements.
- ° Impacts of the workforce on local fishing.

5.0 PUBLICITY

The proponent arranged regular consultative group meeting reports to the Augusta-Margaret River Mail and the Busselton Margaret Times. From November 1989, the proponent inserted fortnightly advertisements in both newspapers to promote proponent open days and update project planning information.

5.1 DISPLAYS

The proponent produced two sets of shopping centre displays. The first was an introduction to the project proposals; the second was an outline of transport and land use proposals. In each case, identical displays were set up in Margaret River and Augusta shopping centres for 2-3 weeks in November, 1989 and three weeks in February, 1990.

5.2 OPEN DAYS

The programme includes four on-site open days, where updated displays and proponent representatives are available to explain the project to local residents and visitors. Three open days - on October 27, 1989, January 13, 1990 and February 10th, 1990 have been held. One more is planned for March, 1990.

5.3 COMMUNITY TALKS

Project co-ordinator Erica Smyth and BHP Exploration Manager Phil Harman, have solicited speaking engagements at the meetings of local service clubs and community organisations. The meetings have provided an effective forum for discussions on the project. Proponent representatives have also attended public meetings organised by local concerned groups, answering questions and providing information on the project.

5.4 DIRECT MAIL

Letters to all Augusta-Margaret River Shire residents have outlined the project planning and review timetable. The letters, which attempt to address some local issues, have listed

the opportunities for public involvement. A second mail distribution to local residents, identified the proposed mineral transport route.

5.5 COMMUNITY ISSUES

A survey of community leaders in the Augusta-Margaret River Shire was undertaken in November, 1989 to identify the main areas of concern regarding the project. The issues identified by this survey were categorised for convenience into six groups:

- ° Quality of life issues.
- ° Mining and minesite issues.
- ° Product transport (road) issues.
- ° Product transport (sea) issues.
- ° Community issues.
- ° Economic issues.

These concerns were taken into account during the preparation of the ERMP, particularly the socio-economic study. The concerns raised are dealt with in the appropriate section of the ERMP.

5.6 SUMMARY OF COMMUNITY INVOLVEMENT/INFORMATION

Open days

Date	Time	Approximate numbers
27.10.89	2-4 pm	180
13. 1.90	10am-4pm	60
10. 2.90	10am-4pm	45

Community talks

	Approximate numbers
Augusta Ratepayers Association	25
Augusta Lions Club	50
Augusta Businessmens Association	10
Augusta CWA	15
Leeuwin Conservation Group	20
Margaret River Branch W.A. Liberal Party	30

Margaret River Pensioners League	15
Busselton Provost	25

Public meetings addressed

Augusta : Leeuwin Conservation Group June 1989 approximately 50 people
 Molloy Island : Annual Residents Meeting Dec. 1989 approximately 60 people.

Public meetings attended

Scott River : Scott River Study Group Dec. 1989 approximately 110 people
 Blackwood Conference : S.W. Development Authority Feb. 1990 approximately 200 people.

Letters and visits from public direct to Company (up to 1st Feb. 1990)

	Number	%
Contractors looking for work	44	56
Individuals enquiring about jobs	11	14
Individuals wanting more information about project	9	11
Individuals protesting about project	4	5
Groups wanting donations	4	5
Groups wanting more information about the project	2	2.5
Groups making submissions/suggestions	1)
Individuals supporting project	1)
Groups supporting project	1)
School children wanting school project information	1) 6.5
School children protesting about project	1)
	<hr/>	
	79	100

6.0 LONG TERM CONSULTATION

If the project is approved, the proponent sees a continuing role for community consultation during construction and operational stages. As the project develops, it is envisaged that the community group membership could be expected to alter to suit the changing community needs. This long-term consultation will allow on-going concerns to be raised with mine management on a regular basis (say every three to six months) and to provide an avenue for quick response by the proponent to any unexpected events in the community or mine.

7.0 **COMMUNITY CONSULTATIVE GROUP GREAT LAKES
STUDY TOUR, NOV 13th-17th, 1989**

Report prepared by Alison Lane-Glover in association with the other attendees, excluding BHP personnel.

