TIO2 CORPORATION NL

COOLJARLOO MINERAL SANDS PROJECT

DRAFT ENVIRONMENTAL IMPACT STUDY/
ENVIRONMENTAL REVIEW & MANAGEMENT PROGRAMME

MAUNSELL & PARTNERS PTY. LTD.

NOVEMBER 1987

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CONSULTING ENGINEERS & PLANNERS

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ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME

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

This Environmental Review & Management Programme (ERMP) for the Cooljarloo Mineral Sands Project has been prepared by TIO2 Corporation NL in accordance with Western Australian Government Procedures. The ERMP will be available for comment for weeks, beginning on and finishing on .

Comments from Government agencies and from the public will assist the EPA in preparing an Assessment Report, in which it will make a recommendation to Government.

WHY WRITE A SUBMISSION?

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

All submissions received 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
- suggest recommendations, safeguards or alternatives.

POINTS TO KEEP IN MIND

It will be easier to analyse your submission if you keep in mind the following points:

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

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

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

REMEMBER TO INCLUDE

YOUR NAME

ADDRESS

DATE

THE CLOSING DATE FOR SUBMISSION IS:

SUBMISSIONS SHOULD BE ADDRESSED TO:

The Chairman
Environmental Protection Authority
1 Mount Street
PERTH WA 6000

Attention: Mr. D. Koontz

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SUMMARY

1. INTRODUCTION

1.1 GENERAL

This Environmental Review & Management Programme (ERMP) describes a proposal by TIO2 Corporation NL to mine and process mineral sands in the south-west of Western Australia. The proposed minesite is at Cooljarloo near Cataby, approximately 170km north of Perth. Initial processing on-site will produce heavy mineral concentrate which will be transported by road to a final process plant at Muchea 40km north of Perth. This plant will produce ilmenite, rutile, zircon, monazite and leucoxene which will be railed to Kwinana and Fremantle for export.

The purpose of the ERMP is to enable the Western Australian Environmental Protection Authority (EPA) to evaluate the proposal. Submissions from members of the public and other interested parties are sought as inputs to this evaluation and a guide to the preparation of submissions is provided at the beginning of this ERMP.

1.2 THE PROPONENT

TIO2 Corporation NL is a Western Australian company incorporated in 1985. It has two subsidiaries, Tific Pty. Ltd. which controls a mineral sands deposit near Jurien and Yalgoo Minerals Pty. Ltd. which controls the Cooljarloo deposits.

1.3 PROJECT TIMING

Construction of the process plant and preparations for mining are scheduled for 1988. Production will commence in 1989 and full operational capacity will be achieved by 1992. Estimated reserves indicate a potential project lifespan of more than 30 years.

1.4 LEGISLATIVE FRAMEWORK

The Cooljarloo Project must obtain approvals under a number of statutes and regulations and must comply with any conditions associated with such approvals. The key statutory requirements are listed in the ERMP.

1.5 THE ERMP PROCESS

The environmental evaluation process in Western Australia is prescribed by the Environmental Protection Act 1986. This enables the EPA to require a proponent to prepare an ERMP. Public review of the ERMP is an integral part of the evaluation process and submissions from interested parties are considered by the EPA in the development of their Assessment Report on a proposal. That Report is made via the appropriate Minister to the State Government which determines final approval and conditions. The Act enables interested parties to appeal against the Assessment Report within a prescribed period of time prior to Government consideration.

2. NEED FOR THE PROPOSAL

TIO2 Corporation NL believes that the need for the Cooljarloo Project can be defined in terms of economic benefits including expenditures, employment, revenue and royalties. Construction expenditure will be in the order of $40-50M by the time the plant is fully operational. Annual operating expenditures will be in the order of $18M. The project will directly employ an estimated 109 people and, allowing for consequential employment, should generate about 234 jobs in total.

Western Australia is currently a major world supplier of titanium minerals producing 43% of all ilmenite, 21% of rutile, 40% of zircon, and 54% of monazite. Demand and prices for these minerals are increasing. The major markets are in North America, Western Europe and Japan and alternative potential suppliers are located within or close to these regions. Western Australia needs to develop available mineral sands deposits such as Cooljarloo in order to maintain its position as a supplier which can meet long term contracts.

3. EVALUATION OF ALTERNATIVES

3.1 MINING METHOD

After careful evaluation of the suitability and costs of various alternatives, dredging in tandem with a floating wet concentration plant has been chosen as the best method for mining the Cooljarloo deposits. Excavation of the deposits will intercept the underlying shallow aquifer over much of the site and the resulting wet conditions enable the use of a floating dredge system. However, a dry dredge in front of a floating concentration plant may be used. Other alternatives would involve large scale site dewatering which could cause unnecessary environmental impacts.

Very large quantities of waste material will also have to be mined and treated in order to extract the useful minerals. Transport of this waste to a fixed process plant would involve significant costs, whereas a floating concentration plant can be placed directly behind the dredge to enable direct pumping of mined material.

3.2 MINESITE REHABILITATION

Various options for land-use after mining have been evaluated but the proponents consider that return of the site to its present status is the most suitable alternative. This will involve the re-establishment of native vegetation over most parts of the tenement and restoration to sheep/wheat production for the remainder.

3.3 SITE SELECTION

A specific analysis has been prepared to compare the cost implications of alternative sites for the dry process plant at Muchea and at Narngulu near Geraldton, and for export through Geraldton rather than through Kwinana and Fremantle. The environmental implications of these alternatives are considered to be equivalent.

The analysis indicated that the Narngulu alternative would involve additional capital recovery costs in excess of $3M. This arises mainly from regional differences in construction costs and the development of a road/rail transport system. Transport by road to Eneabba and from there by rail to Narngulu offers the lowest cost transport system for this option, but would involve an additional $3M operating costs each year compared to transport to the Muchea site.

4. THE PROPOSAL

4.1 TENEMENTS

The Cooljarloo minesite is covered by four mining leases and twenty-six mineral claims which cover an area approximately 18km long by 5km at the widest point and with a total area of about $60km^2$. The tenement area runs northward from about 6km north of Cataby and is west of, but relatively close to the Brand Highway.

4.2 THE DEPOSITS

The Cooljarloo deposits contain proven and probable ore reserves of about 288Mt with an average grade of 4.4% (about 13Mt) heavy minerals.

4.3 MINING PLAN

The deposits are classified as upper level, mid-level, and basement according to their physical position and/or the nature of mineralisation.

The mining plan involves three stages as follows:

- exploitation of upper level strands in the first 2-5 years of mining followed by
- excavation of large mid-level deposits over a period of 12-13 years, then
- mining of deposits at various levels which have not been fully assessed to date.

An option of exploiting the large mid-level deposits first is being considered.

4.4 MINING OPERATION

A single suction dredge will be used for the first phase of the mining plan. A second dredge will then be required to strip overburden covering the deeper deposits. The mining dredge will pump the ore directly to a wet concentrator plant which will float behind it in the dredge pond.

4.5 THE WET PROCESS PLANT

The function of the wet process plant is to separate waste tailings and slimes in the ore from the heavy minerals and to produce a concentrate of the latter. This separation is achieved by a series of physical processes and especially gravity separation. Waste materials (eg quartz) in the ore have lower specific gravities than the heavy minerals and the two streams separate as they pass through spiral concentrators. The waste can then be used to backfill the dredge pond while the wet concentrate will be stockpiled and solar dried awaiting transport to Muchea for further processing.

4.6 DISCHARGE OF TAILINGS AND SLIMES

Mining and rehabilitation at Cooljarloo will be integrated. As mining proceeds, tailings from the wet concentrator plant will be used to fill the rear of the dredge pond. A series of slimes receival ponds will then be constructed using sand tailings on the filled area and a new tailings disposal area will be commenced in the dredge pond.

Slimes will then be fed into the receival ponds up to a depth of 2m. Then after two months of drying, the pond walls will be levelled to cover the slimes with a 1m layer of sand. The placement of slimes and sand will be varied to achieve planned contour variations. The sand will then be covered with topsoil up to a depth of 30cm and rehabilitation will commence.

Once mining is underway, a tailings placement area, slime receival ponds, slime drying area, and rehabilitation will all be operational in sequence behind the dredge pond.

4.7 MINESITE INFRASTRUCTURE

The main infrastructure requirements at the minesite are water (10,000kl to 30,000kl per day) and a 33kV power supply. An artesian bore system will be developed on-site to supply the former and SECWA proposes to install a distribution line from Moora to supply electricity to the mine.

4.8 THE DRY PROCESS PLANT

Wet concentrate will be delivered from the mine to the dry process plant at Muchea by road-train at the rate of one delivery per hour. At Muchea, the concentrate will be dried and will then pass through a complex series of electrostatic, magnetic and gravity separation equipment. The entire process relies on the fact that each of the heavy minerals has a unique combination of electrical and magnetic properties and specific gravity.

Ilmenite and rutile are electrical conductors while zircon and monazite are non-conductors. Therefore, as the concentrate passes through an electrical field, the conductors and non-conductors separate and can be collected. As ilmenite is magnetic, it can then be separated from the rutile by passing this stream through a magnetic field and a similar process can be used to separate magnetic monazite from non-magnetic zircon. Gravity separation is used to further refine some of the final product streams.

The annual output of the Muchea plant is expected to be in the order of:

Ilmenite	311,200tpa
Rutile	18,200
Leucoxene	2,800
Zircon	42,700
Monazite	2,100
Waste	61,000
	438,000tpa

The waste material will be returned to Cooljarloo and buried. The products will be transported by rail to Kwinana for export except for the monazite which will be railed to Fremantle in containers.

4.9 THE KWINANA FACILITY

Most of the products will be exported through Kwinana using the existing jetty and loading facilities of the Australian Iron & Steel industrial site. Some storage sheds will be constructed on this site.

5. DESCRIPTION OF THE EXISTING ENVIRONMENT

5.1 NATURAL ENVIRONMENT AT THE MINESITE

The Cooljarloo tenements consist predominantly of low dune ridges with interdunal swales subject to seasonal waterlogging. The general features are typical of the Bassendean Sand Formation which covers most of the Swan Coastal Plain.

At the southern end, the tenements also include a small area of the Gingin Scarp which bounds the Bassendean Formation to the east. Mullering Brook and various unnamed small watercourses run off the scarp across or onto the tenements.

The site is underlain by a shallow aquifer which features relatively slow flow rates to the west and discontinuities caused by the presence of clay layers. The level of the groundwater appears to be determined mainly by winter rainfall and evapotranspiration losses rather than throughflow.

The vegetation consists mainly of Banksia low woodland of various types with areas of wetland heath, mixed low heath, Xanthorrhoea reflexa low heath (on the Gingin Scarp), and restricted occurrences of Hakea obliqua scrub heath and Eucalyptus low woodland. There is also a large property which has been completely developed for farming and which supports only remnants of the original vegetation. A total of 305 plant species have been recorded from the site.

To date 6 frog, 13 reptile, 61 bird and 9 mammal species have been recorded at Cooljarloo during two surveys. None of these are rare, restricted or endangered. The vertebrate fauna is considered to be depauperate relative to similar sites elsewhere as a result of frequent bushfires in the area.

The climate at Cooljarloo features predominantly winter rainfall, high evaporation rates, and high and occasionally extreme temperatures in summer. Easterly winds occur in the morning throughout the year but the afternoon wind pattern is variable although south-westerlies feature in summer.

5.2 THE MINESITE SOCIAL ENVIRONMENT

An assessment of Aboriginal sites at Cooljarloo has been made with the assistance of representatives of the local Aboriginal community. The location contains one known archaeological site which consists of a few scattered artefacts and which has been disturbed by agricultural activities. This site is considered to have low significance.

The area however, has religious and economic importance to the contemporary Aboriginal community as Mullering Brook is associated with a Waugal (Rainbow Serpent) belief and wildflowers are collected there on a commercial basis. The brook will be disturbed by mining but will be restored subsequently. This is acceptable to the community and approval has been given to disturb the site. Commercial wildflower picking will continue during mining and will be assisted by the installation of better tracks.

The Cooljarloo tenements are located within an area of vacant Crown Lands and large agricultural properties. The Badgingarra National Park and two other conservation reserves are nearby and a proposed extension of the park overlaps part of the tenement (678ha).

The local population is small and dispersed. The nearest locality is Cataby which is a small roadhouse complex on the Brand Highway 6km to the south. The site is within the Shire of Dandaragan. The town of Dandaragan has a population of less than 200 (1981 figures) and is about 20km to the east. Other local centres are Badgingarra, Cervantes, and Jurien (total population less than 1,500).

5.3 THE DRY PROCESS PLANT SITE - NATURAL ENVIRONMENT

The Muchea site is flat and, apart from shade trees, has been cleared of natural vegetation for many years. The natural values are therefore relatively limited. It is bounded to the east by Ellen Brook although this important environmental feature is not on the property. The general locality is low lying, is underlain by a shallow aquifer and is prone to waterlogging. However, the site itself is slightly elevated and remains dry during winter.

The general climate is similar to that of Perth, with predominantly winter rainfall, relatively high evaporation, and warm to hot and dry summers. Easterlies dominate the summer wind patterns with frequent south-westerly sea breezes in the late afternoon, while northerlies dominate in winter.

5.4 THE DRY PROCESS PLANT - SOCIAL ENVIRONMENT

The plant site has no known Aboriginal sites. It, and land in the area generally, has been developed for agriculture for many years. The proposed plant site and several adjacent blocks near Muchea are currently in the process of being zoned for industrial purposes by the Shire of Chittering. Muchea, 2km to the south, is a very small community. Other population centres are Bullsbrook (12km south) with a population of about 1,000, and Gingin (24km north) which has a population of about 400.

5.5 THE PORT SITE (KWINANA)

The site proposed for the storage and export facility at Kwinana has been developed for industrial purposes and contains the BHP Steel/Australian Iron & Steel Works which are currently limited to wire, rod and bar production. The surrounding land is both zoned and substantially in use for heavy industry.

6. ENVIRONMENTAL IMPACTS

6.1 THE MINESITE - NATURAL ENVIRONMENT

Mining at Cooljarloo will involve the removal of vegetation above the orebodies and changes to the existing topography including modification of wetland depressions. However, these impacts will be offset by site restoration which will involve:

- the complete backfilling of mined areas with overburden and tailings (about 95% of the dredged material will be returned as backfill),
- variation in topography,
- creation of wetlands, and
- revegetation of all disturbed land with local native species, or restoration to agricultural use in the case of the existing farming property.

It is anticipated that groundwater levels under the tenements will not be substantially affected because low permeability of the aquifer and manipulation of water levels in the dredge pond will mitigate against localised drawdown. In addition, all water requirements will be met by an artesian rather than shallow bore.

The vegetation impact has been evaluated by assessing the extent of similar associations on the tenements that will not be affected by mining, and by determining the distribution of vegetation locally, including within nearby conservation reserves. All of the vegetation associations that will be disturbed by mining are locally extensive and are well represented in the reserve system. While similar comparative surveys of vertebrate fauna have not been made, it is assumed that the species found on the proposed minesite will be locally widespread due to the extent of the major vegetation associations.

The proponents believe that the project will benefit the local environment outside of the mined areas to the extent that a comprehensive fire management plan based on fire exclusion and suppression will be implemented. It is expected that this will lead to greater plant and animal diversity. It will also protect the rehabilitation areas.

6.2 THE MINESITE - SOCIAL ENVIRONMENT

Mining at Cooljarloo will not involve the disturbance of any known archaeological sites. However, Mullering Brook which is important to the contemporary Aboriginal community will be disturbed. It is proposed to restore the brook and this proposal has been accepted by the local community and by the Western Australian Museum. All necessary approvals have been granted.

Otherwise, mining will not permanently interfere with existing land uses. Commercial wildflower collectors and beekeepers will be allowed to continue their operations and will be assisted by the provision of a well made track system installed for general management purposes. The use of the farming property will be suspended for several years while mining and rehabilitation are in progress, but will eventually be restored.

Estimates provided in the ERMP indicate that a minimum of about 90 direct and indirect jobs will be created by mining activity at Cooljarloo. About 54 of these are likely to be filled by local people and 36 by non-locals. Half of the non-locals are expected to move into the local area and, allowing for families, this represents an inflow of about 45 people. It is considered that no special provisions in terms of community planning will be required to provide for this population inflow.

6.3 THE DRY PROCESS PLANT - NATURAL ENVIRONMENT

Detailed design of the Muchea site will take into account the natural features of the site. In particular, no contaminated drainage or other emissions will be made into Ellen Brook and a priority will be placed on retaining the mature trees on the site. Waste process water will be disposed of by on-site evaporation and the sewerage system will be designed to prevent contamination of groundwater. The on-site water supply will cause only slight drawdown of the aquifer.

Given these features, the impact on the natural environment due to plant construction and operation is considered to be slight.

6.4 THE DRY PROCESS PLANT - SOCIAL ENVIRONMENT

The operation of the dry process plant is not expected to influence land use in the vicinity either for agricultural or industrial purposes.

The Muchea plant is expected to generate 66 direct and 75 consequential jobs in the local area and the Perth Metropolitan Region. It is expected that some of the employees may choose to relocate in order to live close to the site, but the general availability of land in the Shires of Chittering and Swan indicates that no particular planning provisions need to be made on account of the Cooljarloo Project.

The additional road-train traffic on the Brand Highway represents a very minor addition to existing heavy haulage levels.

6.5 KWINANA

Use of the Kwinana site is considered to involve no potential environmental impact.

- semi-automatic bagging of monazite
- shielding of the monazite storage bin and monazite hand
- transport and shipment of bagged monazite in container

A Radiation Officer will be appointed and will be instruction of employers on safe practices.

A radiation monitoring programme will also be implemented to

- pre-operational and operational background radi mine and process plant site
- workplace radiation levels including monitoring indivi
- radiation levels in groundwater at the mine and proces
- any contamination of monazite transport units and wh

The background radiation study will detect any chang processing but is expected to confirm that no significant chan

8. CONCLUSIONS

The Cooljarloo Project presents an opportunity for t new mining and mineral processing venture in W consequential benefits in terms of expenditures, emp royalties. These benefits will occur at the national, State and

Against these benefits the potential costs, in the v consist mainly of site impacts due to mining. It is will be offset by rehabilitation which will restore t and current use potential. TIO2 Corporation NL is c very high standard of rehabilitation based on deta sites to be mined and will engage specific staff wit In addition, native plant production and seed collecti rehabilitation progress. The success of rehabilitation and structure of vegetation and recolonisation by carefully monitored.

7. ENVIRONMENTAL MANAGEMENT

7.1 INTRODUCTION

The principal concerns of environmental management for the Cooljarloo Project are the rehabilitation of mined areas, fire management in the tenement area, and radiation protection in the processing, handling and transport of monazite.

7.2 MINESITE REHABILITATION

Detailed planning for rehabilitation of the minesite will occur continuously during the life of the project. This planning will be based on site specific information on soils, topography and vegetation and will specify post-mining soil profile, contours, drainage, and revegetation methods and objectives.

Rehabilitation planning will conform with the overall objectives of replacing existing vegetation types and land uses and of re-establishing a landform similar to that which currently exists. It will also be based on techniques which have been proved in Western Australian conditions. These include:

- creation of a soil profile utilising dried slimes at depth where possible covered by sand and then by 25cm of topsoil
- removal, storage and replacement of upper and lower topsoils separately to ensure that seeds and organic materials remain close to the surface
- replacement of topsoil during optimal weather conditions for seed survival and germination
- cultivation following topsoil replacement
- establishment of a cereal cover crop to protect the topsoil for the first two years
- sowing of seed collected on-site from native plants to encourage quick growing species and a diverse flora
- hand planting of trees and shrubs to quickly re-establish structure and variety in the vegetation
- placement of trees and shrubs removed from the mine path onto the rehabilitation areas to provide seed source, nutrients, niches for fauna, and to assist in the prevention of soil erosion
- weed control if necessary

The progress and success of rehabilitation will be moni
designed to assess both revegetation and recolonisation by
The results of these studies will be regularly reported to the
the Department of Mines.

7.3 FIRE MANAGEMENT

The biological surveys of the Cooljarloo tenements sugge
and fauna of the area have been negatively affected by the
fires which has occurred there over many years. TIO2 th
draw up a comprehensive fire management plan in cons
Department of Conservation & Land Management, designed to
diversity and stability in those areas which will not
protect rehabilitation. The primary objective will be to
as much of the area as possible for the first 15 years
enable recovery of flora and fauna populations. To ensure
safely achieved, a network of firebreaks will be establish
fighting equipment will be maintained on-site, and cert
trained in fire management practices and fire-fighting techniques

7.4 RADIATION PROTECTION

Radiation protection measures are required during the mi
of monazite because of the presence of the radioactive el
main concerns are to prevent exposure to irradiation and
particles. Methods for ensuring such prevention are spe
the Western Australian Code of Practice in the Minin
Mineral Sands (1982) and the Draft Commonwealth Co
Radiation Protection in the Mining and Milling of Radi
The latter has been used as a basis for planning for th
as it is contemporary and is expected to be generally a
future. The standards in this Code provide for a high
are expected to apply well into the production period.

Work practices and design features that will be imp
radiation protection for the Cooljarloo Project include:

- limitations on access in the dry process plant
- separation of monazite in a dedicated building sep
plant
- dust control measures based on automatic r
extraction and collection

The proponents have also made commitments in this ERMP to develop and implement a fire management plan for the minesite, to maintain groundwater levels so that nearby vegetation is not affected by drawdown and to reconstruct surface features such as wetlands and Mullering Brook. At Muchea, a detailed map of the existing remnant vegetation will be completed as the first step in site planning for the process plant and the objective will be to retain as many mature trees and other vegetation as possible. Protection of Ellen Brook which is adjacent to the site will also be guaranteed.

The Project will also comply stringently with State and Commonwealth Codes for radiation protection in the processing and handling of monazite. In this respect the company is committed to specific design measures to separate the monazite process circuit, to suppress dust, and to ensure safe handling and transport. There will also be a radiation monitoring programme on and around the mine and process plant site.

TIO2 Corporation is therefore committed to a high level of environmental management and monitoring as an integral part of the Cooljarloo project. It intends to conduct its operations with the highest level of corporate social responsibility and is firmly committed to the principle that mining should involve a transient impact on the environment. On this basis, TIO2 Corporation NL believes that the proposal warrants approval.

1. INTRODUCTION

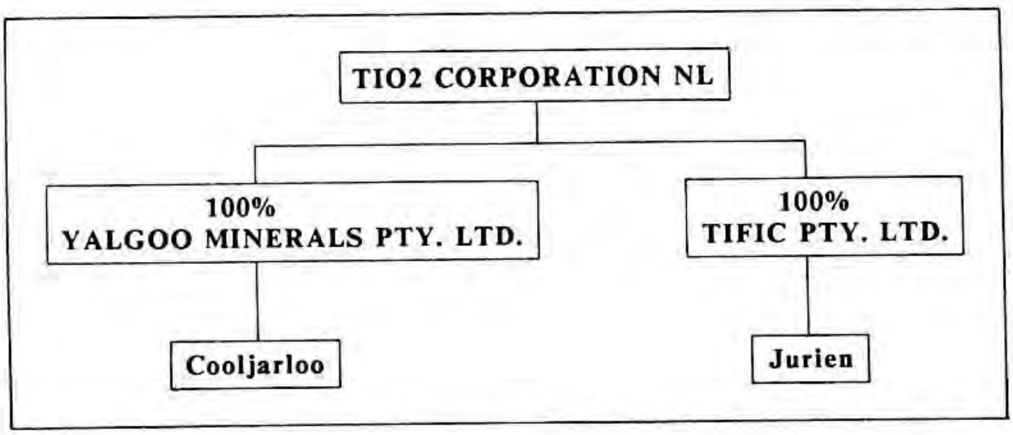
1.1 PURPOSE

TIO2 Corporation NL proposes to establish a mineral sands mine at Cooljarloo, and to process for export ilmenite, rutile, leucoxene, zircon and monazite at a site near Muchea. These locations are respectively 170km and 40km north of Perth, Western Australia. This Environmental Review & Management Programme (ERMP) provides a detailed description and analysis of the proposal in accordance with the provisions of the Western Australian Environmental Protection Act 1986. It has been prepared in accordance with Guidelines provided by the Western Australian Environmental Protection Authority (see Appendix 1).

The purpose of the document is to enable the State environmental authorities to evaluate the proposal and to enable the public and other parties to consider and comment on any matters of interest to them, or for which they have statutory responsibilities. A guide to the preparation of submissions is provided at the beginning of this ERMP.

1.2 THE PROPONENT

TIO2 Corporation NL was incorporated in Western Australia on 6th March, 1985, as Tula NL. The company acquired Yalgoo Minerals Pty. Ltd. on 16th March, 1985, and on 22nd March, 1985, Yalgoo purchased the Cooljarloo mineral sands deposit from WMC Securities Ltd. Tula NL became TIO2 Corporation NL on 14th June, 1985. Another subsidiary of TIO2 Corporation NL, Tific Pty. Ltd. controls a further mineral sands deposit near Jurien Bay. The company structure is therefore:



In August 1987, Minproc Mining Pty. Ltd., a wholly owned subsidiary of Minproc Holdings, became the major shareholder in TIO2 Corporation NL.

The primary activities of TIO2 since 1985 have been the preparation of feasibility assessments for both the Cooljarloo and Jurien deposits. The former acquired priority in 1986.

1.3 OVERVIEW OF THE PROPOSAL

The proposal has two major components; a minesite at Cooljarloo near Cataby and a process plant near Muchea. The former is approximately 170km and the latter about 40km north of Perth. Heavy mineral concentrates will be transported from the mine to the process site by road and products for export will be transported to Kwinana and Fremantle by rail. These principal locations are shown on Figure 1.1.

The mineral sands deposit at Cooljarloo is a little over 18km in length and is estimated to contain 288Mt of proved and probable ores including 13Mt of heavy minerals. The minerals involved are ilmenite, rutile, zircon and monazite. In addition, leucoxene will be separated at Muchea. The general features of these products are as follows:

- Ilmenite ($FeTiO_3$)is the most common commercial source of titanium dioxide (TiO_2 content 54-60%). It is used to make white pigment which has various applications in paint, paper and plastics manufacture. Cooljarloo ilmenite contains a relatively high 60% titanium dioxide content. Annual production will be about 311,200t.

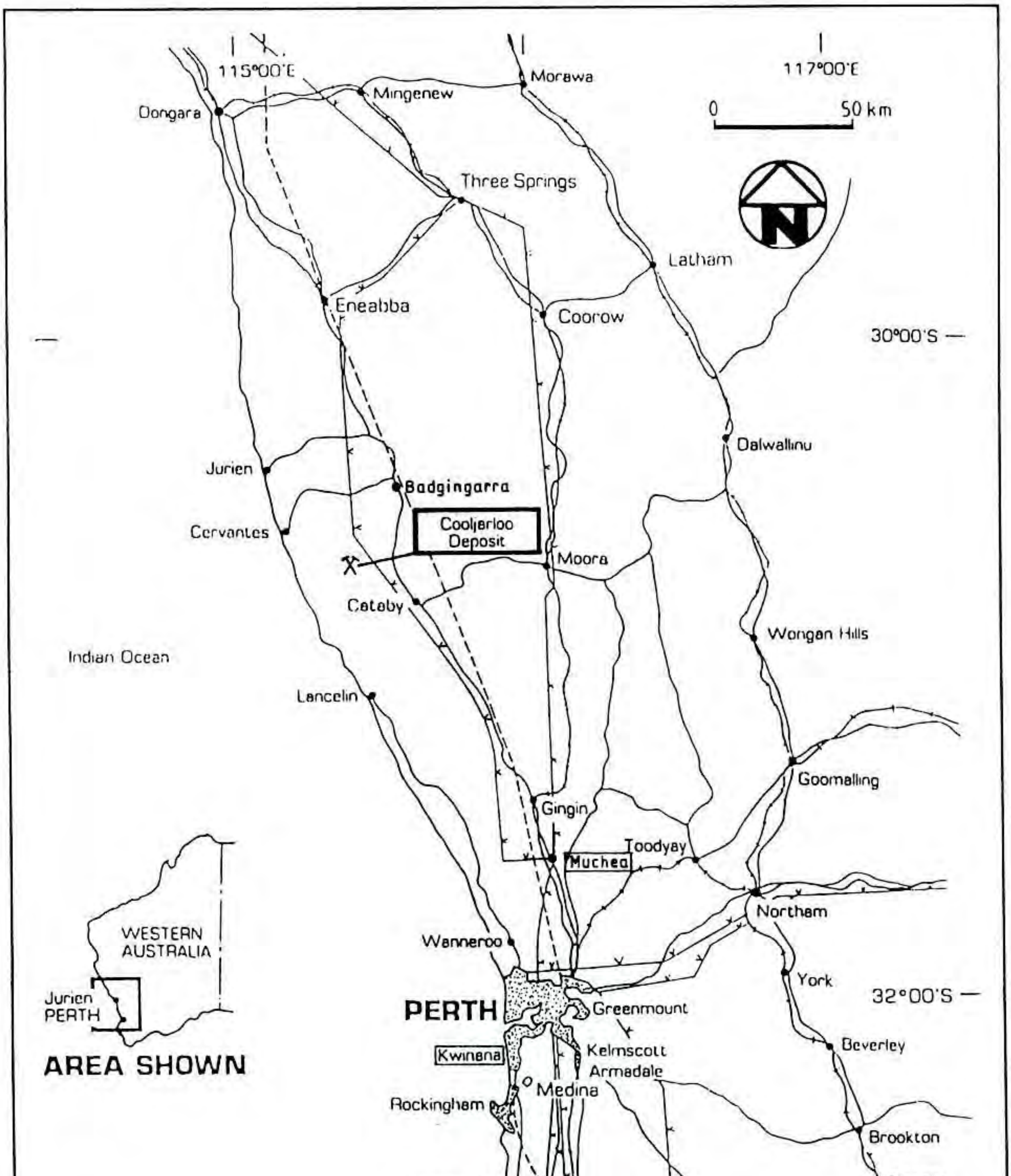
- Rutile is the pure form of titanium with 96% titanium dioxide. The high purity is required in certain manufacturing operations. Annual production will be about 18,200t.

- Zircon is a zirconium silicate which is used in certain glass and steel manufacturing processes and in frits and glazes for decorative tiles, whiteware and sanitary ware. Annual production will be about 42,700t.

- Monazite is a source of various rare earths used primarily in the petroleum, metallurgical, ceramic, glass, and electronic industries. Annual production will be about 2,100t.

- Leucoxene is altered ilmenite containing a relatively high level (87%) of titanium dioxide. It is used in the production of welding electrode coatings and white pigments. Annual production will be about 2,800t.

The nature of the Cooljarloo deposit is such that in order for the operation to be economic a floating dredge will be required for mining. This will be connected with a floating process plant which will produce a wet ore concentrate on-site. The wet concentrate will then be further processed at Muchea by magnetic, electrostatic and gravity separation to produce the various heavy minerals.



LOCATION OF THE MINESITE (COOLJARLOO), PROCESS PLANT (MUCHEA) AND PORT (KWINANA)

FIGURE 1.1

Tailings from the wet plant at the minesite will be returned to the mined area for rehabilitation purposes and reject material from the dry plant will be backloaded for the same purpose. Final site treatment will involve re-establishment of the current land use, that is revegetation with indigenous plants or return to agricultural production.

The ilmenite, rutile, leucoxene and zircon will be transported by rail to Kwinana and stored prior to loading into ships by conveyor. The monazite will be bagged on-site at Muchea and stored in a controlled area prior to delivery to Fremantle by rail in 20 tonne shipping containers.

1.4 PROJECT TIMING

Preparations for mining and the construction of facilities at Cooljarloo, Muchea and Kwinana are scheduled to commence during 1988, assuming that the environmental assessment procedures are completed and the necessary approvals are granted early in that year. The estimated reserves will enable a project lifetime in excess of 30 years with production commencing in 1989.

1.5 LEGISLATIVE FRAMEWORK

In Western Australia, the Mining Act 1978-1981 and associated Regulations define terms and conditions for the Cooljarloo mining leases. The Environment Protection Act, 1986 enables the Environmental Protection Authority to consider and make recommendations on the proposal by means of the ERMP process (see Section 1.6). Further, the establishment of the process plant at Muchea must conform with planning requirements at both the State and Local Government levels as provided for in the Town Planning & Development Act 1928 and the Local Government Act 1960.

Operation of the minesite and plant will largely be governed by the Mines Department inspection system established under the Mines Regulations Act (1946-1974).

Finally, the transport of materials is governed by various statutes and regulations which restrict the maximum weight of vehicles and prohibit the use of road trains in the Metropolitan area, and which provide safety standards for the transport of monazite.

Some of these statutes are discussed further in relevant parts of the ERMP but others, such as the statutory planning provisions, are essentially parallel processes which are consequential to or independent of environmental assessment.

1.6 THE ERMP PROCESS

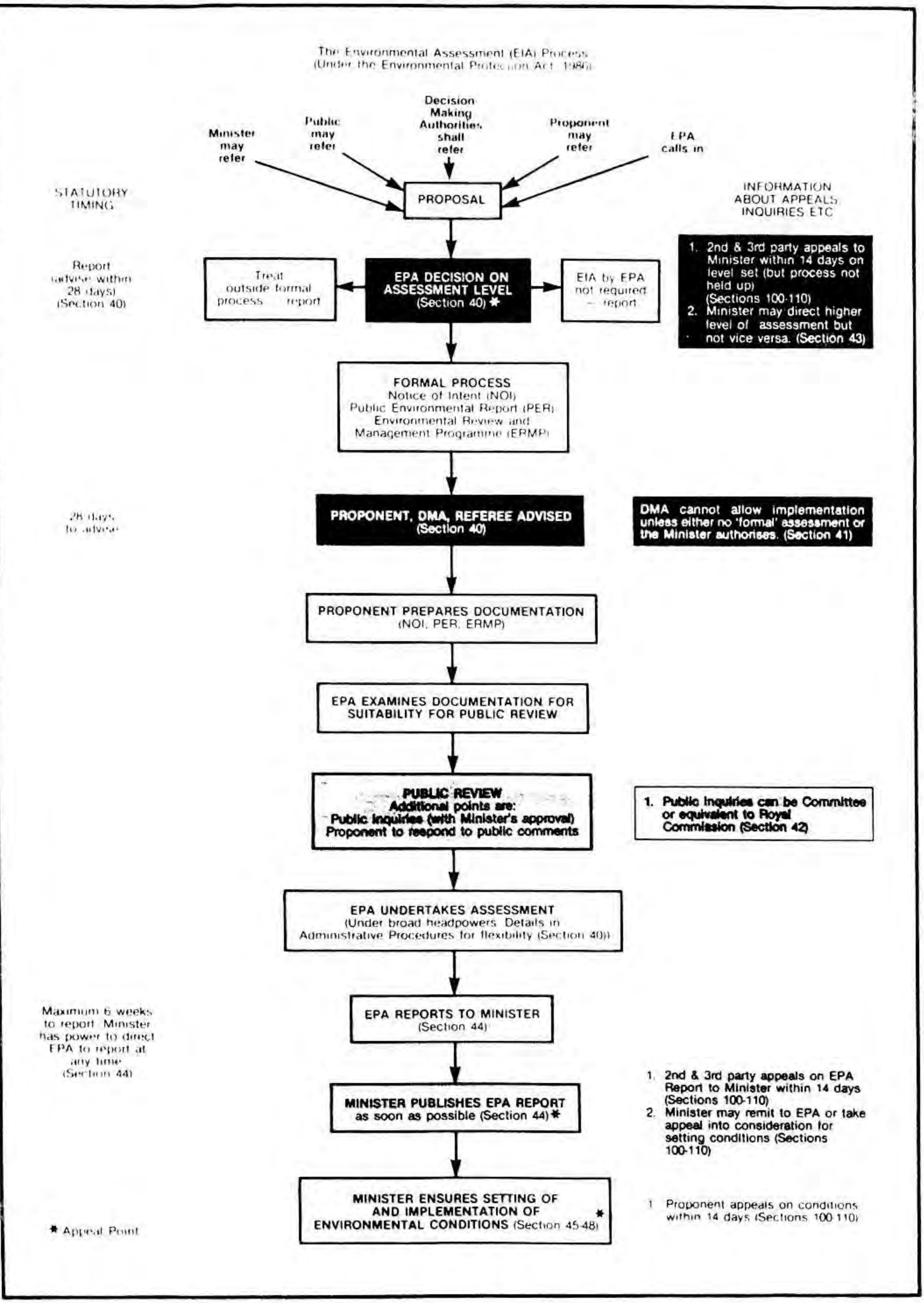
The ERMP process is designed to enable State authorities to consider in detail the environmental and social implications of development proposals. These considerations are based on technical assessments of the nature and extent of changes to the existing natural and social environments, on the handling of any wastes, on proposed management strategies to control or limit adverse changes, and on monitoring programmes designed to document and analyse the effectiveness of such strategies.

The ERMP process also enables members of the public to obtain details of the proposal and to formally comment on any matters of interest to them. These inputs are required within specified public review periods and are considered together with the technical assessments.

The Western Australian environmental impact assessment process is outlined in the Guide to the Environmental Protection Act (Environmental Protection Authority, 1987) and is illustrated in Figure 1.2. Essentially, the proponent is required to notify the Environmental Protection Authority (EPA) of the proposal. This is usually done by letter and then by means of a Notice of Intent (NoI). The EPA determines the need for a more detailed document such as an Environmental Review & Management Programme (ERMP), on the basis of the NoI and provides the proponent with a set of Guidelines for the preparation of that document. The Guidelines for the present ERMP are provided in Appendix 1.

After the ERMP has been prepared it is reviewed by the EPA to ensure that it provides sufficient detail and a comprehensive coverage of issues. When this has been established, the ERMP is released for a public review period. At the end of this, copies of the public comments are provided to the proponent and a response is sought. The EPA then prepares an assessment of the ERMP, public comments, and proponent's final report.

The results of the assessment are published in the form of an Assessment Report which includes recommendations made to the Minister for Environment. Interested parties can appeal against the level of assessment sought by the EPA, and against the content of and recommendations in the EPA assessment report.



WESTERN AUSTRALIAN ENVIRONMENTAL ASSESSMENT PROCESS **FIGURE 1.2**

2. NEED FOR THE PROPOSAL

2.1 INTRODUCTION

TIO2 Corporation NL believes that the need for the Cooljarloo Project can be defined in terms of economic benefits including employment, revenue and royalty payments and capital and operating expenditures. In addition, the project will contribute to the growth of the mineral sands export industry and will yield foreign exchange earnings.

The current high world requirement for mineral sands, which forecasts suggest will be maintained, also reflects user demand (or need) for the end products such as titanium white pigment and associated zircon products.

2.2 PROJECT BENEFITS

2.2.1 Expenditure

Construction expenditure for the Cooljarloo Project will be in the order of $50m in the first year and an estimated further $8m in the subsequent three years at which time the plant will be fully operational. The major items of expenditure will be as follows:

.	Process equipment	40%
.	Construction contracts, and supplies	34%
.	Site preparation	16%

Most of the equipment required including all separation plant will be manufactured in Australia.

Once the project is fully operational in Year 4, annual operating expenditures will be in the order of $18m, about 20% of which will be on wages and salaries. Taxation and various other Commonwealth and State charges will also be payable, including State royalties.

These figures represent a significant contribution to revenues and to local, State and Commonwealth economies.

2.2.2 Employment

The Cooljarloo Project will employ an estimated 109 people. Forty-two of these will be at the minesite, 66 at the Muchea plant and 1 at Kwinana.

The Community Needs Study for the proposed Kemerton Aluminium Smelter suggests that 1.14 flow-on jobs may be assumed conservatively for every permanent job created by a project of this nature in the south-west of Western Australia (Dames & Moore, 1985). This implies that the Cooljarloo Project will stimulate a further 125 indirect employment opportunities, and in total 234 jobs. Further projections relating to the workforce and indirect employment are provided in Sections 6.2.3 and 6.4.3.

2.2.3 Products

The Cooljarloo Project will produce the three titanium minerals (ilmenite, rutile and leucoxene) and zircon and monazite. The major users of titanium minerals are manufacturers of titanium dioxide pigments, of welding rod coatings, and of titanium metal. The complex relationships between the minerals and the end products are shown in Figure 2.1. World demand for 1981 is also shown on the figure and reflects the dominant use for white pigment (86%).

Growth in world demand for titanium minerals in the period 1975-85 has been rapid and is increasing. Furthermore, current projections suggest that the level of demand will be sustained for some time into the future. Western Australia is currently a significant supplier producing 43% of the world's ilmenite, 21% of the rutile, 40% of zircon and 54% of monazite (Playford Work Party, 1987). However, the markets are predominantly located in North America, Western Europe and Japan and potential alternative sources of supply are available within or close to these regions, in Norway, Sierra Leone, South Africa, Canada and the USA. The need for Australia to maintain a competitive advantage in this market and derive the consequential export earnings is evident and is partly dependent on the development of deposits such as Cooljarloo which can guarantee a long term supply.

The major demand for zircon is in the foundry, refractories (steel, glass etc), ceramics, abrasives and metals industries. Zirconium metal is also used as a structural material and for cladding fuel elements in nuclear reactors. It is also used in chemical processing involving chlorine, hydrochloric acid and caustic alkalis because of its resistance to corrosion.

Monazite is used as a source of rare earths (yttrium, europium, terbium, samarium and thorium). These are used as petroleum catalysts, in ceramics and glass, and in various specialised applications such as in colour television tubes, X-ray screen intensifiers and high-strength magnets. Thorium is a radioactive element with specialised applications in refractories, alloys, electronics, welding rods, and other products. It can also be used as a fuel in high-temperature gas-cooled nuclear reactors but only one thorium reactor is actually in operation.

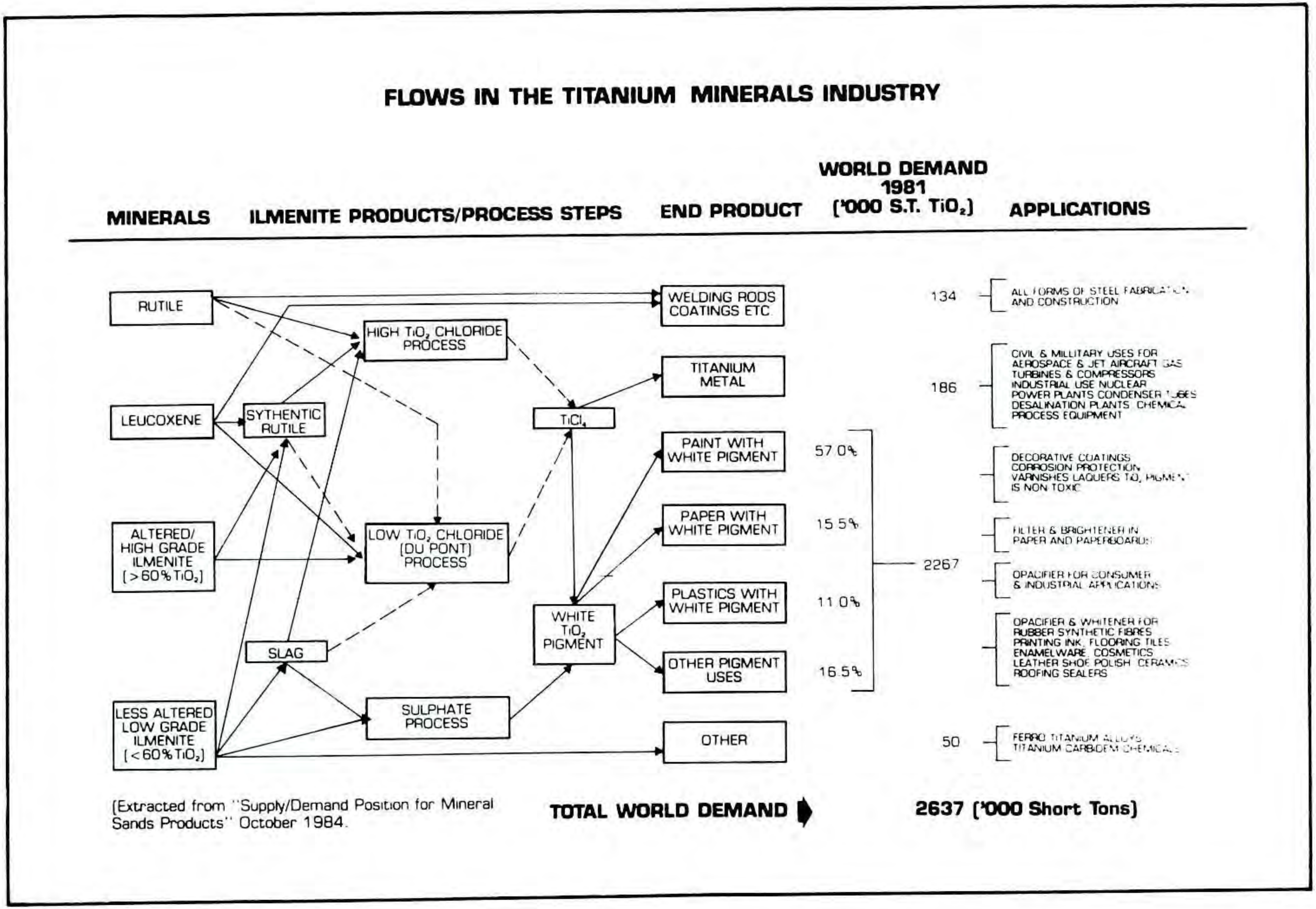
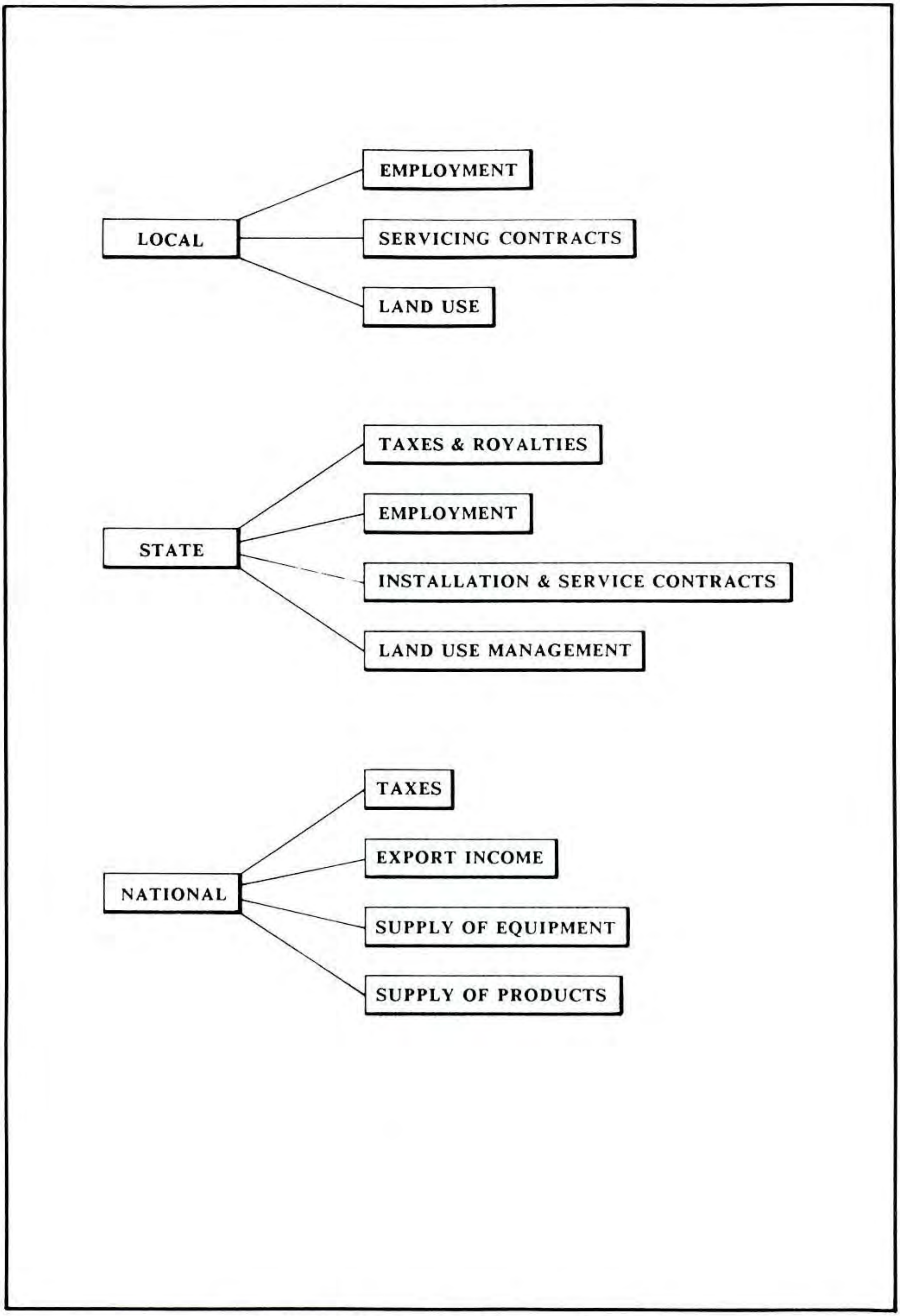