Attendees

David Patmore (Chairman)	Augusta-Margaret River Shire Council
Len Calneggia	Augusta-Margaret River Shire Council
Peter Glead	Augusta-Margaret River Shire Council
Alan Colyer	Augusta-Margaret River Shire Council
Anne Jaworak	Augusta Ratepayers Association
Terry Adams	WA Fishermen's Association
	Augusta Businessmen's Group Inc.
John Koeyers	Leeuwin Conservation Group Inc.
Alison Lane-Glover	South West Development Authority
David Lean	BHP
Phil Harman	BHP
Erica Smyth	BHP
John Nayton	BHP
Jodie Elvin	Busselton-Margaret Times

Itinerary

Tuesday 14th November	Inspection Stockton Mine Site Inspection Viney Creek Mine Site Inspection Myall Lake Golf Course
Wednesday 15th November	Meeting with Great Lake Shire Inspection Bridge Hill Ridge
Thursday 16th November	Inspection Hawks Nest Dry Mill Inspection Mungo Brush Rehab Meeting with Community Reps

STOCKTON

The area before mining was comprised of unvegetated, shifting dunes which the group considers to be a very sensitive environmental formation.

The company was only required to rehabilitate where it had removed vegetation for mining. It was not required to rehabilitate some of the bare dunes but was doing so by choice to stabilise the area.

The aquifer has not been affected by mining. Even as the operation moved towards the beach and dredged below the salt level no infiltration of salt has been observed. The dredge is currently about 500 m from the beach. The aquifer supplies water for the local township.

The company did not mine areas where there are significant stands of timber. Members of the group saw this as an indication of the level of MDL's concern for the environment.

The dunes were recontoured to match the original topography and fencing was erected across the dunes in various directions depending on the prevailing winds. This helps to stabilise the dunes until sufficient vegetation is established.

There were mines in the area not owned by MDL. They did not compare very favourably with the mine that the group was inspecting. The local shire also acknowledged that other miners didn't show the same standard of concern for the environment.

The lack of noise was significant. This mine was very small in comparison to the size of the proposed Beenup operation but even at Viney Creek, where two dredges were operating simultaneously, the noise was insignificant. It was interesting to note that a nearby airport contributes a large amount of noise pollution to the area without much public comment.

The mine site is lit up at night but there was no indication that anyone in the vicinity objected. With the proposed mine at Beenup a glow on the horizon would be seen. No lights would be seen directly because of the distance. Miners indicated that the mine is lit up "better than daylight".

The road to the mine is in poor condition, especially considering the trucks are only half the size of one the proposed Beenup project will require. The Scott River road will need to be upgraded and maintained to a high standard.

The company is paying a royalty on the road. Comment was made by some local people that the royalty money collected by the shire did not always find its way back into roadworks.

MDL also paid 50% of the cost of the Hawks Nest/Tea Gardens bridge as part of a deal to transport product from Viney Creek to their dry mill.

The group agrees that generally MDL shows itself to be sensitive to issues and approachable, not just with their standard of rehabilitation but also their contribution to community infrastructure. MDL's attitude appears to be one of responsibility towards the environment and community.

VINEY CREEK

This mine site appeared dramatically different because of the colour of the soil due to the high organic content.

There is a severe dust problem as a result of a very large area of exposed soil, awaiting rehabilitation. It is a fairly isolated area so the dust doesn't seem to be affecting anyone directly, apart from the workers. There are no residential areas in the vicinity. MDL may need to address the possibility of the existence an occupational health hazard to workers from the inhalation of dust.

This site is quite unique because of the shallowness of the deposit. The dredge moves at a very fast rate leaving large areas behind it that have to wait for the topsoil to be replaced so that rehabilitation can begin. The speed also makes preclearing necessary, to break up the soil.

The proposed mine at Beenup would not require earth works of that magnitude. There is a small area of laterite in the northern section that may need to be broken up.

The winds at Viney Creek are nowhere near as strong as the winds experienced around the Beenup/South coast area. MDL indicated that though the exposed area at Beenup would be much less than at Viney Creek, if a dust problem still persisted then it would look at an oil-water mix to spray on the soil. The contention is that oil is difficult to remove from an aqueous environment and an environmentally safe alternative is required.

Viney Creek was a degraded pine forest however the company was asked to rehabilitate back to natural vegetation. This area is to be returned to national park as part of an agreement with AMP and the government. Rehabilitation is in its early stages and is dominated by a few species e.g. flannel flower, which will later be reduced by the growth of the larger, slower growing species. This sam process was used at Bridge Hill Ridge, which is at a later stage.