FIGURE 2.1
FLOWS IN THE TITANIUM MINERALS INDUSTRY

Again, as with the titanium minerals, the demand for zircon and monazite reflects the level of need for these materials. Although the quantities involved are small, their importance derives from their specialised applications.

2.2.4 Spread of Benefits

A general overview of the types of benefits which will accrue from this proposal at the local, State and National level is provided in Figure 2.2.



SPREAD OF BENEFITS FROM THE COOLJARLOO PROJECT **FIGURE 2.2**

3. EVALUATION OF ALTERNATIVES

3.1 MINING METHOD

A number of mining methods could be used and have been considered for the Cooljarloo Mineral Sands Project (Fluor Australia Limited, 1986). These include draglines, scrapers, excavators and trucks, conveyors and dredges. Mining by bucket wheel suction dredge has been chosen because it is the most suitable and most economic method available.

The Cooljarloo tenements are underlain by a shallow watertable. Therefore in order to excavate the mineral sands it may be necessary to either dispose of the water that would be exposed by mining or to adopt a mining method which is suited to a wet environment. The former alternative would be technically difficult and costly and would also involve probable environmental impacts at the water disposal site(s). In contrast, a floating dredge uses the exposed watertable to advantage and is, as a result, conventional equipment in such conditions. However, a dry dredge linked to a floating concentration plant is also a practical alternative at Cooljarloo and may be used.

The nature of the Cooljarloo deposits is such that a considerable amount of waste has to be mined and treated with the ore in order for the maximum quantity of useful minerals to be extracted. Separation occurs in a wet concentrating plant. The plant has to be positioned relatively close to the mine face so that large quantities of material do not have to be transported to it and low operating costs can be maintained. The plant therefore has to be mobile and again this can only be achieved economically by floating it in a pond.

3.2 MINESITE REHABILITATION

The entire area of the Cooljarloo tenements was assessed for agricultural soils in 1963 and it is understood that at a later date the Shire of Dandaragan proposed agricultural development. Theoretically, three or four farms could be established of about 1,500ha each and one such has actually been developed on the southern portion of the area.

With this in mind, TIO2 Corporation NL has considered and evaluated three rehabilitation options:

- Return to present use. That is, rehabilitation of unoccupied Crown lands with native vegetation and return of the farming property to wheat/sheep production;
- Rehabilitation of all mined land to agricultural pastures; and
- Rehabilitation of all mined land to native vegetation.

The potential for the development of permanent wetlands at Cooljarloo has also been considered and is discussed in Section 7.2.

The conversion to farmland option would initially involve slightly lower costs than rehabilitation to native vegetation. The longer term costs of this alternative however, are estimated to be appreciably higher because of the necessity for soil improvement programmes, for the clearing and development of unmined land in order to establish viable properties, and for general farm management and stocking during the development phase. The consequential clearing could also be considered as a further environmental impact.

The proponents have also participated closely in the review of conservation and rehabilitation practices in the Western Australian mineral sands industry co-ordinated by the Department of Mines (Playford Work Party, 1987). That review recognised a preference for rehabilitation with indigenous plants except in established farming areas, and especially when mining has required clearing of natural vegetation.

For these various reasons, the decision has been made to return the mined areas to their present use. This means that re-establishment of native vegetation will be the main rehabilitation objective. This objective could extend to parts of the present farmland which have only recently been cleared, but the predominant objective in this part of the tenements will be to re-establish a viable agricultural property.

3.3 DRY PROCESS PLANT AND PORT SITE SELECTION

The principal consideration of alternatives has centred around the choice of an optimal site for the dry process plant and of a port for shipment. These matters have been the subject of a special analysis and report (TIO2 Corporation NL, 1987) which compared the cost implications of plant sites at Muchea and Narngulu, and of export from Kwinana and Geraldton respectively. Narngulu is an industrial suburb of Geraldton located approximately 12km to the south-east of the city and is the site of the Allied Eneabba dry mill which treats mineral sands from Eneabba and the Associated Mineral Consolidated (AMC) synthetic rutile plant.

Narngulu offers better soil and drainage conditions than Muchea and these factors would result in reduced site preparation costs. The Port of Geraldton is also suitable in terms of availability of space and some facilities. However, the analysis indicated that development at Narngulu would entail additional capital recovery and operating costs in the order of $3.9m each year. The additional extra capital recovery cost of $3.4m would arise substantially from regional differences in plant construction costs and the development of a rail transport system.

Transport of the concentrates from the minesite to the dry process plant is the critical factor in the additional $0.5M operating costs. The Cooljarloo minesite is about 260km from Narngulu but only 120km from Muchea. A rail link exists to Narngulu from Eneabba, but the latter is still 100km north of the proposed minesite. In developing cost comparisons, three transport options to Narngulu were considered:

- Extension of the rail link from Eneabba to Cooljarloo
- Road haulage
- Road haulage to Eneabba and then rail to the dry plant site

The comparisons assumed that reject material from the dry process plant would be returned to the minesite for rehabilitation purposes as would occur from the Muchea site. Transport of final products from Narngulu to Geraldton would be by road.

Of these three options, it was predicted that the combined road/rail system would cost at least $1m less than road transport every year and $2m less than the rail only option. The road/rail system to Narngulu however, would involve substantial costs for a transfer facility at Enneabba, and approximately 30% additional transport costs annually than road transport between Cooljarloo and the alternative plant site at Muchea and road/rail of products from Muchea to Kwinana.

The transport system proposed in the Muchea option results from the fact that the closest rail transport terminal to Cooljarloo is at Moora (60km) and the roads to the terminal are unsuitable for road trains whereas a direct road link to Muchea is provided by the Brand Highway. Road transport of wet concentrates is therefore the obvious preference. Transport of the final products by road train to Kwinana is not an option however, as such vehicles are not permitted in the Perth Metropolitan area. Therefore, the final products will be transported by rail.

The actual Muchea site was chosen because it is strategically located on the Brand Highway which provides the transport link with Cooljarloo, and is adjacent to the Perth Metropolitan area where a labour force is readily available and to Kwinana. In fact it is virtually as close to Kwinana as possible given the dependence on road trains to transport the ore to the dry process plant site and the prohibition on such vehicles in the Metropolitan area.

Alternative sites are theoretically available in the Muchea area as zoning potentials permit industrial development both north and south of the town. No other site however is considered to offer any environmental, social, or practical advantage over that chosen.

4. THE PROPOSAL

4.1 THE MINESITE

4.1.1 Tenements

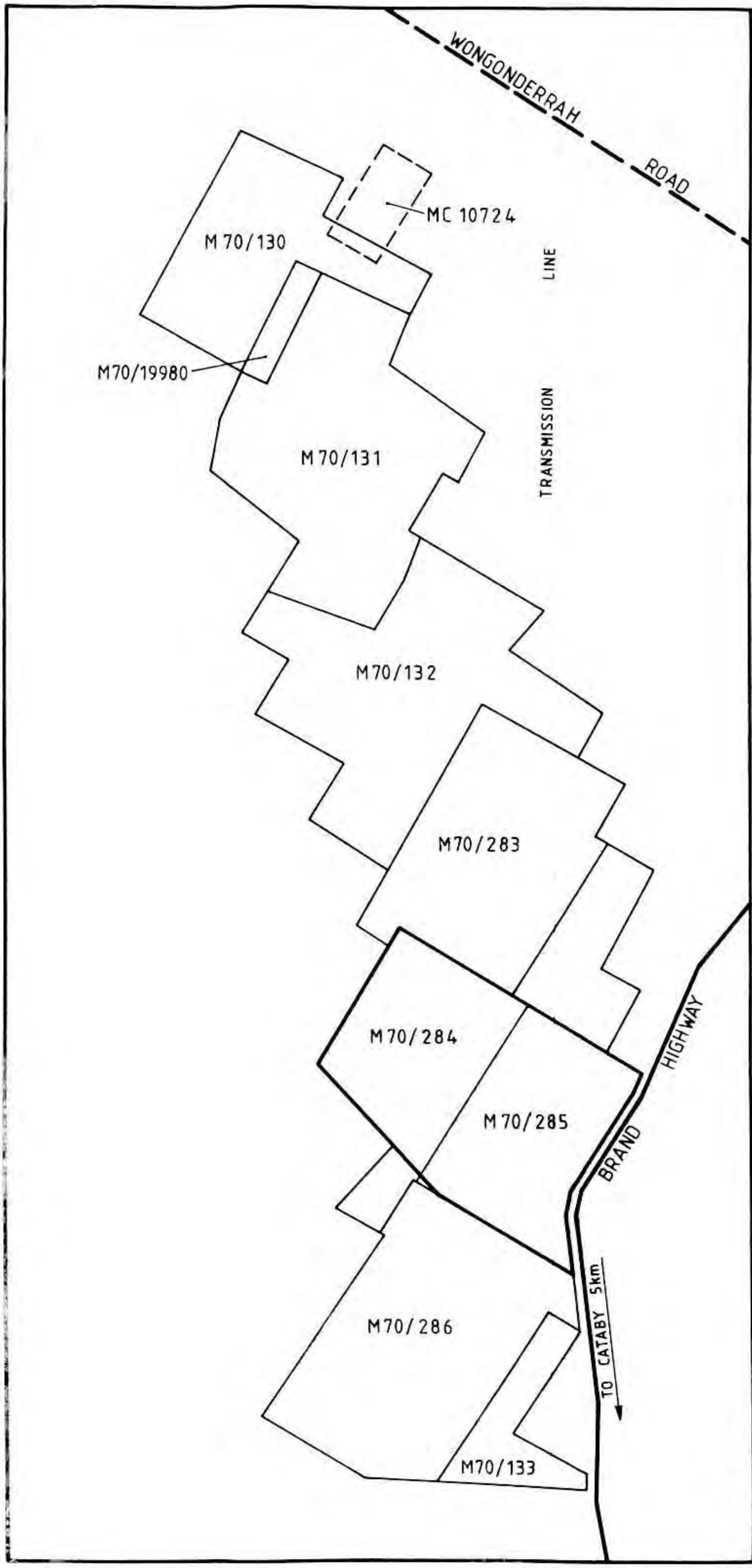
The proposed Cooljarloo minesite involves a series of four mining leases and twenty-six mineral claims east of the Brand Highway commencing about 6km north-west of Cataby and 170km north of Perth (Figure 4.1). The mineral claims are under application to be converted to a further four mining leases. The tenements run approximately 18km northwards from their southern boundary toward Wongonderrah Road while the highway turns to the north-east and away from the future minesite. They are approximately 5km from east to west at their widest point and cover about $60km^2$.

4.1.2 General Geological Setting

All of the currently exploited mineral sands deposits in Western Australia occur on the Swan Coastal Plain which extends for about 450km from the vicinity of Busselton in the south to Geraldton in the north. The plain is bounded to the east by the Darling Scarp which formed when the adjacent Archaean Yilgarn Block uplifted along the Darling Fault at the end of the Mesozoic era, roughly 65 million years ago.

The mineral sands occur at the top of a series of sedimentary deposits, within a sequence of relatively recent (Quaternary) unconsolidated sands. They generally originate from material eroded from the adjacent Yilgarn Block which has been transported by river and streamflows and deposited as beach sands along former coastlines. With time the sea has receded, and the mineral sands now typically occur as successive north-south linear deposits well inland from the present coast. In places this pattern has been disturbed by further erosion caused by rivers crossing the plain which have transported and redeposited the sands. Some deposits have been converted by the chemical action of water into iron oxide formations such as laterite and 'coffee rock'.

Mineral sand deposits of economic importance occur predominantly in the southern and northern sections of the Swan Coastal Plain. Those in the north are centred on Eneabba and are generally components of the Bassendean Sand Formation at the foot of the Gingin Scarp which trends north-westerly as a lateral of the Darling Scarp. These are enriched in rutile and zircon whereas in the southern deposits near Capel there are higher proportions of ilmenite minerals.



COOLJARLOO MINING TENEMENTS

FIGURE 4.1

4.1.3 The Cooljarloo Deposits

The Cooljarloo deposits are located in a series of former coastlines known collectively as the Munbinea Shoreline. They have been defined and assessed in detail in a series of exploration programmes by various tenement holders including TIO2 Corporation NL. To date these have indicated areas containing mineralised strands or placer deposits as shown in Figures 4.2, 4.3 and 4.4. The area has been subject to upward faulting and the strands are now 60-90m above sea level and abut against the Gingin Scarp. The trend of the deposits is north-westerly and they dip gently to the north probably as a result of tilting of the land surface.

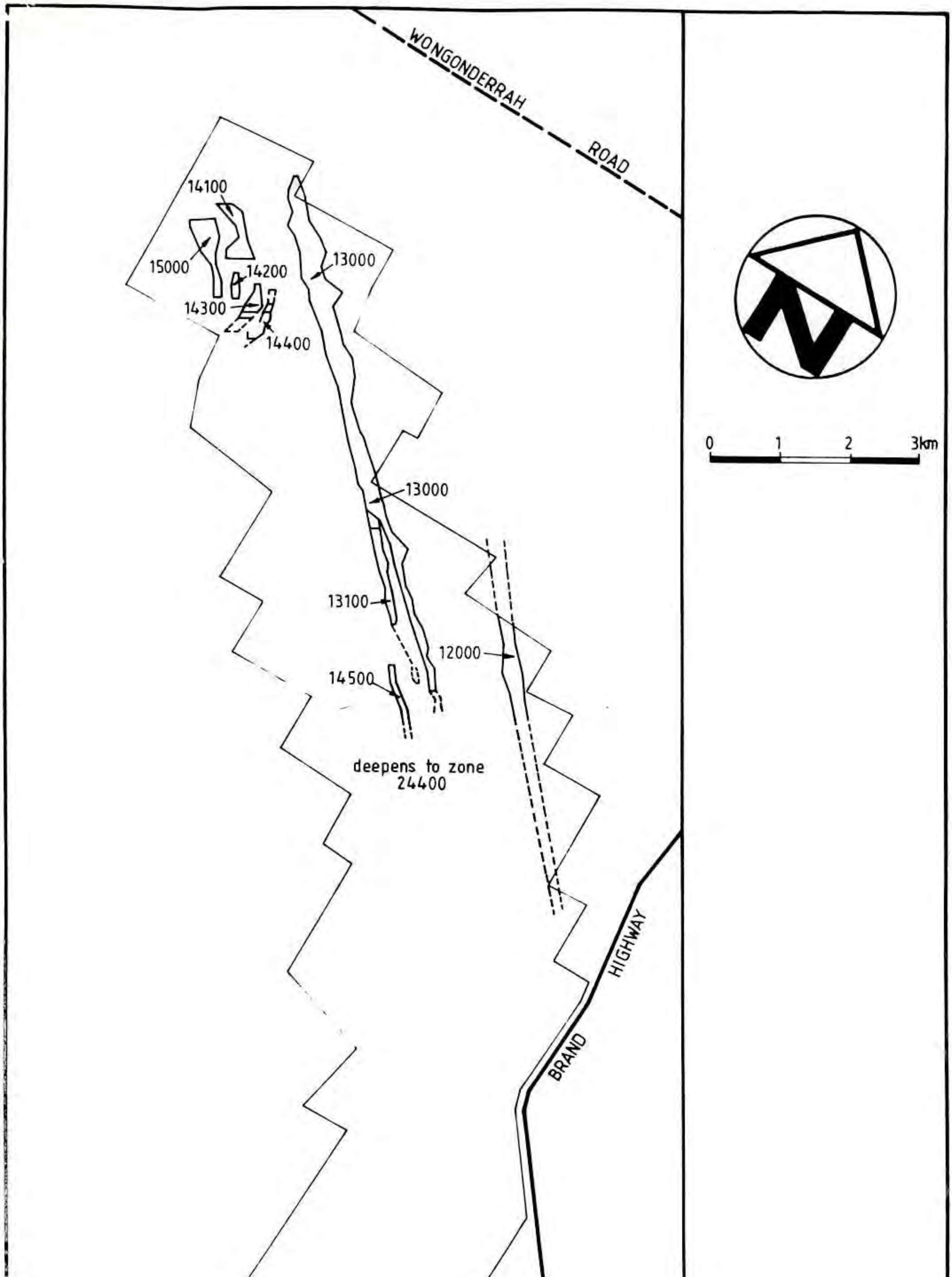
The deposits are classified in three categories according to their physical position and/or nature of mineralisation. Upper level deposits which have no overburden occur in the northern half of the tenement area. Mid-level deposits are covered with varying depths of non-mineralised material which will have to be removed. These include the largest mineralised strand at Cooljarloo (No. 27000) in the southern half of the tenement area. Finally, basement deposits are also covered with overburden but are geologically older than the mid-level deposits and consequently differ in their mineral composition.

4.1.4 The Mining Plan

The proposed mining plan involves two stages. The first will concentrate on upper level strands and will take approximately 2-5 years to complete. The longer time interval will result if all of the upper strands are excavated. Excavation is currently planned to commence at the northern boundary of Zone 13000 and proceed southwards. In this case, at the end of year 1 the total area mined will cover about 71.3ha over a distance of 2.26km and with an average width of 316m. The depth of the pit will average 8m. Zone 13100 may be mined at the same time as the southern part of 13000. Then Zone 14500 will be mined. In this stage, a single production dredge will operate at a rate of 1,700tph total excavation. The operations may then concentrate on the other upper level strands or immediately move to Stage 2.

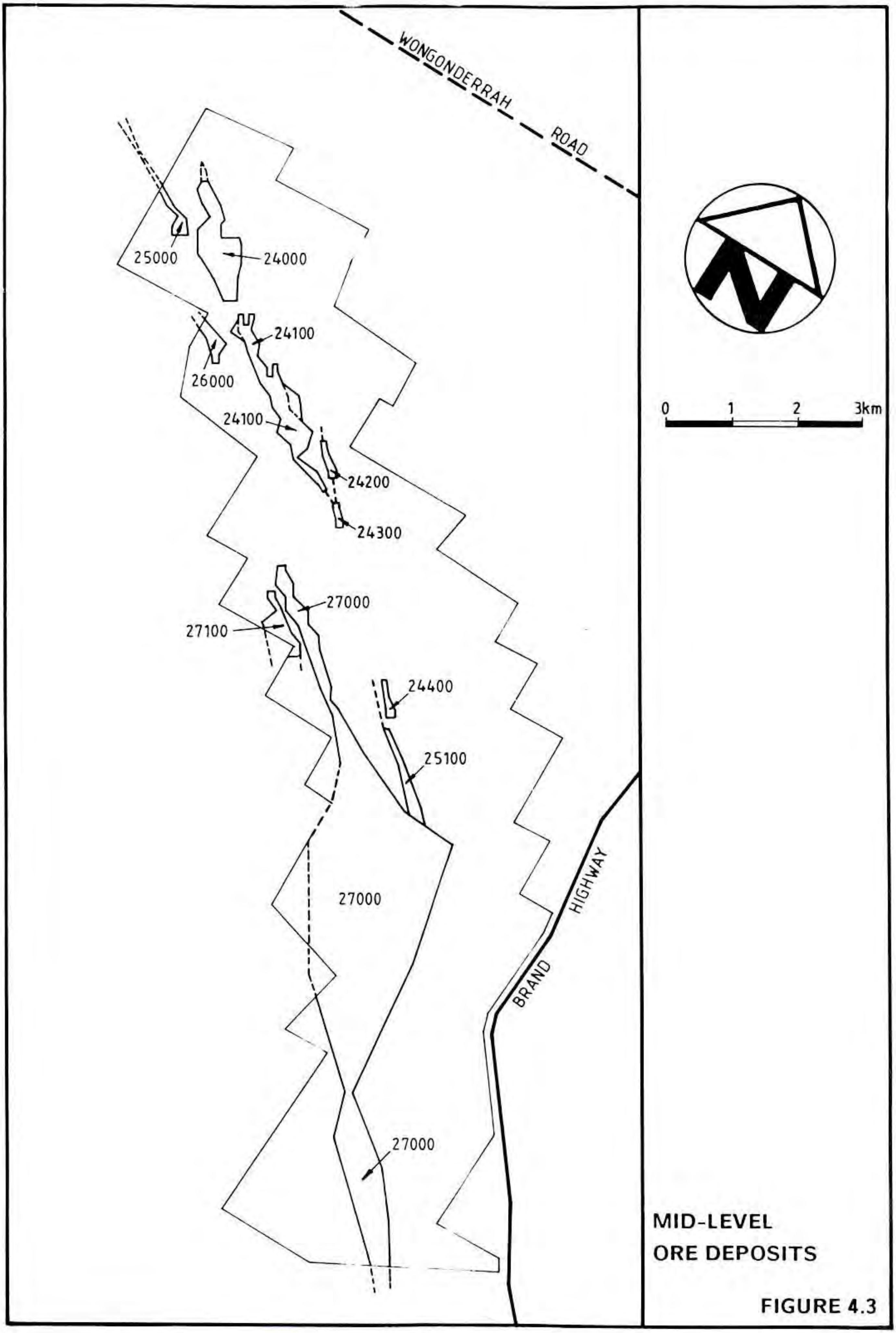
Stage 2 of the Mining Plan will commence with the two small orebodies Zones 24400 and 25100 and then proceed to the very large Zone 27000. Zone 24400 is immediately south of the point where Stage 1 will terminate. The option of developing Zone 27000 first is also being considered at this stage.

The Stage 2 deposits are covered with an overburden which will be removed by a stripping dredge with a nominal capacity of 2,400tph. This will be followed by the production dredge as in Stage 1. Full exploitation of these strands is expected to take 12 or 13 years. The various strands elsewhere in the tenement including the basement deposits may then be excavated, depending on the results of detailed assessment, market economics and other factors.



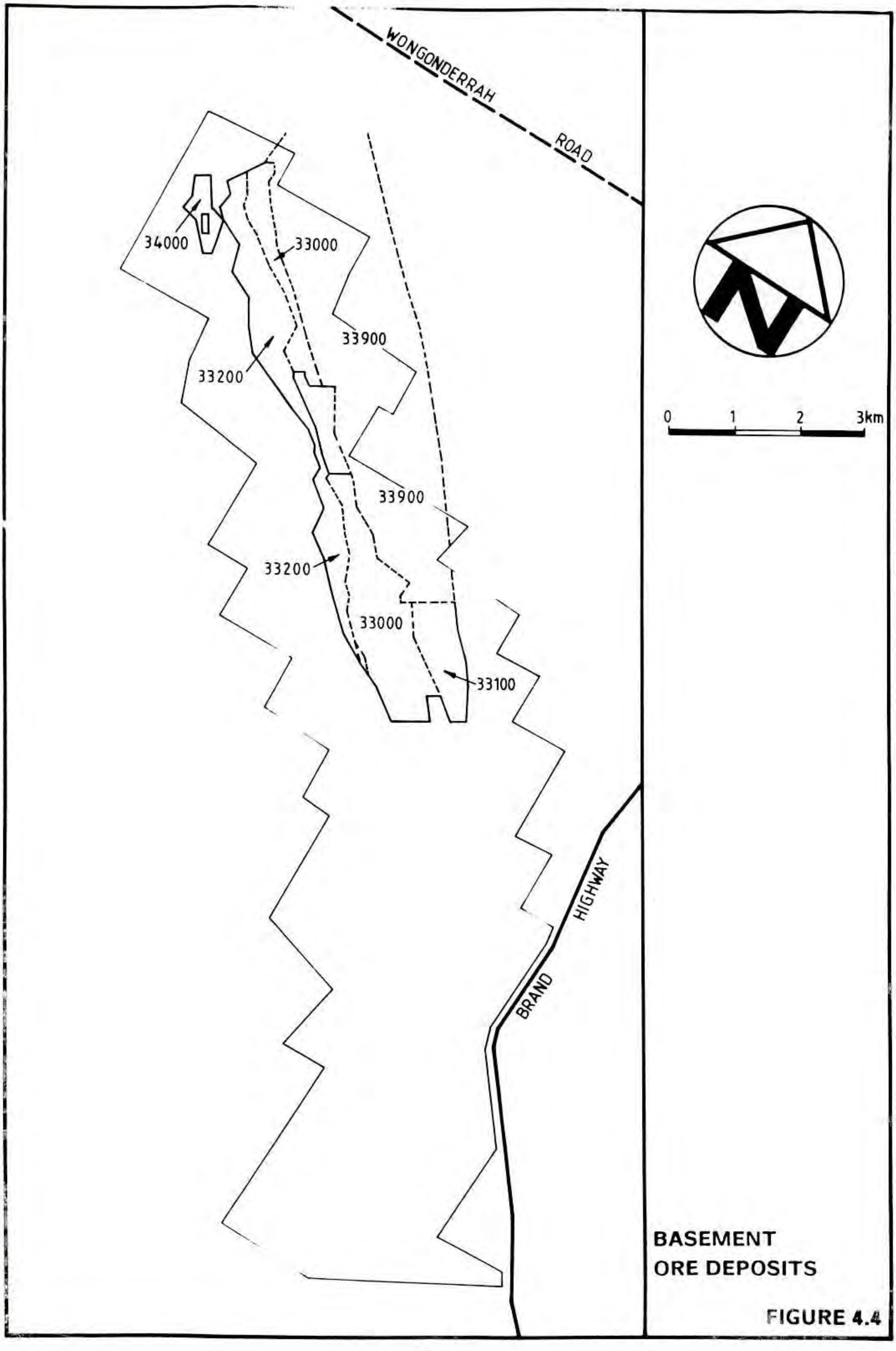
UPPER-LEVEL
ORE DEPOSITS

FIGURE 4.2



MID-LEVEL ORE DEPOSITS

FIGURE 4.3



BASEMENT
ORE DEPOSITS

FIGURE 4.4

4.1.5 The Mining Operation

Mining will involve a single dredge for the first phase of the mining programme when upper level deposits will be exploited but two dredges will work in tandem in subsequent phases when deeper excavation is required (Figure 4.5).

Mining will commence with the excavation of a pit to below the level of the water table to create a pond in which the wet concentration plant can float and operate. A floating dredge may operate in the same pond, or a dry dredge may be used in front of it. Thereafter, as the dredge advances the pond will be maintained by the mining process which will involve excavation below the water table.

The dredge basically consists of a cutter wheel which digs out the sand and a submerged suction pump and attached hose which is placed close to the mine face and which draws off the sand with water from the pond. It will be controlled by one operator.

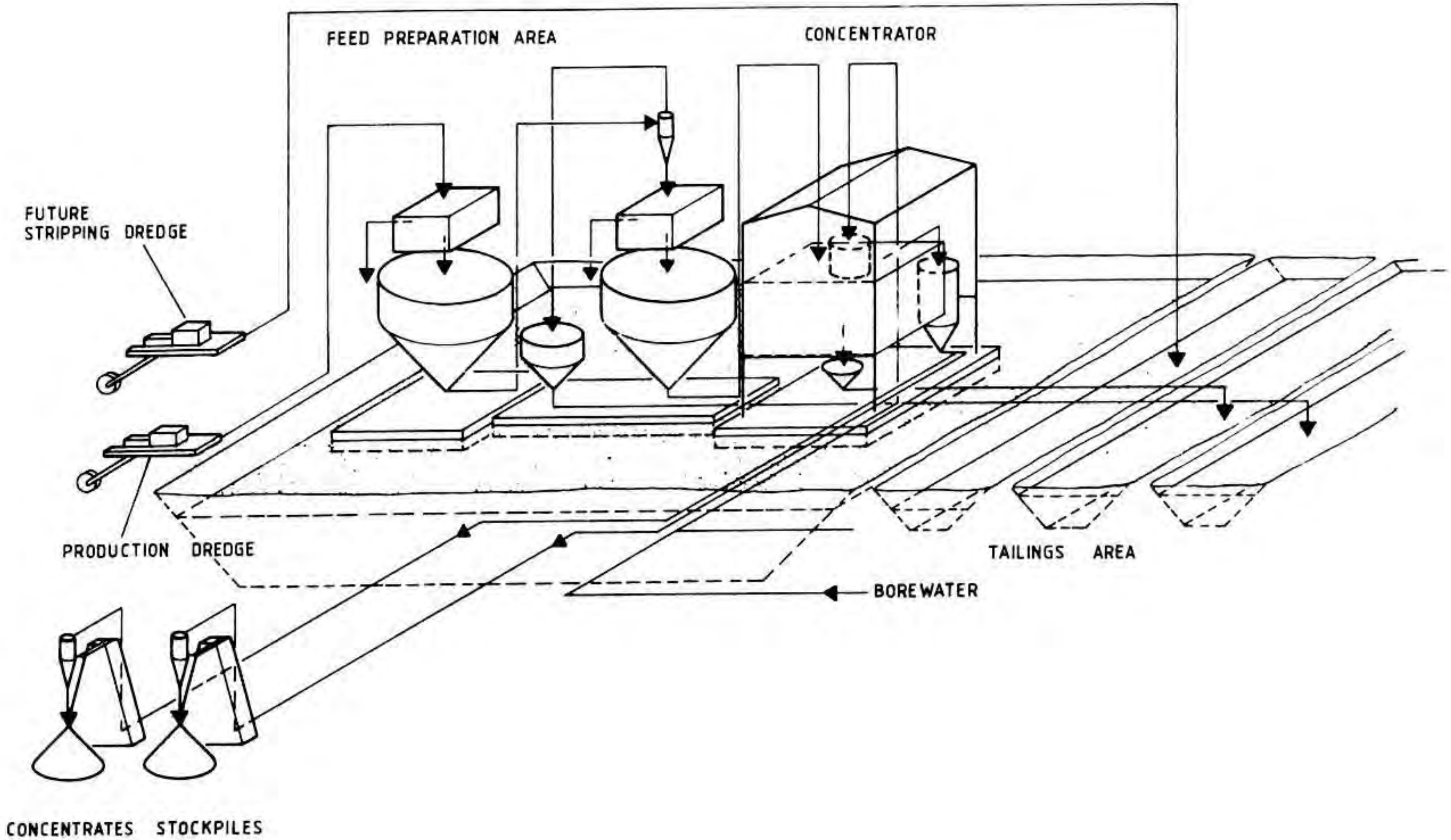
4.1.6 The Wet Process Plant

The mined material will pass from the dredge through a feed preparation circuit and concentrator as shown in Figure 4.5. The feed preparation cycle will involve three consecutive processes:

- Screening out of all solids more than 2mm in size.
- Removal in hydrocyclones of very fine suspended material known as slimes.

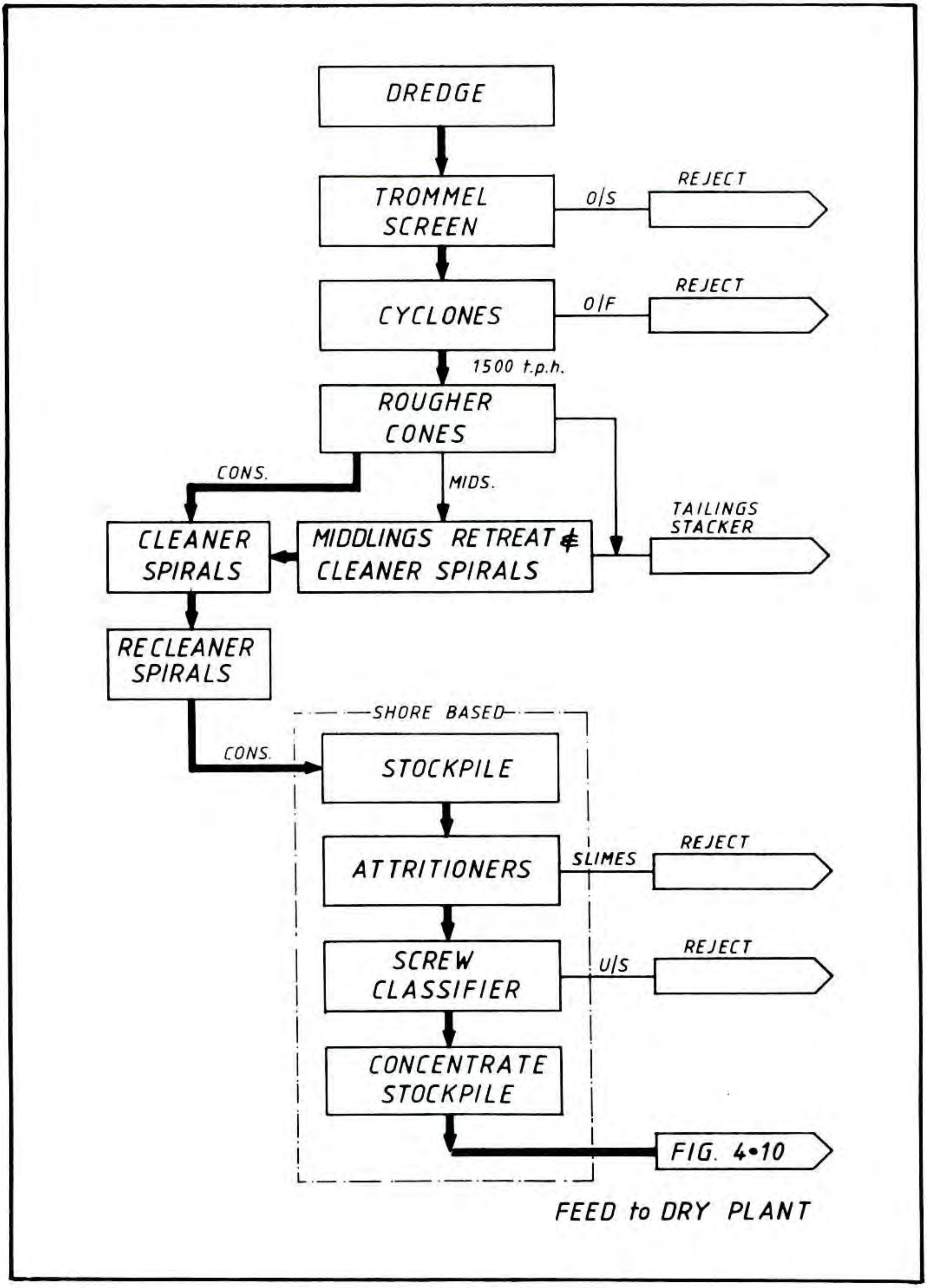
The concentrator plant will consist of a single multi-storey barge (approximately 34m long x 30m wide x 30m high) which will contain various process equipment designed to separate (or concentrate) the heavy minerals from waste material (tailings). This includes spirals, cone concentrators and associated distributors, pumps, hoppers and launders, a tank for process water, and pumps and hopper to discharge the concentrate and tailings. A flow chart is shown in Figure 4.6.

The process is essentially mechanical and uses gravity for the separation. As a result, there are no chemical additives or effluents. Gravity separation is possible because the various minerals which occur in the sand deposits have different specific gravities as shown in Table 4.1. The clear difference between quartz, the principal waste material (SG less than 3.0), and the valuable heavy minerals (SG greater than 3.5) makes separation of the two relatively straightforward but separation of the light-heavy minerals from the valuable heavy minerals is more difficult.



MINING AND WET CONCENTRATOR PLANT
AT COOLJARLOO

FIGURE 4.5



FLOW CHART OF DREDGE AND 1500 TPH CONCENTRATOR

FIGURE 4.6

TABLE 4.1

APPROXIMATE SPECIFIC GRAVITY OF MINERALS IN MINERAL SAND DEPOSITS

Mineral	Approximate SG	Classification
Feldspar	2.55 - 2.76	Light
Quartz	2.65	
Tourmaline	3.00 - 3.25	Light-Heavies
Hornblende	3.00 - 3.30	
Kyanite	3.56 - 3.66	
Staurolite	3.65 - 3.75	
Garnet	3.50 - 4.30	
Leucoxene	3.50 - 4.50	Heavy
Rutile	4.18 - 4.25	
Zircon	4.20 - 4.86	
Ilmenite	4.50 - 5.00	
Xenotime	4.59	
Monazite	5.00 - 5.30	

The principal items of equipment in this initial gravity separation are the spiral and cone concentrators. As the feed moves down the spiral the lighter particles such as quartz move to the outside of the channel and the heavy particles separate and are discharged through outlets.

The wet concentrates will be pumped to a dewatering cyclone unit mounted on land adjacent to the mining area and stockpiled awaiting transport to Muchea for further processing. Drying by drainage and evaporation will take place in the stockpiles.

The initial on-site processing is required in order to reduce the volume and moisture content of the mined material prior to transport and thus to avoid unnecessary costs. The concentrate is not totally dried on-site because this would require a fixed drying plant which would be difficult to co-ordinate with the mining and wet process cycle. Retaining a moderate moisture content also eliminates any problems from dust at the minesite or in the transport of concentrate.

4.1.7 Discharge of Tailings and Slimes

The large material screened out in the feed preparation cycle will be discharged directly into the dredge pond. However, the slimes and tailings from the wet concentrator plant, will be systematically discharged as backfill for the mined area. In the mining plan as shown on Figure 4.7, the tailings placement area will be filled with tailings to 3m below the final desired contour height of the rehabilitated minesite. A series of slimes receival ponds will then be constructed with perimeter bunds of sand tailings. A new tailings area will then be commenced immediately behind the dredge pond.

The slimes not locked within sand tailings will be fed into the receival ponds to a depth of about 2m commencing at the furthest point from the dredge pond. Slime particles between 2 and 70 micrometres will tend to settle in the receival area and this process may be assisted by the addition of flocculents to promote aggregation. Non-aggregating particles smaller than 2 micrometres and all material less than 0.2 micrometres will remain in suspension and will be drained through the bunds and active tailings area back into the dredge pond.

When each slimes pond is full, it will be allowed to settle and dry for approximately two months, and then will be covered with up to 2m of sand tailings using a swamp bulldozer. The fill will then be covered with 25cm of topsoil and rehabilitated. Details of rehabilitation are provided in Section 7.2.

In practice once mining is underway, a tailings placement area, a slime receival pad, a slime drying area, and final rehabilitation will all be operational in sequence behind the dredge area as shown in Figure 4.7. When the dredge first commences operation however, a tailings area and slimes receival pond will have to be established simultaneously on unmined ground.

4.1.8 Buffer Vegetation and Mine Traffic

During the mining of Zone 13000 in the first 2-3 years of the project, it will be possible to retain strips of vegetation immediately adjacent to the mine path and to site access roads, topsoil storage areas and other requirements beyond these buffers. This will not be the case however, during subsequent mining of Zone 27000 as this will involve a series of mine paths next to each other.

The vegetation strips will reduce the potential for wind erosion of topsoils replaced after mining and will provide a reservoir of plants and fauna which will promote recolonisation of the adjacent rehabilitation areas. Other benefits include the improvement of stability on the edges of the dredge pond and better screening of the mine operations.

4.1.9 Minesite Infrastructure

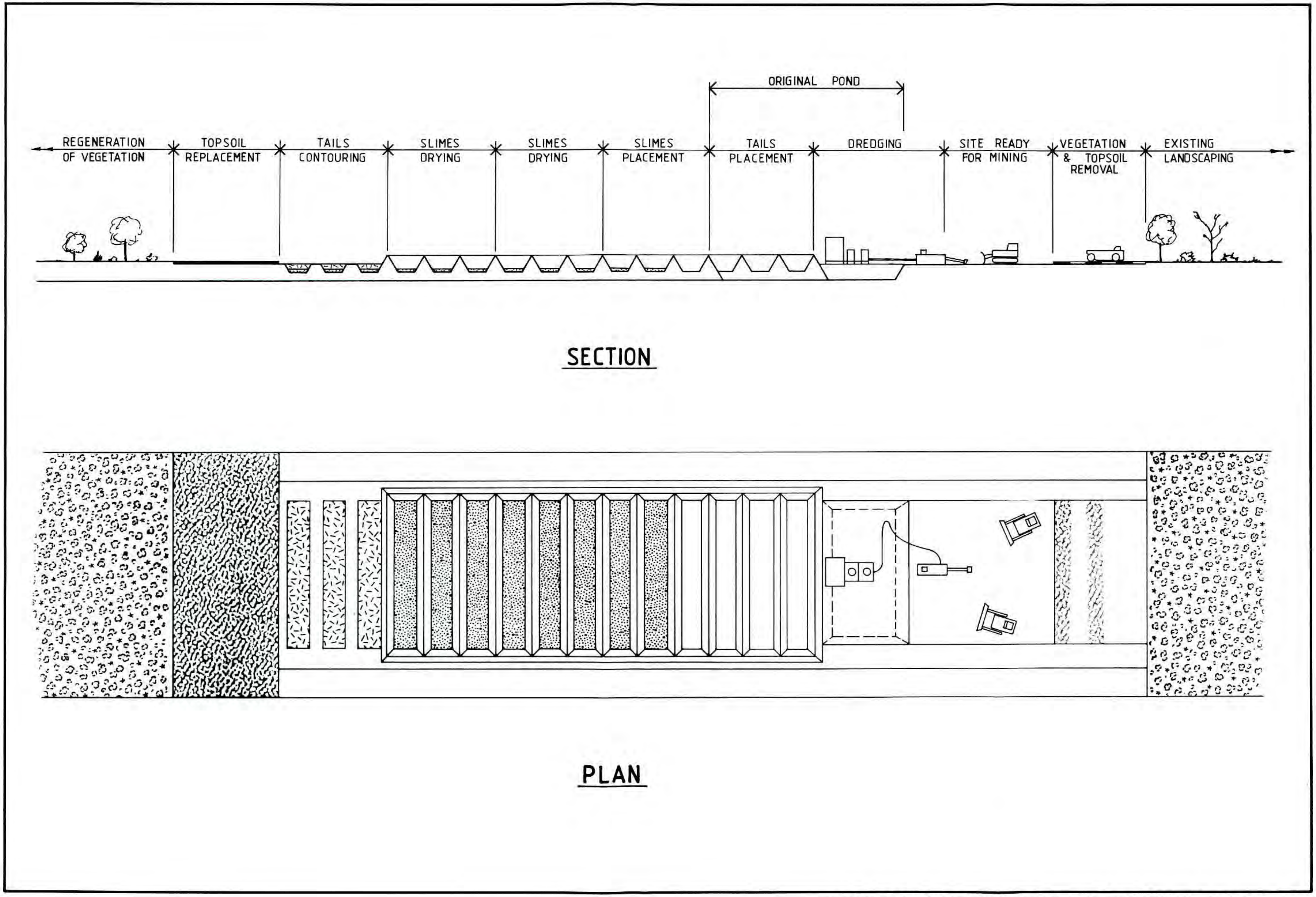
(a) Process Water

Approximately 10,000-30,000 kilolitres of water will be required each day for the wet concentration plant. The dredge pond will provide some of this requirement but it is anticipated that there will be the need for a supplementary supply from a specifically developed borefield. This source would also supply potable water for various on-site purposes.