THE BASKETS

The Myall River Golf Club was not a full eighteen hole course prior to the mining period and MDL built the four remaining holes at the conclusion of mining. Both activities co-existed for some time. The dredge actually ended up outside the club rooms.

Local people commented on the improvement to the course by MDL and agreed that it was a much better course as a result of the company's work.

The standard is impressive, especially considering that mining has so recently concluded. It is a very pleasant golf course.

MEETING WITH GREAT LAKES SHIRE COUNCIL

The purpose of the visit was to discuss aspects of MDL's mineral sands operations in the Great Lakes Shire, specifically relating to economic, environmental and social impacts, negative or positive.

The Shire President, Mr. Warren Williams, indicated that a recent fire at the council offices had destroyed a considerable amount of historical data so they were unable to produce accurate statistics, however a general picture could be given.

The shire's most important industry is tourism followed by fishing. Mining is not significant on a shire wide basis but it has varying significance within local areas. For example, in the Tea Gardens/Hawks Nest area about 15.7% of the workforce are mining employees. Add to this the multiplier effect and mining has significant impact on that area. Overall mining employs about 1.5% of the shire's workforce.

An interesting historical fact is that when the price of rutile dropped on the international market a few years ago the school population in the shire dropped by about 20-30%.

Mineral sands mining has not attracted any other industry to the region either in the form of downstream processing or other supporting industry. There has, however, been positive spin-offs to local businesses. A note of caution was expressed about local businesspeople overanticipating the impact of the industry on their businesses. This occurred in the Great Lakes shire as a temporary situation.

It is vital to the region that the tourist character remains dominant and is not changed by the presence of other industrial developments. Tourism grossed \$69 million last financial year.

It has been the experience of the Great Lakes shire that sand mining is not detrimental to tourism. Generally the mines sites are remote from areas attractive to and used by tourists. There has been some comment on:

1. Truck traffic at Tea Gardens (Truck now operate only in daylight hours - from 7.00am to 6.00pm on local roads)
2. Visual impact at Smith's Lakes.

However, it does not stop the level of tourist activity.

Even the enormous amount of heavy traffic on the highways leading to tourist destinations doesn't discourage tourist movements to the region. These highways (e.g. Pacific Highway) provide the most direct links to major tourist facilities and tourists may accommodate heavy traffic because of their preference for the quickest routes.

A number of new roads have been built as a result of sand mining which have opened up areas (mainly beaches) for tourists.

A point made about the use of rail to transport mineral sands related to the Singleton experience. A rail system was put in to handle the coal but because of the unreliable nature of the mode of transport due to strikes and industrial unrest the product was put back onto the road in trucks.

The Great Lakes has the highest population growth rate in the state. This includes a high percentage of retirees. There is also a high level of unemployment as a significant number of people move into the area without having jobs to come to. The president suggested that the mine may pick up workers already locally employed. It had been their experience that some council workers had moved to the mine and council had to train new employees.

The existing infrastructure can handle a population increase of between 30-50%.

1. About 1,100 to 2,000 lots are presently available.
2. There is a limitless water supply, however the capacity of the pipeline may be a temporary constraint.
3. Sewerage could handle a 50% increase.

Comparing mining areas with non mining areas the population characteristics are similar and changes in land prices are a result of factors other than the impact of the industry.

The state government's policy is to actively encourage a high density urban development. A recent publication of intention to build a high rise structure in the shire attracted no objections from the public. This same kind of development is unlikely in the Margaret River Shire because of an 8 m building height restriction. In any case it is likely that a similar proposal would raise objections from local residents. Based on census figures population pyramids have been drawn for the Augusta-Margaret River shire.

There is built into the state's environmental protection legislation a requirement for contributions from developers for infrastructure. Under that section a road transport levy has been set at 40c per tonne of raw material (indexed), netting the

shire about \$4,000-\$5,000 per month. This money goes towards upgrading local roads. The shire could also ask for contributions for community services but they have not encountered any demand for such services which can be directly attributed to the presence of the mining industry.

The council spoke of MDL's financial involvement in a number of community projects. The most recent is the provision by MDL of a large quantity of surplus sand for the shire to sell. It was stated that the sand was pretested for radiation and passed by the New South Wales Health Department as safe. MDL's share is 25% and the rest goes to the community.