The hydrology of the minesite and the implications of process water supply and of borefield development are discussed in Sections 5.1.3 and 6.1.2.

(b) Electrical Power Supply

A 132kV electrical power line to Geraldton passes just to the east of the minesite. The State Energy Commission of Western Australia (SECWA) has advised that this line may supply the minesite requirement of 33kV. Alternatively a new 60km, 33kV distribution line from Moora to the mine may be required.



COOLJARLOO MINING AND REHABILITATION CONCEPT

FIGURE 4.7

This supply will meet the initial wet plant load when only one dredge is operational but when two dredges are in use the power requirement will double. At that stage SECWA expects to be able to supply from increased capacity at Geraldton or from Three Springs.

Power distribution on the actual minesite will be the responsibility of TIO2 Corporation NL which will install overhead lines along the length of the orebodies as mining proceeds. Mobile substations will be used to supply power at 6600 volts to the wet plant facility for the dredge and major pump motors. Further transformers will be installed on the plant for 440 volt, 3 phase and 240 volt, single phase supplies.

(c) Compressed Air

A small compressor with refrigerated air dryer and filters will be installed for instrument air supply.

(d) On-site Facilities

All on-site facilities will be located on the floating concentration plant.

(e) Accommodation

It is proposed to provide accommodation for personnel near Cataby about 4km south of the minesite where some social infrastructure is available. There is the possibility however, that part of the tenement area itself will be developed for accommodation if no suitable site is available at Cataby.

The accommodation will comprise two and four room units with shared ablution facilities. A mess and recreational facility will also be provided.

Further information on employment and social implications is provided in Section 6.2.3.

4.2 THE DRY PROCESS PLANT

4.2.1 Delivery of Wet Concentrate

Wet concentrates (less than 6% water content) will be transported from the minesite via the Brand Highway to the dry process plant at Muchea by 53 tonne capacity road trains. The trucks will return to the minesite with tailings from the plant. It is estimated that approximately 1 truck per hour will travel the route in each direction on a continuous basis (ie 24 hour, 7 days a week).

4.2.2 Location

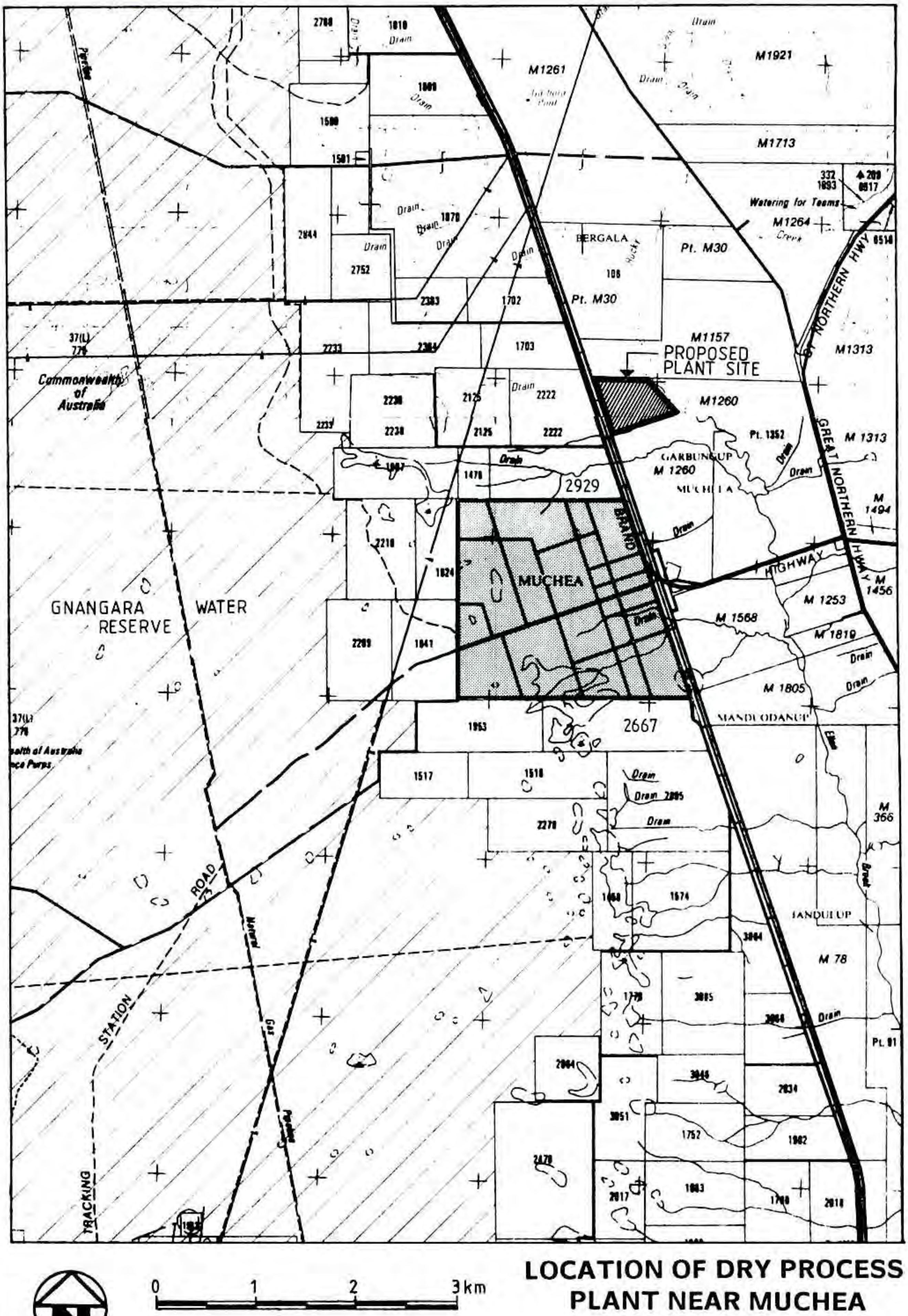
The proposed plant site is Lot 4 of Swan Location 1352 which is 2km north of Muchea townsite (Figure 4.8). It has a western boundary adjacent to the Midland Railway and Brand Highway and an eastern boundary next to Ellen Brook (Lot 9 of Location 1352, vested in the Crown). The site has an area of approximately 41ha.

4.2.3 Basic Principles of Separation

The process of extracting the valuable heavy minerals from the mined material and then of separating the various heavy minerals from each other and increasing their purity involves a complex series of treatments. The first of these will occur at the minesite where the bulk of the waste material (tailings and slimes) will be separated and disposed of and a concentrate with relatively high levels of heavy minerals will be produced. This process of gravity concentration has been described in Section 4.1.6.

Further processing at the Muchea plant will involve the reduction of moisture content by drying, then a series of sequential treatments to separate the ilmenite, rutile, leucoxene, zircon, monazite and some other minor products from each other. Screening and other methods of extracting waste material will also be integrated with all of these treatments. The main treatment methods apart from gravity concentration are:

- Electrostatic separation: This technique is based on the principle that material carrying a surface electrical charge will either be attracted to or repelled by an electrode. It is applied in two types of equipment, high tension roll separators and electrostatic (plate and screen plate) separators.



LOCATION OF DRY PROCESS PLANT NEAR MUCHEA

FIGURE 4.8

In the former the feed is carried by an earthed rotating roll which is subject to ion bombardment. This causes the conductor particles in the feed (ilmenite and rutile) to lose their charge to the earthed roll and to be thrown outwards by the centrifugal force. They can then be channelled to collection for further processing. The non-conductor particles (zircon and monazite) acquire an opposite charge to the roll surface and are therefore attracted to and stick to that surface. They are then dislodged by a brush and collected.

In the electrostatic (plate and screen plate) separators the feed moves down an earthed plate into an electrostatic field induced by a large electrode. The conductor grains are attracted toward the electrode and separate from the non-conductors and the two streams are channelled into different outlets.

- Magnetic separation: As described above, electrostatic separation will be used to separate the feed into two streams, conductors (ilmenite + rutile) and non-conductors (zircon + monazite). The component minerals of these feed streams can then be separated by passing them through magnetic fields. As ilmenite and monazite are magnetic they are attracted to the magnets from where they can be collected while the rutile and zircon pass through the systems. Four types of magnetic separators (cross-belt, induced roll, lift roll, and disc) will be used in the Muchea plant.

- Gravity separation: The principle involved in gravity separation is the same as for gravity concentration (Section 4.1.6). Gravity separation equipment includes air tables, wet shaking tables and spiral sluices. Sprial sluices are described in Section 4.1.6 above.

The air table is used to separate particles with the same size but different specific gravities. The table has a cloth top through which air can be passed from below. Incoming material is fed onto the table where the air partly suspends the grains. At the same time, the table shakes from side to side and this action causes the lighter particles to separate from the heavier and the two streams can then be collected.

The wet table uses water instead of air to separate the minerals. The feed comes onto the table and is held in a series of parallel troughs. Water is run into the troughs and at the same time the table shakes and these actions cause the feed to separate into heavy, middling, and light particles. These are washed off the table and can be collected separately.

- Screening: This technique is simple filtration with the size of the filter mesh set to separate large from small particles.

4.2.4 The Process Cycle

The dry mill or processing plant involves nine components as follows:

- feed preparation
- high tension separation of conductor minerals (ilmenite and rutile) from non-conductors (zircon and monazite)
- magnetic separation of ilmenite and rutile
- processing of rutile
- screening of the zircon rich feed
- separation of zircon and monazite
- final treatment of fine zircon
- final treatment of coarse zircon
- final treatment of monazite and xenotime
- disposal of reject material

A schematic plant layout and process flow chart are shown in Figures 4.9 and 4.10 respectively.

Incoming wet concentrates from Cooljarloo will be delivered to a covered stockpile and then transferred by a reclaiming system to the feed preparation cycle. This will involve attritioning screening to remove any contaminants, then removal of water by evaporation in a fluid bed dryer. The proposed dryer will have a capacity in the order of 80 tonnes per hour and will reduce the moisture content to less than 0.2%.

The dry concentrate will then be screened to remove oversize material (larger than 500 microns) to a waste stockpile. The undersize fraction is then fed into the primary high tension circuit. This circuit will separate the conductors from the non-conductors. Ilmenite and rutile are electrical conductors while zircon and monazite are non-conductors.

The conductors will then be fed to magnetic separators which will separate (magnetic) ilmenite from a (non-magnetic) rutile rich fraction. The former will pass into a product silo while the latter will move on for further processing.

The further processing for rutile will firstly involve separation by screening into coarse (+212 microns) and fine fractions. The fine and coarse material will then be separately treated by further electrostatic and induced roll magnetic separation to produce a rutile product and other titaniferrous material (leucoxene).

Leucoxene may be separated in the processing circuit and stored in a concrete bunker. Further bunkers will be provided for wastes, and for titaniferrous middlings.

The non-conductors (the zircon and monazite rich fraction from primary high tension separation) will be screened at 180 microns. The fine stream will be magnetically fractionated for monazite removal. The coarse stream will be magnetically fractionated primarily for the removal of waste alumino-silicates such as staurolite.

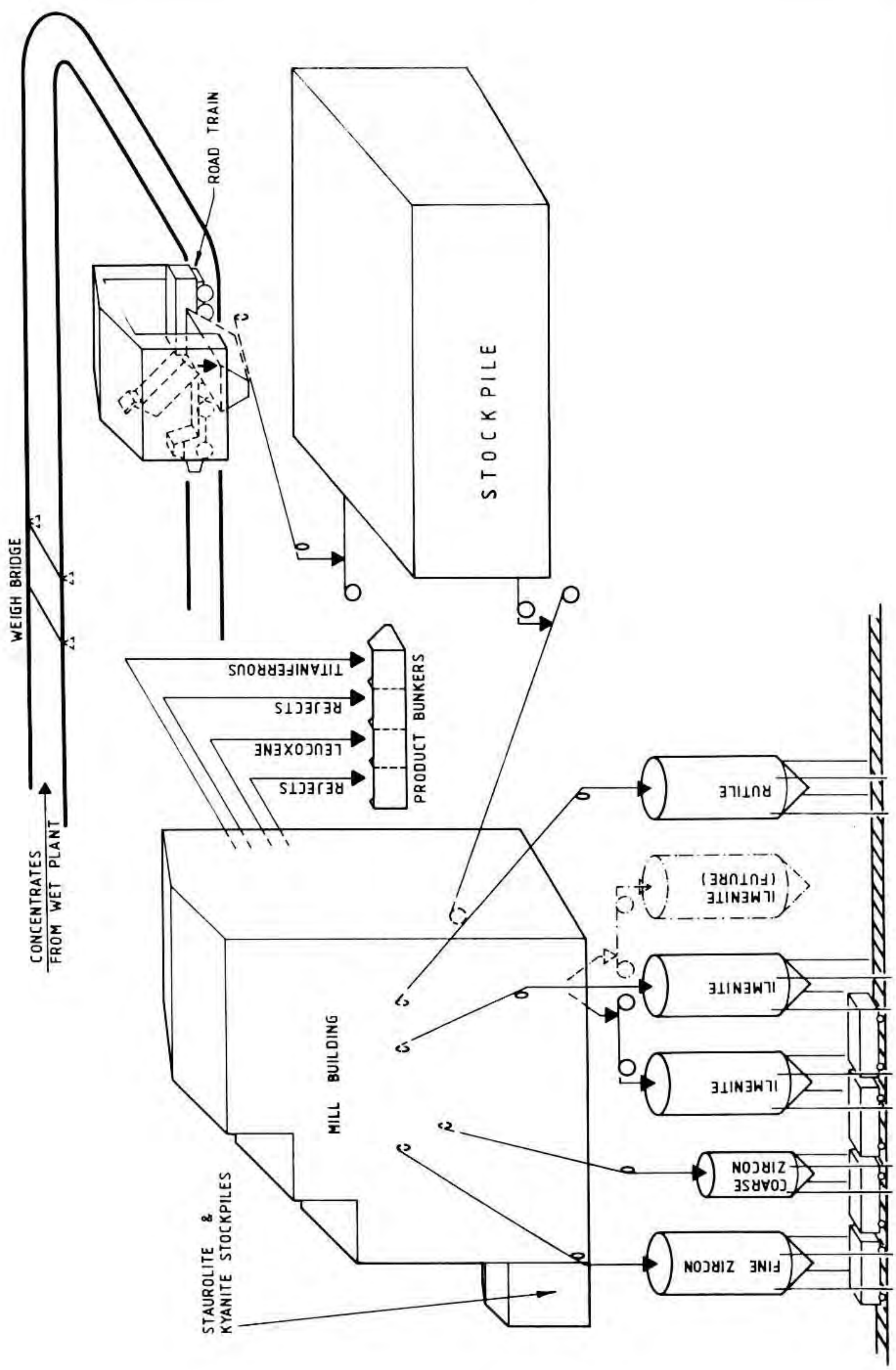
Both coarse and fine streams will then be subjected to gravity concentration and the resultant heavy concentrates will receive further cleaning on electrostatic and magnetic separators to produce the final coarse and fine zircon products for storage in transhipment silos.

The monazite stream will also be further processed and the final product will then be stored in bins and bagged and containerised for transport. A description of radiation protection measures proposed for the handling of monazite is provided in Section 7.4.

In full production, the total feed rate to the dry mill will be in the order of 500,000 (dry) tonnes per annum. The estimated production of saleable minerals from this feed is:

Ilmenite	311,200tpa
Rutile	18,200
Leucoxene	2,800
Zircon	42,700
Monazite (and Xenotime)	2,100
Total:	377,000tpa

The ratio of products to waste will improve with metallurgical refinement of the circuit. The waste material will be stockpiled prior to return to the minesite or reprocessing. Wet waste material will be dewatered prior to transport back to Cooljarloo.



SCHEMATIC LAYOUT OF THE MUCHEA DRY PROCESS PLANT **FIGURE 4.9**

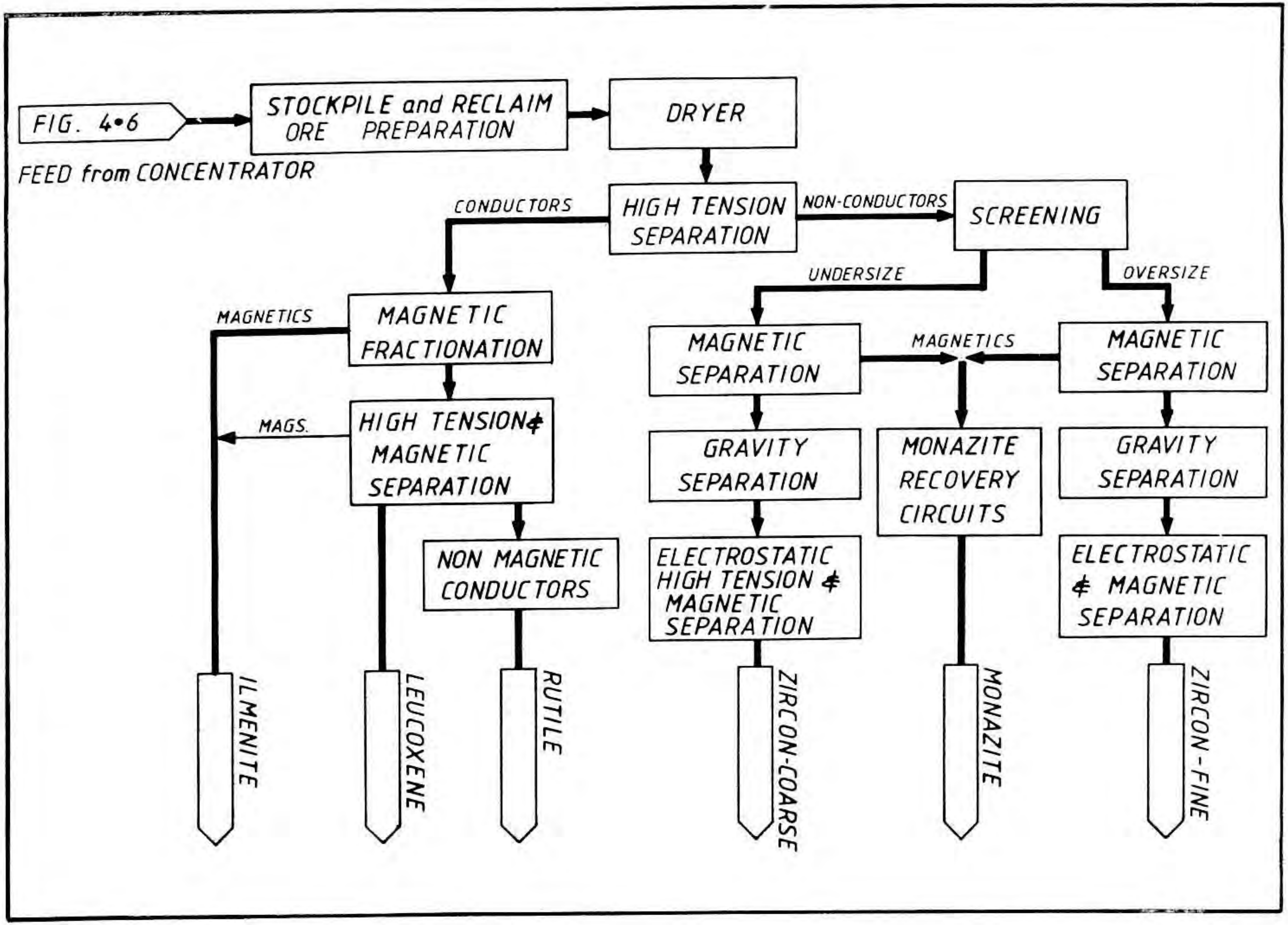


FIGURE 4.10

FLOW CHART FOR DRY CONCENTRATOR PLANT

4.2.5 Dry Process Plant Services

(a) Process Water

Approximately 240 kilolitres of process water and 60 kilolitres of potable water will be required each day for the dry plant. It is proposed to supply this from a bore on site.

(b) Gas Supply

The initial drying of the wet concentrates in the feed preparation circuit will be fuelled by natural gas drawn from the Dampier to Perth pipeline which is located 1.5km to the west of the Muchea site.

(c) Electricity

There are no large individual electric power loads in the dry mill. Power will therefore be supplied from the available SECWA grid at the conventional level of 440 volts, 3 phase, 50 Hertz.

(d) Compressor Air

A standard compressor will be installed to supply air for instruments.

(e) On-site Facilities

Workforce facilities at the Muchea site will consist of canteen and ablution requirements typical for an industrial plant. No accommodation will be provided as it is expected that the workforce will commute from their private homes. Support buildings will include a store and a workshop.

Part of the site will also be developed as the administration centre for TIO2 Corporation NL operations in Western Australia.

(f) Sewage Disposal

Sewage will be generated from the canteen and ablution facilities to be provided as part of the site infrastructure. Principal source's of sewage will be the toilet and shower facilities. Quantities of kitchen waste will be minimal since the canteen facilities to be provided will not allow for preparation of meals.

Examination of various sewage disposal options has been based on consideration of the following factors relevant to the proposed plant site. These are:

- the area is subject to high water tables particularly in winter;
- the plant site is in close proximity to Ellen Brook;
- the possibility of using groundwater from the shallow aquifer at the site for process and potable purposes.

Total sewage flows are estimated to be 80 litres/day/person giving a total daily flow of 6,400 litres.

The sewage will be separated into two streams, these being:

- waste from the toilets and hand basins that will be directed to a septic tank, and
- waste from the showers that will be piped directly to the storage and evaporation pond that will form the disposal facility for waste water from the main plant.

The septic tank will be a purpose built fully sealed concrete structure. Liquid effluent will be disposed of via a fully inverted leach drain similar to those used for normal domestic septic systems in the Muchea townsite area. This type of leach drain is used to offset the effects of the near-surface water table that is common in and around Muchea during winter and requires the construction of a raised sand pad into which the leach drain is installed.

It will be necessary to site the leach drain at least 30m from any groundwater bore and as far as possible but not less than 30m from any surface watercourse. Nominal size of the pad will be approximately 30m x 30m x 1m deep.

The grey water from showers will be directed as a separate stream to the main plant waste water disposal pond. This will be a sealed pond used to store the water and sized to allow disposal by evaporation.

4.3 THE PORT FACILITY

4.3.1 Location

It is proposed to use the existing BHP Steel/Australian Iron & Steel site at Kwinana as the port facility (Figure 4.11). The site has been used for many years for steel production but current activities are limited to wire, rod and bar production.

4.3.2 Site Description

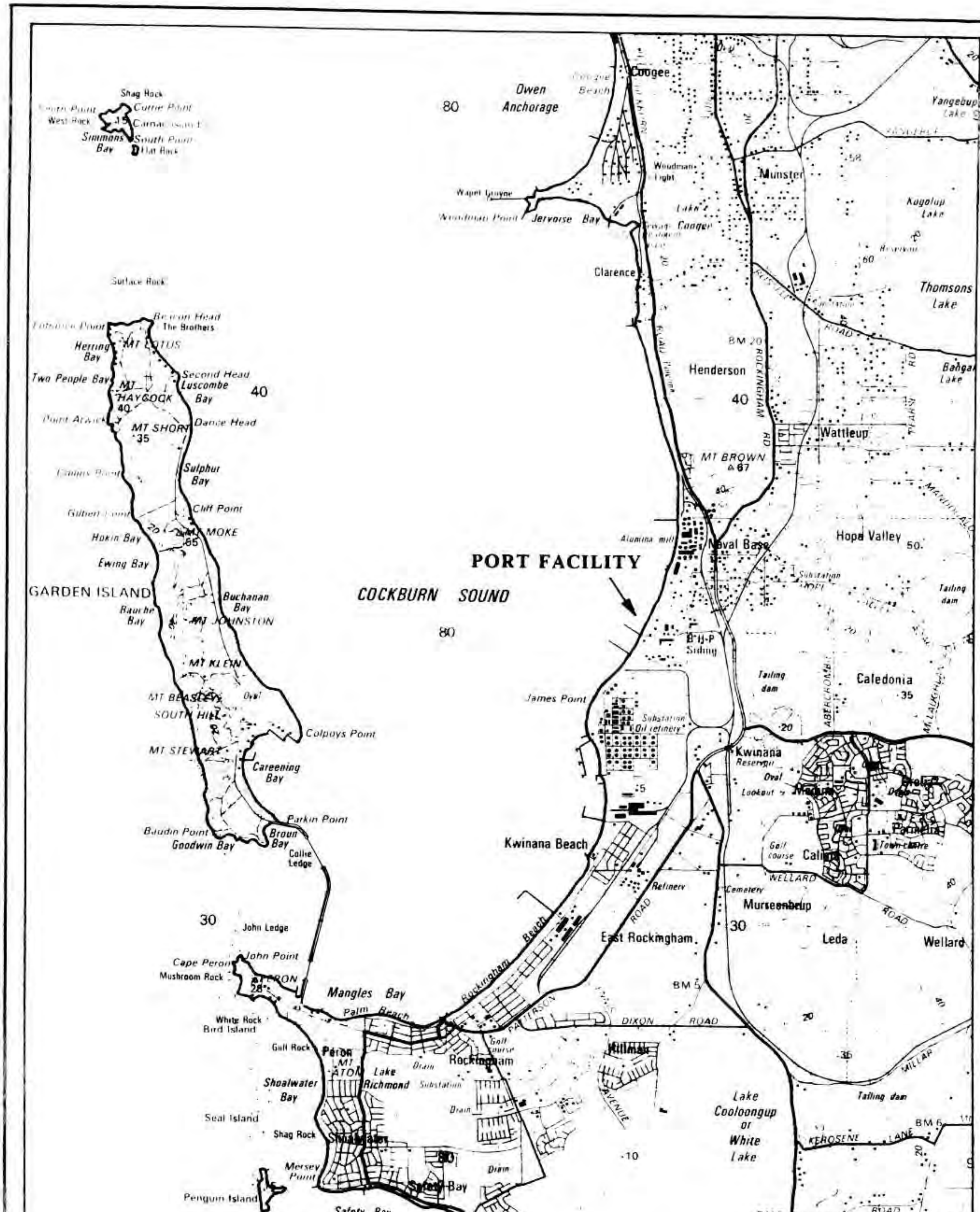
The Kwinana site contains blast furnaces and associated infrastructure. These steelworks were supplied with iron ore from Koolyanobbing but the mine and works ceased production several years ago and are currently on a care and maintenance basis. The TIO2 project would use the existing shiploader and some existing storage and other equipment but would construct some specific receival hoppers, conveyors and covered storage.

The products delivered by train would be unloaded into a dump hopper and transferred by conveyor to a stacker which would fill the various covered product stockpile sheds through their roofs. Material would be moved from storage by being pushed through drop-out areas onto a tunnel conveyor belt which would feed to the shiploader conveyor which would transport it for direct loading into the ship holds.

4.3.3 Transport of Products - Muchea to Kwinana

All of the major heavy mineral products except monazite and xenotime will be transported in bulk to Kwinana in railway wagons. The Midland railway line runs next to the western boundary of the Muchea site and the connection to this will be made by a small on-site siding or by tracks leading to the various storage silos. The railway route to Kwinana would be via Midland, Kewdale and Canning Vale.

The monazite would be bagged and placed in containers at the Muchea site and then transported by rail to Fremantle. Delivery will occur only when a receival ship is in berth so that direct loading from rail wagons by container crane can occur and there will be no need for storage at the port. The containers will be clearly labelled to identify their contents as required in various regulations and guidelines (Section 7.4).



LOCATION OF PORT FACILITY AT KWINANA

FIGURE 4.11

5. DESCRIPTION OF THE EXISTING ENVIRONMENT

5.1 THE COOLJARLOO MINESITE - NATURAL ENVIRONMENT

5.1.1 Landscape

The topography of the Cooljarloo area is shown in Figure 5.1. The tenements are bordered to the east by the low rise of the Gingin Scarp which is the most prominent feature of the area. Below this, the landscape is gently undulating with low dune ridges and interdunal swales which are subject to waterlogging and seasonal swamp development. These features are typical of the Bassendean Sand Formation and are extensive on the Swan Coastal Plain. Overall the site gradually slopes to the west.

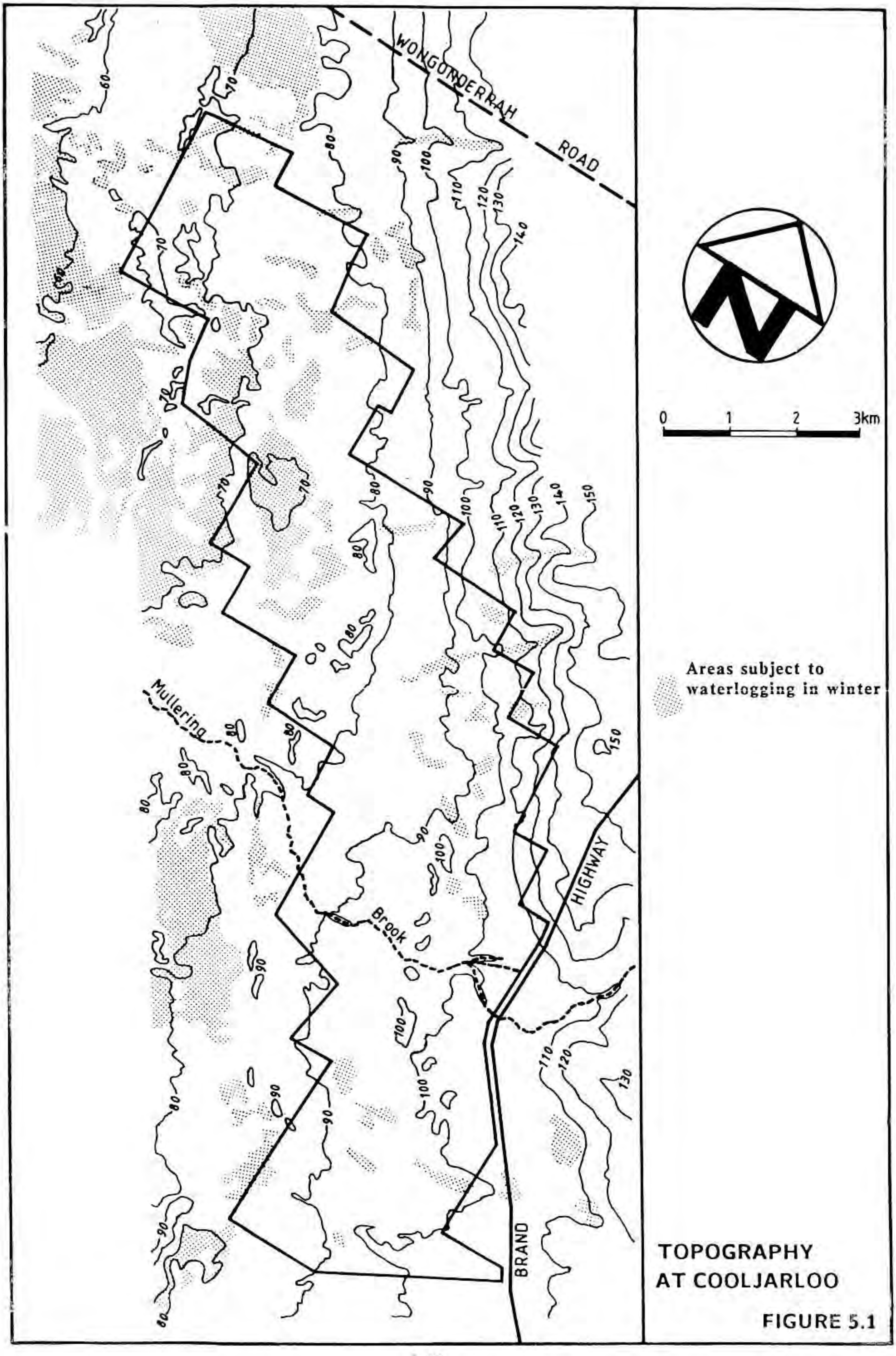
The tenements are intruded from the east by minor watercourses originating from the Gingin Scarp and are traversed by Mullering Brook. It appears that some of the temporary swamps may coalesce in particularly wet winters and may then flow westwards towards the brook.

The major soil types of the area are closely related to the dominant features of the landscape. On the Gingin Scarp where erosion has strongly influenced the landscape, the soils are skeletal. Directly below at the foot of the escarpment are lateritic podzols which give way to podzols with deep sands originating from earlier coastline deposits and humus podzols in the interdunal wetlands. The latter have originated from the high level of organic material associated with the availability of water.

5.1.2 Climate

Rainfall, temperature, evaporation and wind patterns are critical factors for rehabilitation planning and success. Data for the Cooljarloo district is therefore presented below.

The Cooljarloo site lies centrally in the western region of the south-west climatic province of Western Australia. The climate here is controlled by a succession of high and low pressure systems which move from west to east and a southerly flowing offshore warm ocean current (the Leeuwin Current) during the winter months. The movements of the low level atmospheric pressure systems is typical for these latitudes, but the Leeuwin current is unique and produces a higher winter rainfall (450 to 750mm) than that found at the same latitudes on the west coasts of Africa and South America.



TOPOGRAPHY AT COOLJARLOO

FIGURE 5.1

During summer, high pressure systems are dominant and frequently become slow-moving or stationary when centred over the Bight. The associated anti-clockwise circulation produces hot and dry north-easterly winds originating from the interior. This is followed by the formation of a low pressure trough off the west coast into which north-westerly winds may bring warm and humid air of tropical origin. When the trough moves inland, rain and thunderstorms may occur, the anticyclone is displaced to the east and winds become south-westerly then south-easterly to produce a cool change. These conditions persist until a new anticyclone becomes established. Other rare occurrences of summer rain may arise from middle-level cloud of tropical origin, or an extreme southerly movement of a tropical cyclone.

Annual rainfall data for Tuyali (the nearest location to Cooljarloo) is given in Table 5.1. Generally the monthly median rainfalls are lower than the means especially from mid-summer to autumn. This is because these months feature rare heavy rainfall events which distort the averages upwards. Annual evaporation at Cooljarloo is 2,150mm.

Examination of the rainfall-evaporation relationships indicate that there are very few months with a net rainfall input to the soil, and that in general rainfall exceeds evaporation in only one month per year. However, replenishment of soil moisture normally occurs in June and continues during the winter months and perhaps into early spring. Then a soil moisture drying phase commences which is accentuated from January to May when evaporation and transpiration are highest and rainfall is lowest.

Mean daily maximum and minimum air temperatures for Badgingarra are presented in Table 5.2. The Cooljarloo site is approximately 30km south and slightly west of Badgingarra, and is about 20km closer to the coast.

Winds have the potential to cause soil erosion and therefore the wind patterns at Cooljarloo must be taken into account in planning earth movements, soil stockpiling, and rehabilitation. The nearest wind recording stations are at Jurien and Eneabba and data from these have been collated to present a regional picture. In the morning (0900 hours) there is a clear dominance of easterly wind patterns during the year. The afternoon (1500 hours) pattern however, changes with the season. In summer, south-westerly sea breezes predominate while in winter the wind directions are more variable.

TABLE 5.1

RAINFALL DATA FROM TUYALI STATION NEAR COOLJARLOO (1968-84)

	Jan	Feb	Mar	Apl	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec	Year
Mean	3	14	16	39	78	127	113	96	56	32	20	9	603
Median	0	0	7	38	74	135	88	96	64	29	14	2	569

TABLE 5.2

MEAN DAILY MAXIMUM AND MINIMUM TEMPERATURE BADGINGARRA (1965-82)

	Jan	Feb	Mar	Apl	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec	Year
Max^{o}C	34.7	35.4	32.3	26.9	22.6	18.7	17.8	18.3	20.7	24.4	28.0	32.5	26.0
Min^{o}C	16.6	17.3	15.6	12.8	9.7	8.0	6.9	6.5	7.2	9.2	11.8	14.8	11.4

5.1.3 Ground and Surface Waters

A specialist report on hydrology at Cooljarloo has been prepared by Australian Groundwater Consultants (1986) and further detailed hydrological studies will be made prior to mining.

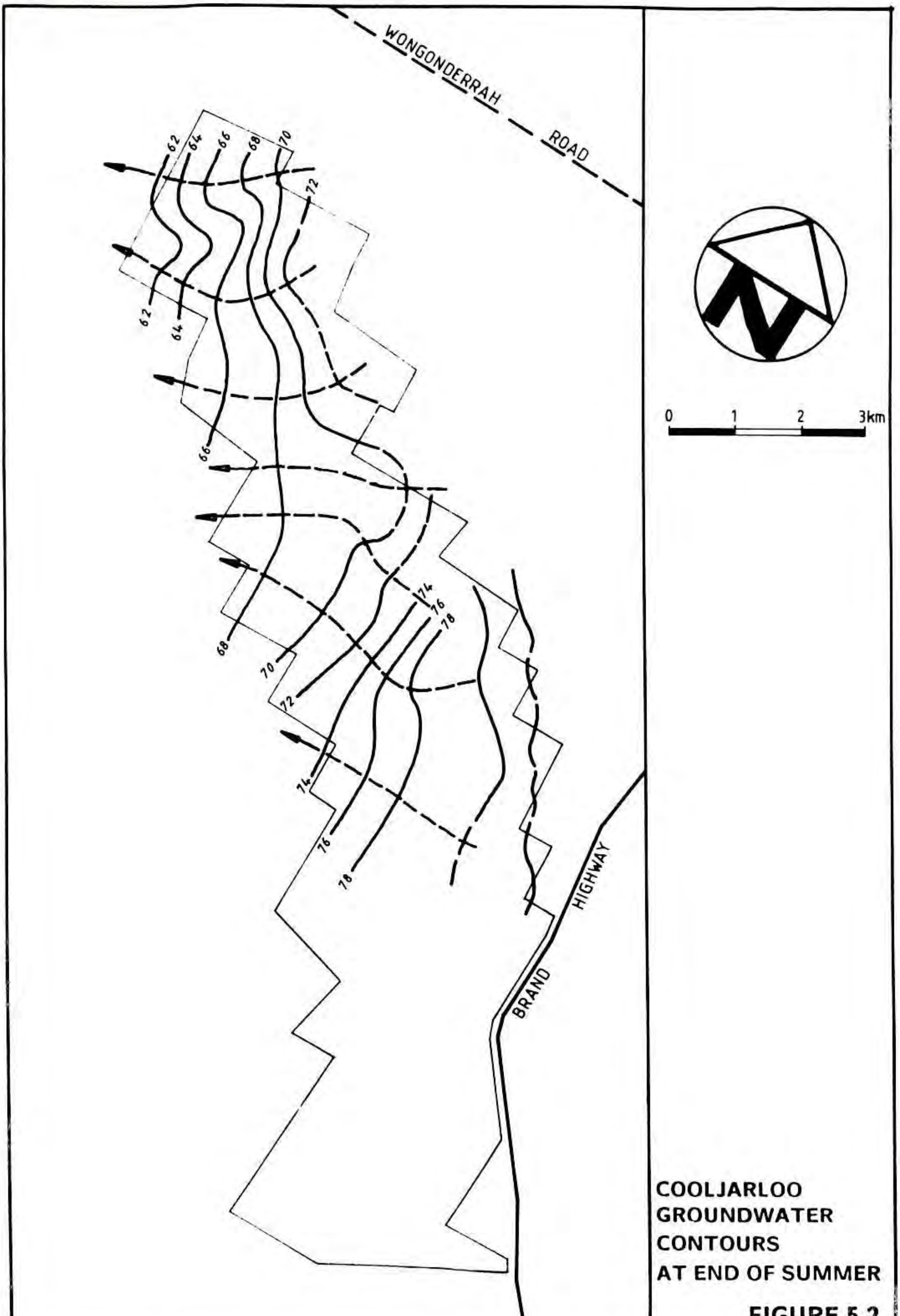
The only definite drainage channel in the Cooljarloo tenement area is Mullering Brook, a tributary of the Nambung River. This is a relatively small intermittent watercourse which drains a catchment to the north-east. Lesser watercourses carry intermittent flows from the Gingin Scarp onto the tenement area in winter and dissipate in the sandy terrain. The sparsity of drainage channels suggests that the soils must be porous so that rainfall permeates the soil profile instead of becoming run-off. Actual site investigations however, have indicated that while the surface soils may be porous they are underlain by less permeable material which cause the seasonally swampy conditions.

Mineral investigations have enabled the hydrological contours of the groundwater to be determined for the superficial sands. An example of these is shown in Figure 5.2 for May 1986. As these contours are at the end of the summer-autumn dry season they represent the lowest groundwater levels and in winter the contours are expected to be as much as 5m higher.

The contours indicate the westward slope of the watertable which has a gradient of 3-4m/km. In detail however, the superficial formations of the Bassendean Dunes contain alternate layers of sands and clays. The sands are moderately permeable while the clays are poorly permeable, so the latter may present barriers to groundwater flow. The clayey layers for example, cause perching of the groundwater in places which are winter wetlands. The sands also contain significant proportions of clay slimes which inhibit flow. As a consequence conductivities at Cooljarloo are estimated to be in the order of 0.3 to 0.8m/day whereas in the Bassendean Sands near Perth flows may exceed 10m/day.

The total groundwater throughflow under the tenement area has been calculated to be about 500kL/day which is relatively small. This suggests that winter replenishment and evapotranspirative loss at other times are the main determinants of the groundwater levels rather than horizontal flow to the west.

Groundwater quality appears to be variable across the lease area both in total salinity and in the proportions of the various dissolved solids. This variation is thought to be due to a combination of influences relating to the hydrology and pattern of evapotranspiration, recharge and seepage. Increases in salinity can be expected where throughflow is inadequate to flush out salts concentrated by evaporative processes.



COOLJARLOO
GROUNDWATER
CONTOURS
AT END OF SUMMER

FIGURE 5.2

5.1.4 Vegetation

A report on the flora and vegetation at Cooljarloo has been prepared (Elkington, 1987). This concentrates on a broad scale assessment and it is intended that more detailed analyses of actual impact areas will be carried out prior to mining to provide site specific information for rehabilitation planning.

A vegetation map for the tenements and surrounding areas is shown in Figure 5.3. Structurally the vegetation is of two types: low woodland and heath. The low woodland features various tree species which may attain heights of about 10m but which provide a sparse cover (10-30%). In contrast the heath comprises a mixture of low shrubs from 0.5-1m high but with mid-dense (30-70%) and, in places, dense (70-100%) cover. Larger individual trees and shrubs may be emergent above the heaths.

The two vegetation formations are represented by six major associations but these will be further subdivided in the more detailed mapping. The greater part of the area is covered by Banksia low woodland. In this, B. attenuata, B. menziesii and B. prionotes are very common, and B. ilicifolia is common. This association also typically features the Pricklybark (Eucalyptus todtiana) and the Christmas Tree (Nuytsia floribunda). In the southern part of the tenements Pricklybark may be locally dominant (Pricklybark/Mixed Banksia low woodland). Here the understorey comprises mixed shrubs up to about 1.5m in height with Melaleuca scabra, Astroloma xerophyllum, Calytrix flavescens, Calytrix leschenaultii and Leucopogon conostephioides well represented and a ground layer in which the grass Amphipogon turbinatus, sundews (Drosera spp.) and trigger plants (Stylidium spp.) are common. A total of 114 plant species have been recorded in this southern area.

The tree density increases in the central part of the tenement area and the most common species in the understorey change. Here Amphipogon turbinatus and Alexgeorgea arenicola are abundant, and Andersonia heterophylla, Eremaea pauciflora, Conostylis teretifolia, Schoenus curvifolius, Mesomelaena stygia and Restio sphacelatus are common. The tree density increases further in the northern section of the tenements.

In the wet depressions B. littoralis var. littoralis may be present in the Banksia low woodland and, in two locations, the Swamp Paperbark (Melaleuca preissiana) is also present. These areas also feature closed heath and scrub heath, the former characterised by Banksia telmatiaea, Calothamnus villosus and Hypocalymma angustifolium to about 1m, and the latter by Melaleuca hamulosa, M. incana and Kunzea recurva. The variety of species is low compared to other associations in the tenement area.

Mixed low heath occurs in the southern-central part of the area. Here Hibbertia crassifolia, Melaleuca scabra, Baeckea grandiflora, Cryptandra glabriflora and Opercularia spermacocea are common shrubs. These heaths feature the greatest variety of plants per unit area within the tenements and a total of 113 plant species have so far been recorded from them.

The association with the greatest number of species in total however, is the Xanthorrhoea reflexa low heath in which 126 species have been recorded. This association is restricted to the lateritic gravels on the slopes of the escarpment and therefore has a limited occurrence in the tenement area. It features various species of Hakea (H. incrassata, H. lissocarpha, H. conchifolia, H. erinacea and H. stenocarpa), and Mesomelaena stygia, Conostylis androstemma, Beaufortia elegans and Schoenus subflavus are common to abundant.

Hakea obliqua scrub heath has a limited distribution along the north-east boundary of the tenement area. In this association H. obliqua grows to 3m above an open heath assemblage with 109 species recorded so far. Common species include Schoenus subflavus, S. curvifolius, Mesomelaena stygia, Eremaea asterocarpa, Dasypogon bromeliifolius, Melaleuca scabra, and Lysinema ciliatium while Banksia candolleana, B. attenuata and B. telmatiaea occur occasionally.