It is the Council's opinion that MDL has been generous in their dealings with council in comparison to other mining companies.

The council also considers that MDL's rehabilitation is of a high standard and acceptable to the local community and the state government.

Other companies in the past have failed in their attempts to rehabilitate to an acceptable level but MDL's corporate attitude to rehabilitation is more responsible.

A government committee has been established to oversee ongoing rehabilitation. A report is prepared by the Mines Department every 6 months and a major report every 2 years. The committee evaluates these reports and makes recommendations to the government. Other departments involved in the monitoring process are the Department for Mineral Resources and the National Parks and Wildlife Service. To date both departments are satisfied with the job that MDL are doing.

BRIDGE HILL RIDGE (SMITHS LAKES)

There have been some complaints by local skiers that they could see the mining operations while recreating in the area and later, complaints were made about the different colour green of the rehabilitated sections.

Most members of the group were very impressed by the rehabilitation of the dunes. The height and angle of the dunes is outstanding. There was some difficulty reforming them to their original dimensions because of their size but MDL seems to have completed the work successfully.

As part of its rehabilitation strategy the company removed large palms from in front of the operation and replanted them behind. These plants are very slow growing and there was some concern as to their ability to successfully rehabilitate. They appear to be thriving.

The company admits that not 100% of existing species will be returned to the area but the percentage has increased greatly with the continuing development of rehabilitation technology.

A committee, comprised of government, shire and company representatives, oversees and monitors the rehabilitation. Dr. John Lewis is about to give his final report on an early section. Bridge Hill Ridge is to be included in an existing national park. The group would be interested to hear comment from the relevant authority controlling national parks, on the degree of success of MDL's rehabilitation of this area.

The greatest damage to the environment is inflicted by surfers and bikers who camp in the area. Closure of the road into the area is under debate at the moment. Council wants it to remain open.

The risk of fire is a worry because it could do enormous damage to the rehabilitating areas.

HAWKS NEST DRY MILL

This plant is relatively old (about 25 years) and new equipment (electrostatic separators) is about to be installed. This will reduce dust levels in the plant. Some of the electrostatic separators are not completely covered however they comply fully with NSW occupational safety legislation. The risk of electric shock becomes an issue with large groups of people, or children, in the confined spaces. It does not pose a problem with normal staffing levels.

Also the workers do not wear radiation badges. On investigation it was found that the badges were originally issued to the workers, however they stopped wearing them after a period of about five years because the Health Department no longer required them. It was stated that the radiation levels were so low the badges were not registering anything. The Winn Report (1984) may lead some members to question the efficiency of these devices and whether the lower sensitivity limit was reliable.

These occupational health issues appeared not to concern the workers. Comparison with the proposed Beenup dry mill is not appropriate because the latter will have the latest dust suppressing technology and will be a more modern construction. Also the radioactivity of the dust will be much lower because of the lack of monazite.

Also the WA Occupational Health regulations are more stringent and the proposed Beenup plant will be required to conform in all aspects including the use of radiation monitoring equipment.

A noticeable feature of the dry mill was the large piles of ilmenite tailings which are being retreated to extract more rutile. The products sold from this mill are rutile and zircon. The ilmenite has no significant value because of its low percentage of titanium and the presence of impurities, particularly chromium. The group is concerned about the visual impact from the nearby Myall Lake and the beach.

This will not occur at Beenup because ilmenite is the valuable and saleable product and will be removed from the site. Mill tailings will be returned to the minesite and covered with topsoil.

The storage of monazite in bags on the floor of the shed in close proximity to workers concerned the group. We were told that there was no guaranteed market for the product and it is left there until shipment is arranged.

Once again there is no comparable situation with the Beenup proposal because there have been no recordable levels of monazite found in the deposit to date.

Apart from the tailings the dry mill did not appear to be visually offensive or noisy. It was understood that all separators were operating.

ERMP BRIEFING

Dr. John Lewis indicated when the ERMP would be ready to present to the EPA and that members of the consultative group would be given copies.

The document is to be written without complex technical data to make it easier to read. The data will be contained in appendices to the document.

All transport options considered by MDL will be outlined and a conclusion will be drawn.

MUNGO BRUSH NURSERY

Most members of the group were very impressed with the nursery operations. Particularly the propagation techniques and the number of varieties of plants that are propagated. Also going to mine locations to carefully study and register the species. Soil from the mine site is taken back to the nursery for growing the seedlings. It reminded one member of similar procedures by the industry observed in the Eneabba area.

MDL indicated that it may not require a nursery at Beenup. The demand for such a variety of plants is not required with a large proportion of the mined area likely to go back to pasture. The work will probably be contracted out to local nurseries.

David Stoupe, the nursery manager, seemed to be both knowledgeable and experienced in this kind of work. His assistants also showed a lot of interest and enjoyment in their work. David stated that MDL use nursery staff to plant out the young seedlings, based on the principle that they will have the greatest interest in the survival rate in the rehabilitated areas. It also provides the workers with a sense of personal satisfaction seeing the job through from beginning to end.

MEETING WITH COMMUNITY REPRESENTATIVES

Caroline Stranger - Hawks Nest Progress Association.

The association was impressed with MDL's performance in the area. MDL workers became active members of the local community, joining service clubs and community groups and the company was happy to support community activities and projects by providing donations.

It has been the association's experience that sand mining has not impacted negatively on tourism, either from a transport point of view or localised tourist activities.

The association appreciated MDL's contribution to the building of the Hawks Nest/Tea Gardens bridge as it was urgently needed.

Geoff Burgess - Hawks Nest Tourist Association.

In the opinion of the local tourist interests past logging has done far more damage to the lakes than sand mining could ever achieve.

Tourism in the region is funded entirely from the shire budget. The state government makes no contribution. They are dependent on the industry.

According to the association the mining operation does not impact on tourism at all.

It was concerned that the levy paid to the shire from MDL did not always find its way back into road works and that they were dependent on the shires commitment to upgrading the roads as a priority.

Ross Fiddon - Newcastle Fishermen's Association.

Ross belongs to the biggest single supplier of fresh seafoods to Sydney markets.

He stated that where mines had been operating in close proximity to coastal or lake systems there had been no drainage problems or noise pollution.

NSW fishery laws are very different to WA. When a workforce comes into an area there is no significant impact on the industry because netting or potting by amateur fishermen is prohibited.

In WA there is no such restriction. The concern is raised because, according to the fishing industry, people settling in an area fish at a much higher level than visiting tourists and, because of the expected age group of the workers, fishing will be a prime pastime. It has been observed in some areas of Western Australia in the past that the combined catch of Australian herring by amateur fishermen exceeds that of professionals.

This assumes that the workforce will be imported which seems to be the case in other areas. It appears that locals form only a small part of the workforce.

Also the local fishing industry has lost some of its workers to the mining industry.

Tony North - Councillor.

Council is generally impressed with MDL's operations and attitude.

The community can only benefit by the interest MDL takes in the area as a result of its mining operations.

Dick Angel - Koala Conservation Society.

Dick said that the local koala colony was very vibrant and healthy and he was committed to keeping it that way. He saw no reason why there should be any conflict with the mining industry.

The habitat runs no risk of being impacted on by mining. He expressed some concern about the urban expansion and saw that as a direct threat.

SUMMARY

Most members of the group were generally impressed by MDL's operations in the Great Lakes region. The company appears to be sensitive to local issues and works within the standards of rehabilitation required by government legislation.

The local shire council and representatives of local community groups supported that impression, speaking positively about MDL's presence in the area and its contribution to community activities and projects.

The great Lakes region's major industry is tourism and the local economy is dependent on the tourist dollar. The unanimous opinion was that sand mining did not affect tourism either by the use road to transport the product or location of the mines in relation to tourist destinations.

Issues of concern to members of the group were:

1. Dust levels both at the mine site and in the dry mill. Whether adequate measures will be taken to ensure acceptable dust levels.
2. Origin of proposed workforce at Beenup. Whether workers will be drawn from local employers, local unemployed or outside the area.
3. Number of plant species in rehabilitation. In the event of part of Beenup being rehabilitated to natural vegetation, whether local nurseries could provide an adequate diversity of species and the soil is capable of supporting the chosen land use.
4. Impact of mining on the hydrology of the nearby national park and associated wetlands.
5. Maintenance of roads. In the event that a road transport option is chosen, whether agreements made between parties ensures that roads are properly maintained.
6. Truck movements. In the event that a road transport option is chosen whether trucks will be operating 24 hours per day or restricted to daylight hours.
7. Impacts on the fishing industry. Whether recreational fishing by the imported workforce will have a negative effect on the local fishing industry.