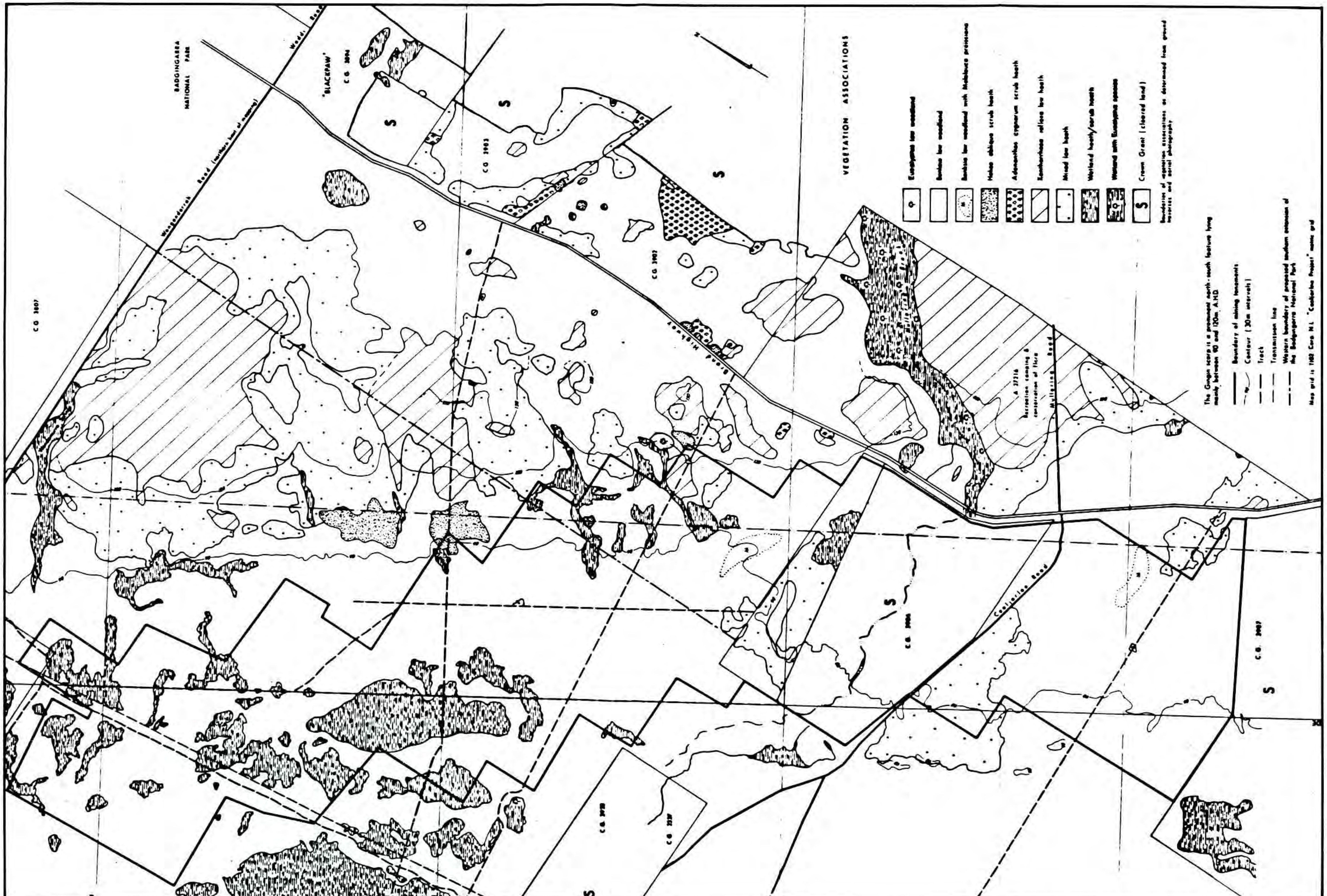
A small patch of Eucalyptus low woodland also occurs on the eastern side of the tenement area near the base of the Gingin Scarp. This features E. camaldulensis, E. rudis and E. calophylla above a sparse understorey.

Finally, the southern part of the tenement area includes a private property which has been developed for farming. As a result most of the original vegetation has been cleared except for scattered banksias, Christmas Trees and pricklybarks.

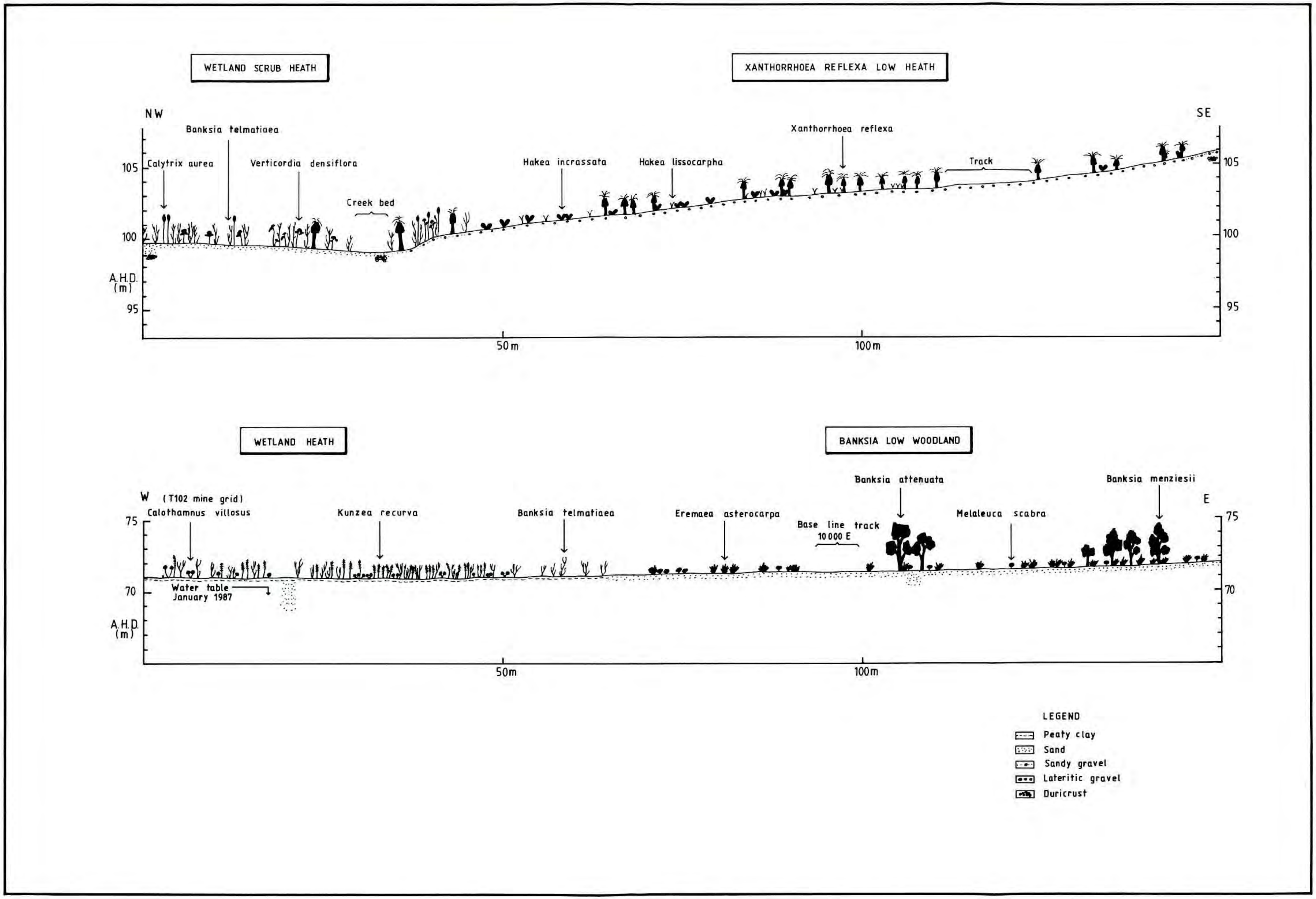
In all a total of 305 plant species have been recorded from the Cooljarloo tenements (Appendix 2). Typical profiles of the vegetation are shown in Figure 5.4 and the banksia/Eucalyptus todtiana low woodland is shown in a photograph in Figure 5.5.

5.1.5 Vertebrate Fauna

The vertebrate fauna (frogs, reptiles, birds and mammals) of the Cooljarloo tenements have been assessed by field surveys in winter and summer (Dunlop & Bamford, 1987). The location of survey sites is shown in Figure 5.6. The fauna is typical of the northern sandplains of south-western Australia, but is considered to be depauperate both in terms of species number and population densities in comparison with similar habitats. This difference may be attributed to the area's short fire cycle (see Section 5.1.6).



VEGETATION AT COOLJARLOO
FIGURE 5.3



COOLJARLOO MINESITE - TYPICAL PROFILE OF VEGETATION

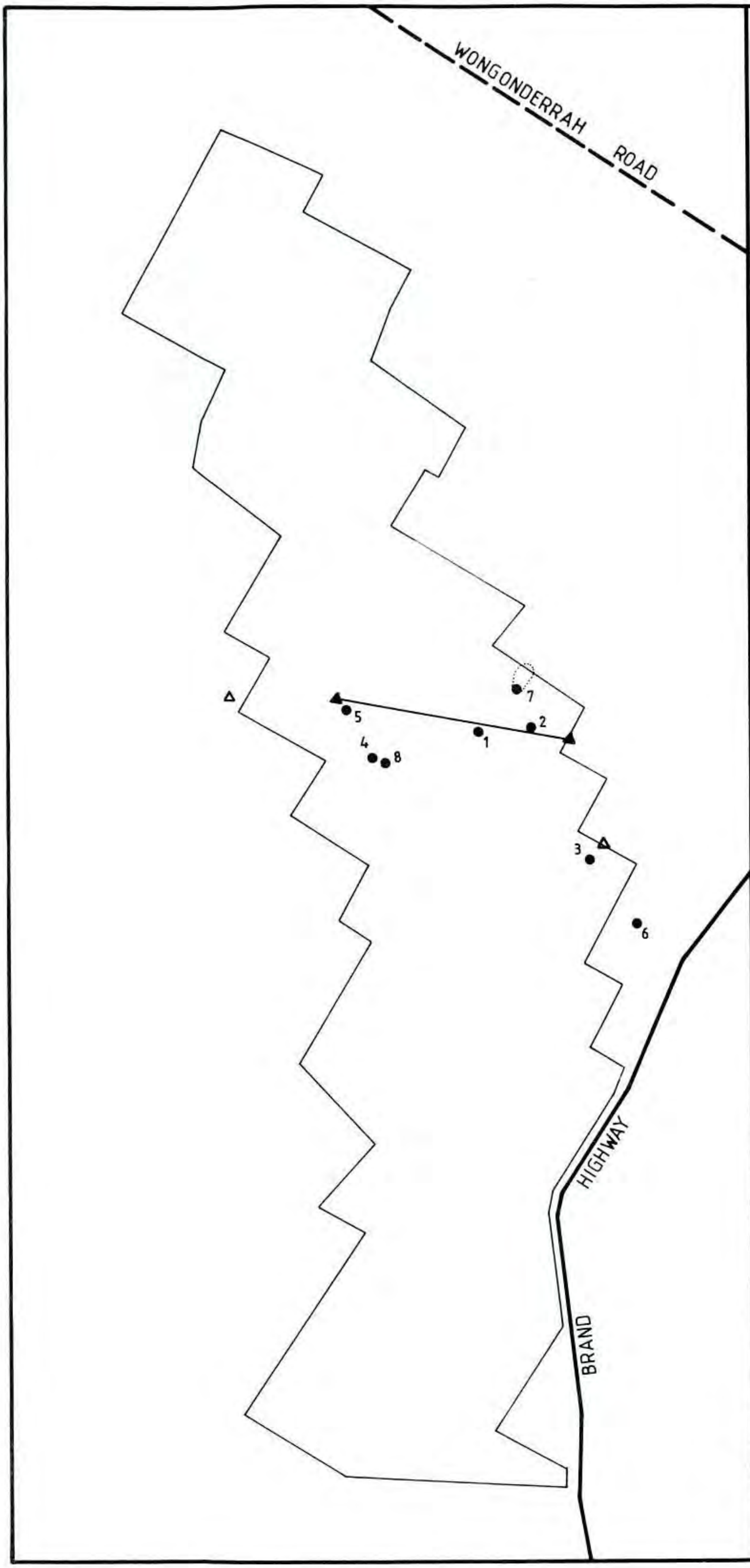
FIGURE 5.4

(a) Typical Vegetation: Cooljarloo Minesite

(b) Process Plant Site Muchea

COOLJARLOO AND MUCHEA SITE

FIGURE 5.5



COOLJARLOO
VERTEBRATE
FAUNA SURVEY SITES

FIGURE 5.6

In all, 6 frog, 13 reptile, 61 bird and 9 mammal (5 native and 4 introduced) species have been recorded from the tenements and nearby areas so far (Appendix 3). The list and particularly the number of reptiles, is expected to increase with further research during the life of the project. None of the species recorded to date are considered to be endangered, or to have restricted distributions.

In the extensive banksia low woodlands Brown and Singing Honeyeaters (Lichmera indistincta and Lichenostomus virescens) are abundant but the many other species recorded typically occur in low numbers. Insectivorous birds in particular are uncommon in comparison to similar habitats which have been surveyed elsewhere and many of the records consist of a few sightings.

The Western Grey Kangaroo (Macropus fuliginosus) is common in the area and the Brush Wallaby (Macropus irma) is also present. Other smaller native mammals recorded are the Honey Possum (Tarsipes rostratus) which appears to be in very low numbers, and the Ashy-Grey Mouse (Pseudomys albocinereus) and Gould's Wattled Bat (Chalinobus gouldii). The absence of the small carnivorous marsupials (Sminthopsis spp.) to date, is notable and again is probably due to the local fire history.

Introduced mammals include the House Mouse (Mus musculus) which has been recorded in all of the major habitat types, the feral cat (Felis catus) and Red Fox (Vulpes vulpes) which are both common, and the European Rabbit (Oryctolagus cuniculus) which is uncommon and may be restricted to wet heathland areas.

The seasonal wetlands within the tenements are obviously the critical habitat for frog species but appear to have little value for other vertebrates. The dense vegetation in particular limits their attractiveness to waterbirds generally but at the same time provides the preferred habitat for the Spotless Crake (Porzana tabuensis) which is common during winter in the largest wetland. The White-breasted Robin (Eopsaltria georgiana) also occurs in woodlands fringing the wet depressions. This is an unusual species in this locality.

5.1.6 Fire History

The fire history of the Cooljarloo tenements has been determined by inspection of aerial photographs taken at intervals since the 1940s.

It appears that since that time most of the area has been burnt every 5 years or at shorter intervals. The pattern of fires has however changed. Thus, whereas approximately 99% was burnt in small fires between 1933 and 1943, since 1970 the fires have been less frequent but more extensive. It is reasonable to assume that these patterns differ significantly from that which occurred prior to agricultural settlement in the area. It is also apparent that the current vegetation in terms of species composition and abundance is strongly influenced by the fire regime. This has undoubtedly favoured fire tolerant species such as the Banksias and discouraged fire sensitive species.

The frequent fires are also considered to have had a marked influence on the vertebrate fauna of the site and to be the main reason for the relatively depauperate species number and populations. While it is thought that Australian reptile and bird species are reasonably resilient to fire damage to their habitats and many species are known to recolonise burnt areas relatively quickly, repeated fires at short time intervals could cause an increasing loss of subtle habitat values such as favoured food items and consequently make the burnt areas less favourable to vertebrates.

The occurrence of a few vertebrate species in very large populations at Cooljarloo and many species at low levels also indicate a simplified fauna habitat. In some ways this community composition resembles those found in plant monocultures such as plantations. In addition, the low numbers of insectivorous birds is difficult to explain in floriferous vegetation where invertebrates should be abundant unless some factor has influenced the occurrence of such food items.

Similarly small mammals in south-western Australia are known to be sensitive to the frequency, extent and intensity of burning. High populations densities of the Dunnart (Sminthopsis griseoventer) in particular have been recorded in Banksia woodland on the Swan Coastal Plain where most of the habitat has been unburnt for 15-20 years, but have not so far been found at Cooljarloo. It is perhaps not coincidental that the principal food of these mammals are invertebrates. The Honey Possum and Pigmy Possum (Cercartetus concinnus) are also thought to prefer habitats which feature at least some unburnt vegetation.

5.2 THE COOLJARLOO MINESITE - SOCIAL ENVIRONMENT

5.2.1 Aboriginal Sites

A specialist report on archaeological sites at Cooljarloo and sites of importance to contemporary Aboriginal communities has been prepared in association with this Draft ERMP (O'Connor & Quartermaine, 1987a). This has been submitted separately to the Western Australian Museum for evaluation.

It appears that at the time of first European settlement of Western Australia, the northern sandplain district did not support a large permanent Aboriginal population probably because of the scarcity of permanent water. Traditional use of the land occurred however, due to seasonal movements from nearby areas and some people became permanent residents when colonial settlement first occurred at Eneabba in 1870. Knowledge of sites of importance have passed from these people to their descendants in the contemporary south-west Aboriginal community.

This contemporary community associates the major rivers which flow from the Darling Range and many of the smaller creeks and other wetlands in south-western Australia with Waugul, a Dreaming ancestor commonly referred to by non-Aboriginals as the Rainbow Serpent. In common with this pattern, a Waugal belief is associated with Mullering Brook which traverses the tenement area. The area is also generally used by some Aboriginal people for picking wildflowers for sale and is therefore of economic importance to them.

Evidence of earlier settlement in the region comes from a coastal shell and artefact scatter located near Jurien which has been dated to 6,000 years ago. In the actual vicinity of the Cooljarloo tenements, previously recorded archaeological sites are all small, low density artefact scatters generally with a predominance of quartz implements. A similar site was located by the survey carried out for this ERMP on agricultural land near Mullering Brook, but no other evidence of early Aboriginal occupation was found. This particular site is considered to be of relatively low archaeological significance for the following reasons:

- The integrity of the archaeological material at the site has been compromised, due to disturbance of the surface by human and natural agents.
- Several similar low density surface artefact scatters have been recorded in the vicinity.
- There is a limited potential for further archaeological information to be obtained.

5.2.2 Land Use

Contemporary land use in the Cooljarloo area is shown on Figure 5.7. The tenement area predominantly comprises a portion of an extensive tract of Vacant Crown Land which extends from the Brand Highway westward to the boundary of the Nambung National Park near the coastline south of Cervantes. The southern part of the tenements however, includes a private property (CG3906) which has been developed for farming. Other farming properties occur nearby to the north and east and the pastures of property 3907 form the southern boundary of the tenements.

The Wongonderrah Springs Nature Reserve (26248) is adjacent to the northern boundary of the tenements and the Mullering Brook Reserve (27216) is adjacent to the south-eastern sector, but is on the other side of the Brand Highway. There is a smaller reserve (12473) within the latter and also a Stopping Place for Travellers and Stock (18294) close to the western boundary of CG3906. Details of these reserves are provided in Table 5.3.

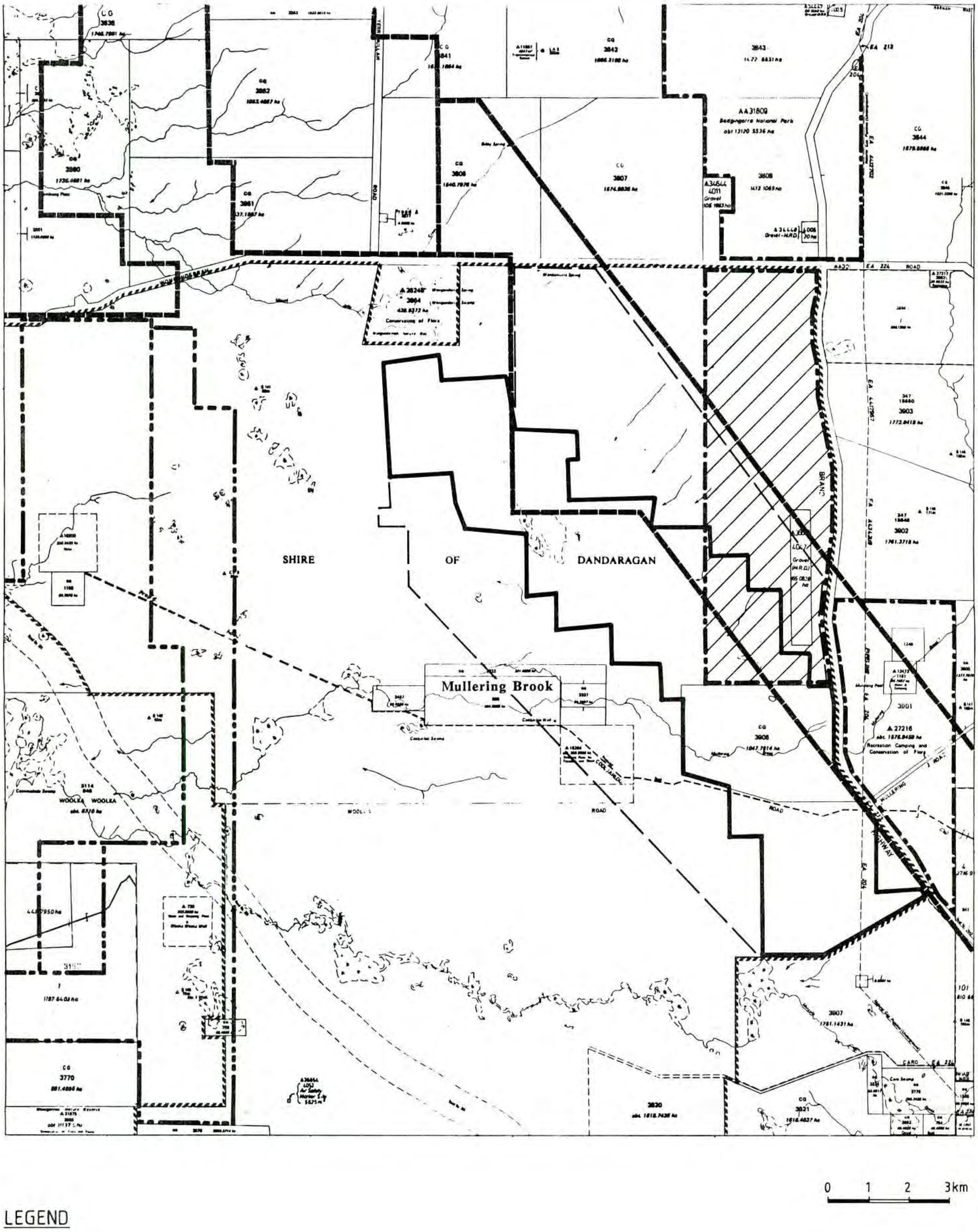
The southern boundary of the Badgingarra National Park is also nearby to the north-east on the northern side of Wongonderrah Road. This park has a total area of more than 10,000ha and is vested in the National Parks & Nature Conservation Authority. The Western Australian Environmental Protection Authority has recommended that the boundaries of this National Park be extended southwards as part of its Conservation Through Reserves programme (Environmental Protection Authority, 1976, Recommendation 5.22[1]). The proposed boundary of the extension is shown on Figure 5.11 and is designed to increase the representation of local flora, to provide a long stretch of reserve next to the Brand Highway where wildflowers could be viewed, and to connect with Reserve 27216 to the south (Conservation Through Reserves Committee, 1974).