Appendix XIII

ABBREVIATIONS

ABS	-	Australian Bureau of Statistics
Australia		
BHP	-	The Broken Hill Proprietary Company
BR	-	Bedroom
CALM	-	Conservation and Land Management
CFC	-	Chlorofluorohydrocarbon
dB(A)	-	A measure of sound levels
dE	-	The mean energy imparted by ionising radiation to matter of mass dm
DRD	-	Department of Resources Development
EPA	-	Environmental Protection Authority
ERMP	-	Environmental Review and Management Programme
Gy	-	Gray, the unit used to measure "absorbed dose", where 1 gray equals 1 joule per kilogram
ha	-	Hectare
ISA	-	Intensive sampling area
Kilogram	-	kg
kl	-	kilolitre (1,000 litres)
km	-	Kilometre
kV	-	Kilovolt
l	-	litre
LPG	-	Liquefied petroleum gas
m	-	Metre
m ³	-	Cubic metre
MDL	-	Mineral Deposits Limited
mg	-	Milligram
ML	-	Mega litre (1,000,000 litres)
mm	-	Millimetre
MMA	-	Mackie Martin & Associates Pty. Ltd.
MRD	-	Main Roads Department
MW	-	Megawatt
NH&MRC	-	National Health and Medical Research Council
OSA	-	Opportunistic sampling area
Park	-	Scott National Park
Proponent	-	Mineral Deposits Limited
SECWA	-	State Electricity Commission of Western
Shire	-	The Augusta-Margaret River Shire
TDS	-	Total dissolved salts
The Company		Mineral Deposits Limited

Appendix XIV

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- Interfluve - The high land between two streams belonging to the same drainage system
- Iron pan - A layer in the soil cemented by iron oxides deposited from a rising and falling water table in the soil over a period of time
- Lignite coal - Brown coal showing traces of plant structure
- Limonic iron ore - An iron-bearing mineral in which iron oxide is deposited as a cement in sandstones
- Mesozoic - The geological era ranging in time from 230 to 70 million years ago
- Metamorphic - Rocks within the earth's crust that have been changed by heat, pressure and chemically active fluids
- Microroentgen - A measure of the amount of energy absorbed as ionising radiation passes through matter. It is one millionth of a roentgen
- Millibecquerel - One thousandth of a Becquerel
- Nucleon - Either nuclear constituent, a proton or a neutron
- Nuclide - Any grouping of nucleons capable of more than a transient existence
- Piezometer - A small diameter cased bore used for water level measurements
- Pleistocene - The period of geological time from 2 million years ago to the last ice age
- Podsol - Soils with a zone of leaching and a zone of deposition. They are typical of considerable areas of cool, temperate climate
- Radionuclide - a nuclide that is radioactive

GLOSSARY

- Absorbed dose - The quotient of dE by dm, where dE is the mean energy imparted by ionising radiation to matter of mass dm
- Becquerel - The unit of measurement of radioactive decay defined as one radioactive disintegration per second. The disintegration may occur as the result of emission of an alpha particle or beta particle
- Cainozoic - The geological era ranging in time from 65 to 2 million years ago
- Concentrator - Gravity separation plant
- Cyclone - Equipment used to remove water from tailings
- Dieback - The decline and death of plants caused by the root fungus *Phytophthora cinnamomi*
- Dredge - Machine used to excavate the orebody
- Electromagnetic separation - The separation of minerals according to their electromagnetic properties
- Electrostatic separation - The separation of minerals according to their electrostatic properties
- Ferruginisation - The concentration of the metal iron
- Groundwater - Underground water contained within a saturated zone or rock, ie. an aquifer
- Holocene - The period of geological time after the last ice age

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- Roentgen - That quantity of X- or gamma radiation such that the associated corpuscular emission per 0.001293 g of dry air (1 cubic centimeter at 0 C and 760 mm of mercury) produces, in air, ions carrying 1 esu of quantity of electricity of either sign. 1 esu of charge is equal to $1/(3 \times 10^9)$ coulombs
- Slimes - Dispersed clay material
- Spirals - Equipment used to separate heavy minerals from a slurry by gravity
- Tailings - Material remaining after the heavy minerals have been removed
- Trommel - A screening device