The EPA recommendations have been implemented in part by the extension of the National Park southwards to Wongonderrah Road and by the vesting of Reserve 27216 in the Shire of Dandaragan. The intervening section however has not been gazetted to date. Part of this section covering about 660ha overlaps with the TIO2 tenements in parts of M70/132 and M70/283 (Figure 5.7).

Other potential land uses, including mining exploration applications and a potential area of interest to the Army as a weapons range are also shown in Figure 5.7.

5.2.3 Regional Setting and Demography

The Cooljarloo area is relatively sparsely settled with farming families on separate properties. The only centre close to the tenements is Cataby about 4km to the south which essentially consists only of a roadhouse and support buildings for staff. The nearest town is Dandaragan (population less than 200) 20km to the east. Cooljarloo is within the Shire of Dandaragan. Badgingarra (population less than 200) is also 20km from the tenements, but to the north. Further away are the small coastal towns of Cervantes (30km west, population 240), Jurien (50km north-west, population 450), Lancelin (50km south-west, population 400), and Moora (60km east, population 1,680).



LEGEND

- TiO2 Tenement Area
- Exploration Permit Application - TiO2 Corporation NL
- Exploration Permit - Western Mining Corporation
- Exploration Permit Application - Western Titanium/Renison Ltd.
- Badgingarra National Park
- Proposed Extension to Badgingarra National Park
- Proposed Defence Area (Application Withdrawn)

FIGURE 5.7
CURRENT AND POTENTIAL LAND USE IN THE COOLJARLOO AREA

TABLE 5.3

DETAILS OF RESERVES CLOSE TO THE COOLJARLOO TIO2 TENEMENTS

Reserve	Purpose	Vesting	Area
27216	Recreation, camping and conservation of flora	Shire of Dandaragan	1576ha
12473	Water and camping	Shire of Dandaragan	65ha
18294	Stopping Place for travellers and stock	Shire of Dandaragan	259ha
26248 (Wongonderrah Nature Reserve)	Conservation of flora	Unvested	439ha

5.3 THE DRY PROCESS PLANT - NATURAL ENVIRONMENT

5.3.1 Landscape

The landscape at Muchea is generally flat and low-lying. Inspection of the local topography reveals that the land traversed by the Brand Highway is a shallow depression bounded by the Gingin escarpment to the east and the extensive area of Bassendean Sand dune ridges to the west.

The Chandala Brook-Ellen Brook stream system flows north-south through the centre of this shallow depression, eventually connecting with the Swan River (see Section 5.3.2 below).

The proposed dry process plant site is shown in the photograph in Figure 5.5. While the site is flat, it is slightly elevated above the surrounding landscape to the west, and along its eastern margin slopes slightly to Ellen Brook which runs along its border.

5.3.2 Climate

The general climatic pattern in south-western Australia has been described above in Section 5.1.2. Specific data for the Muchea district are available from records for the Pearce Air Force Base. Monthly rainfall and temperature trends are shown in Table 5.4. Of more importance to project management and particularly for the planning of air quality monitoring studies, are local wind patterns. In summer when the subtropical high pressure ridge is to the south of Western Australia, a generally easterly airflow can be anticipated over Muchea with speeds reaching a maximum in the late morning. This is replaced in the late afternoon by a sea breeze which directs a south-westerly airflow over the area. The frequency and intensity of the sea breeze circulation is however, generally weaker inland than at the coast. Gentilli (1972) suggests that the coastal sea breeze takes approximately 4 hours to penetrate the 30km inland to Muchea. Infrequent cold frontal passages may also cause south-westerly airflow in summer. In winter northerlies are more common.

Air stability and mixing height over Muchea exhibit both diurnal and seasonal variations. In general, a temperature inversion layer forms overnight, resulting in a stable layer up to 500m above ground level. After sunrise, heating causes this layer to break down, through convection, and an unstable layer of about 1,500m (winter) to 3,500m (summer) forms. Large variations in this diurnal cycle can occur, particularly when cloud is present, or a synoptic air mass change occurs. In these instances the convection will be inhibited and air will be more stable, with a lower mixing height. Furthermore, the progression of the sea breeze will produce a non-uniform horizontal and vertical wind field, which in turn influences the horizontal and vertical mixing and mixing heights.

TABLE 5.4

RAINFALL AND TEMPERATURE DATA FOR PEARCE (1953-82)

(a) Rainfall

	Jan	Feb	Mar	Apl	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec	Year
Mean	6	12	13	44	85	151	141	106	69	38	22	11	698
Median	2	5	5	42	81	143	141	107	65	35	13	3	654

(b) Temperature

	Jan	Feb	Mar	Apl	May	Jun	Jly	Aug	Sep	Oct	Nov	Dec	Year
Max^{o}C	34.1	34.0	30.9	26.1	21.8	18.9	18.0	18.4	20.0	23.5	26.9	30.8	25.3
Min^{o}C	16.9	18.0	16.1	13.2	11.0	9.5	8.6	8.1	8.2	10.0	11.9	14.3	12.2

5.3.3 Ground and Surface Waters

An hydrological assessment of the Muchea site has been made by Australian Groundwater Consultants. The geological succession beneath the site is known from bore and drillhole logs and from published maps and information. The site lies within the Perth Basin and is underlain by a thick sequence of Perth Basin sediments. The succession has been interpreted as follows, in stratigraphic order:

- Topsoil thinly developed, with patchy developments of lateritic horizons
- "Superficial Formations" - Bassendean Formation, Guildford Formation (alluvium)
- Osborne Formation - shale, siltstone and sand
- Leederville Formation - a thick sequence of sandy aquifers of importance for water supplies.

It is to be expected that water would be encountered in all these units, but the Leederville Formation represents the most promising source of water supply. The underlying aquifers would be confined by less permeable strata above, except in the "Superficial Formations" which may prove to be semi-confined or water-table aquifers. The Bassendean Sand is understood to be only poorly represented at the site, and the "Superficial Formation" sands may not be as permeable here as elsewhere to the west.

Shallow groundwater flow beneath the Muchea area is away from the Gnangara Mound eastwards towards Ellen Brook which is in part maintained by groundwater seeping from the shallow aquifers. It is probable that drainage from the site would eventually pass to Ellen Brook. Groundwater flow in the Leederville Formation aquifers would be southwards unless modified by major leakage or abstraction from the aquifers.

Two monitoring bores, GD21 and GN31, have been installed nearby in the Muchea district and are regularly read by the Water Authority. GN31 monitors deep confined aquifers identified as the Leederville Formation, whereas GD21 monitors the water-table aquifer system of the Bassendean Sand/Guildford Formation. The GD21 data indicate an annual water-table fluctuation of about 2m in the area some 500m to the north of the site. Depending upon the seasonal conditions, the water-table may lie at or near to the ground surface. Highest groundwater levels occur in September-October whilst levels recede to their lowest in March-April generally. Conditions at the site may be expected to follow this pattern.

Ellen Brook is the major surface water body nearby and the site lies within the brook's catchment. Ellen Brook flows southwards, eventually contributing to the Avon River, 22km to the south of Muchea. Its flow is maintained from four main sources:

- surface runoff especially from the more clayey "Superficial Formations"
- discharges from shallow aquifers through agricultural drains and natural tributaries
- mound springs in the headwaters of some of the western tributaries, and
- upward leakage from confined aquifers.

Groundwater quality is generally at salinity levels between 500 to 1,200mg/L TDS. Ellen Brook salinity would be more variable. The data indicate that this water ranges from 300 to 1,600mg/L with the higher salinity due to the onset of winter rains and the associated flushing of salts from the catchment.

5.3.4 Vegetation

The proposed plant site has been developed for agriculture and as a consequence little of the original vegetation remains. A number of relatively large Marris (Eucalyptus calophylla) are present in the central and eastern sections of the block but otherwise the vegetation mainly consists of pasture. A botanical survey of the site and the adjacent creek bank will be carried out prior to detailed site planning.

5.3.5 Vertebrate Fauna

The Muchea site has little apparent value for fauna because the original vegetation has largely been removed. Therefore no specific assessment of fauna has been made, but it can be assumed that the pasture would provide feeding habitat for some bird species such as the Willy Wagtail (Rhipidura leucophrys), Magpie-Lark (Grallina cyanoleuca), Magpie (Gymnorrhina tibicen), and perhaps Straw-necked Ibis (Threskiornis spinicollis) which is common in the area in winter. The Marri trees will also provide roosting and nest sites for typical farmland birds of the area.

5.4 THE DRY PROCESS PLANT - SOCIAL ENVIRONMENT

5.4.1 Aboriginal Sites

A check of records of the Western Australian Museum and a site inspection by specialists and a representative of the Aboriginal community indicate that the area has no apparent archaeological or other significance to contemporary Aboriginal people (O'Connor and Quartermaine, 1987b).

5.4.2 Land Use

The predominant land use in the Muchea area is agriculture (Figure 4.8). Immediately to the north of Muchea townsite however, the Shire of Chittering is in the process of gazetting an industrial estate and one industry (Black Granite) is already established. The proposed dry process plant is the northernmost title within this estate.

The Gnangara Water Reserve, and land owned by the Commonwealth for defence purposes associated with the RAAF base at Pearce, bound the agricultural land about 2-3km west of the Brand Highway. The Chandala Nature Reserve (A37060) is some 7km to the north of the site.

Two parcels of land in the vicinity are the subject of recommendations in the System 6 Study (Environmental Protection Authority, 1983, Area C25). Swan Location 2929 is immediately south-west of the site on the opposite side of the Brand Highway. Swan Location 2667 is adjacent to the southern boundary of Muchea townsite, about 3km south of the plant site. These locations provide habitat for various plants which have limited distribution. The recommendations relate to the protection of these plants by co-operative action of State Government authorities and the landowners.

5.4.3 Regional Setting and Demography

The Muchea site is just north of the Muchea town boundary (less than 1km) and is approximately 40km north of Perth. Other nearby population centres, apart from Muchea, are Bullsbrook (Pearce) approximately 12km south, and Gingin 24km to the north.

Demographic data for Muchea are not available, but it is a very small congregation of residences on large lots with few community facilities.

Bullsbrook is in the Shire of Swan and information on the town is available in the Shire's Structure Plan for the townsite (Shire of Swan, 1981). It is the predominant rural centre within the Shire, and despite its proximity to the expanding Metropolitan area, is expected to remain rural for many years due to the viticultural and agricultural importance of the Swan Valley and the presence of the RAAF base.

Most of the land around Bullsbrook is zoned rural under the Metropolitan Region Scheme and Shire of Swan Town Planning Scheme No. 1. The minimum lot size permitted in such areas is 40ha.

The Pearce RAAF base dominates Bullsbrook in terms of land use, population, employment and requirements for essential services. Historically the town was established as an adjunct to the base in 1936 and only the small urban area (292 houses in 1980) known as East Bullsbrook is outside of the base precincts. In 1971, the Commonwealth transferred a number of residential lots to the State Housing Commission (now Homeswest) for the purpose of housing RAAF personnel. As a result, the State Government also has considerable holdings in the town (180 houses).

Bullsbrook has a small shopping centre and an hotel located at the entrance to the town on the Great Northern Highway. There is also a Primary and Junior High School with 526 students in 1980. At that time, the majority of the town's population of slightly more than 1,000 were employed at Pearce, half of whom lived in single quarters on the base, while the remainder lived either in the 180 Homeswest houses or commuted from the Metropolitan area. A further 100 people were employed in farming, retailing and community services. It is assumed that these figures approximately reflect the current demography of the town.

Gingin is a small rural-based community with a population of 380.

5.5 THE PORT SITE (KWINANA)

The proposed location for the storage and export facility at Kwinana has been developed for many years for industrial purposes and is the site of the BHP/AIS iron and steel complex. The complex is largely on a care and maintenance basis. As a consequence of these developments, the location retains virtually none of its former natural environment. The use of existing jetty facilities means that there will be no impact on Cockburn Sound from the Cooljarloo Project.

The surrounding land to the north and south for some distance is zoned for industrial purposes and contains the SECWA Power Station, Naval Base and other facilities. The nearest urban area is also at Naval Base (1981 population, 421).

6. ENVIRONMENTAL IMPACTS

6.1 THE COOLJARLOO MINESITE - NATURAL ENVIRONMENT

6.1.1 Landscape

Mining at Cooljarloo will inevitably alter the existing topography in the mine path and other areas required for the operations. The overall rehabilitation objective however, will be to achieve a landscape which, after the vegetation has regrown, cannot be identified as a reconstruction except upon close inspection and which is integrated with surrounding undisturbed land.

Mining will involve the removal for processing of about 5% of the dredged material and the remaining 95% will be placed behind the dredge path for site rehabilitation. There will therefore be no lowering of the landscape except due to deliberate rehabilitation planning. It is the intention that rehabilitation will involve a range of site-compatible landscaping. This will include the construction of dune formations when substantial volumes of overburden are available. The construction of wetlands is also being considered (Sections 6.1.2 and 7.1).

The upper level deposit which will be mined first is on the middle ground of the tenements between 70m and 83m AHD and contains a few wet depressions in the north and a higher dune in the south. The easternmost upper level deposit, which may not be mined for many years (+15 from project commencement), coincides with the foot of the escarpment where the surface ranges above and below the 100m AHD contour. Here the land has a definite but gentle sloping to the west, but there are lower areas which may be drainage channels and wetlands in winter.

The principal mid-level deposit is in the south-western sector of the tenement area where the topography is relatively flat and gently slopes down towards the west and north from the 100m contour in the south to a 72m AHD wetland area in the north. This deposit is traversed by Mullering Brook and a very narrow strip of land slopes towards this watercourse.

6.1.2 Ground and Surface Waters

(a) Surface Hydrology

During the first 2-3 years of operations the mine path will involve the excavation of most of one wetland depression and parts of two others. Subsequently until about year 15, the operations will concentrate on the mid-level deposits in the southern parts of the tenement area. This includes two winter wet depressions in the far south and a section of Mullering Brook.

At this stage, it is not anticipated that the major wetland areas in the north-west section of the tenements, nor those at the bottom of the escarpment, will be substantially affected during the first 15 years of operation. However, should the mid-level and basement deposits in the former section be mined at a later stage, some of these wetlands would be affected.

It will be necessary to reconstruct the course of Mullering Brook after mining to preserve the general drainage pattern, to prevent the uncontrolled dispersion of water, and to prevent potential downstream impacts. A commitment to reconstruct Mullering Brook has also been made because of its significance to Aboriginal people with traditional links to the area (Section 6.2.1). In addition, the reconstruction of swamplands is planned and the development of new wetlands centred on permanent water is being considered (Section 7.2). This will involve reconstruction of impermeable layers such as those which underlie the present perched wetlands. These measures will mean that the present features of surface hydrology can be replaced to a certain extent.

(b) Groundwater

The primary concern relating to groundwater at the minesite is that mining should not seriously affect existing aquifer levels. It is recognised that the hydrological features of the site are likely to be very important to the survival of vegetation in unmined areas. In this respect, it is intended to maintain the water level in the dredge pond so that it is approximately equal to that of the surrounding aquifer. If necessary, borewater will be used for this purpose.

Make-up water demand will vary according to seasonal and other factors, but has been estimated overall at 150L to 450L/sec. It is considered that this quantity is likely to be obtainable from deep bores into aquifers of the Yarragadee Formation which underlie the site. Potable water (<500mg/TDS) has been recorded from exploratory bores in this formation by the Geological Survey of Western Australia (Briese, 1978).

Without such a procedure, any water losses from the pond could initiate flows from the surrounding aquifer and consequential drawdown effects. However, peizometer testing at Cooljarloo has indicated that lateral flow in the aquifer is impeded due to the presence of clay layers and clay fractions in the sandy soils. The likelihood of significant inflow into the dredge pond is therefore not large in any case.

Given the probable availability of water, the overall objective of maintaining aquifer levels and the low permeability of the aquifer, no adverse impacts due to temporary groundwater changes as a result of mining are anticipated.

6.1.3 Vegetation

During the first 2-3 years, mining will concentrate on the relatively narrow upper level deposits in the northern section of the tenement area. Most of this area supports Banksia low woodland which is the most extensive vegetation association on the tenements. The three wetlands which will be partly affected support wetland heath and scrub heath.

The second phase of mining (to approximately year 15) will involve the removal of further areas of Banksia low woodland including a section with Melaleuca preissiana, most of the mixed low heath which occurs in the tenement areas and a section of wetland heath at the northern extremity of mining zone 27,000. However, a substantial part of the operations in this phase will be based on the cleared agricultural land of CG3906.

Phase 3 mining will involve the removal of Banksia low woodland in the north-western part of the tenement area and also wetland heath and scrub heath in the large depressions.

The Xanthorrhoea reflexa low heath, Eucalyptus low woodland and Hakea obliqua scrub which have limited occurrences on the tenement area will not be affected by the proposal.

Three levels of assessment have been made in order to evaluate the potential impact on vegetation described above. These are:

- comparison of the area of each vegetation association potentially affected with the total area of that association on the tenements,
- a survey of land adjacent to the tenements to determine the local distribution of vegetation associations

- an assessment of the occurrence of similar vegetation associations in nearby Nature Reserves and the Badgingarra National Park.

Substantial areas of the major vegetation associations will not be disturbed by the present proposal. It is suggested below that these unaffected areas of vegetation will benefit from the proposal through the introduction of bushfire management practices (Section 7.3).

The impact on the vegetation will be ameliorated by a rehabilitation programme with the principal aim of revegetating disturbed areas with local plant species by topsoil replacement and direct planting (Section 7.2). While it is not claimed that this programme will achieve the full replacement of species existing prior to mining, it is considered that the general features of the vegetation in terms of structure and floristic composition will be duplicated.

Improvements in rehabilitation techniques enabling better replacement of the original vegetation can also be expected during the life of the Cooljarloo mine.

The vegetation of the land immediately east of the Cooljarloo tenements is indicated on Figure 5.3. The structure of this land is significantly different from the tenements because the dominant landform is the Gingin Scarp rather than the Bassendean Sand Formation. As a result, while all of the vegetation associations found on the tenements occur in this area, Xanthorrhoea reflexa low heath and mixed low heath are particularly extensive because of their preference for lateritic soils. Conversely, the wetland associations which are a feature of the Bassendean Sand Formation are less extensive. Wetland vegetation and Banksia low woodland are however, both extensive on the large area of Crown Land to the west of the tenements.

This information indicates that mining at Cooljarloo will involve the removal of areas of vegetation associations which are locally extensive. They are also well represented in existing nearby Nature Reserves and the Badgingarra National Park.

The Wongonderrah Springs Reserve (Conservation of Flora 26248) contains Banksia low woodland typical of the tenement area, and wetland heath with stands of Melaleuca preissiana. The Mullering Brook Reserve (Recreation, Camping and Conservation of Flora 27216) contains all of the vegetation associations found in the tenements except for Hakea obliqua scrub heath, in addition to other associations such as stands of York Gum (Eucalyptus loxophleba) and Wandoo (Eucalyptus wandoo). Xanthorrhoea reflexa low heath is extensive in this reserve and covers about 664ha.

The northern part of the Badgingarra National Park is essentially a vast area of mixed low heath with small patches of Banksia low woodland and Hakea obliqua scrub heath. The vegetation of the southern extension to Wongonderrah Road also has a large area of mixed low heath and extensive tracts of Xanthorrhoea reflexa low heath and Hakea obliqua scrub.

The three levels of assessment therefore clearly indicate that the vegetation that will be removed by mining at Cooljarloo is widespread on the tenement area, on adjacent lands and in nearby reserves.

6.1.4 Vertebrate Fauna

No survey has been made of the vertebrate fauna of land adjacent to the Cooljarloo tenements, nor of nearby reserves. It is suggested however, that the fauna of these localities, and on those parts of the Cooljarloo tenements which will not be affected by mining, is likely to be very similar to that of the areas proposed for mining. This claim is made on the basis of the similarity of vegetation associations (which are a major element of fauna habitats) of the various localities and their proximity to each other. It is possible that the vertebrate fauna is more diverse and has larger species populations in parts of the nearby areas because of longer intervals since they were last burnt. Frequent fires are however, characteristic of the recent history of the whole local area.

On a basis of regional comparisons, the Cooljarloo tenements are considered to be depauperate in vertebrates relative to sites surveyed elsewhere on the Swan Coastal Plain (Dunlop and Bamford 1987).

It is expected that ground-dwelling vertebrates such as amphibians, reptiles and small mammals in the mine path will largely be destroyed by site preparation although some will survive in the harvested vegetation or will move to adjacent undisturbed areas. Birds will not be directly affected, but will suffer loss of habitats and, in some species, displacement from territories. Behind the mine path, vertebrate recolonisation can be expected as revegetation proceeds and replacement of most vertebrate species is likely to occur eventually. Certain rehabilitation measures such as the replacement of dead logs will be implemented specifically to assist this process by providing specialised habitats which otherwise would take some years to develop. It is also intended to establish a study programme to monitor recolonisation and to provide information about vertebrate niche requirements (Section 7.2).

The potential exists for increasing the diversity and populations of materials at Cooljarloo. At present, all water bodies on the site are seasonal and generally dry by early January. The ecological benefits arising from creating some permanent water bodies behind the mining front have been considered (Dunlop & Bamford 1987, Sections 6.2 and 6.4).

6.1.5 Fire Regime

A beneficial change in the present fire regime at Cooljarloo will occur as a result of environmental management policies associated with the present proposal. In particular, the present frequent occurrence of wildfires will be replaced by a fire management plan which seeks to achieve a relatively long period between fires at any specific location in the unmined areas, and to protect rehabilitating areas from fire. This fire management programme will extend to nearby areas and will be carried out in conjunction with chopped mulch harvesting along firebreaks.

It is expected that the programme will lead to greater plant and animal diversity on the tenements and nearby localities. Such changes in community structure are typical in vegetation/habitat complexes as the time since the last fire increases.

6.2 THE MINESITE-SOCIAL ENVIRONMENT

6.2.1 Aboriginal Sites

The mine plan at Cooljarloo involves disturbance to Mullering Brook which is a significant site to Aboriginal people with traditional links to the region. TIO2 Corporation NL recognises the importance of this impact, and has therefore held on-site discussions with elders and other representatives of the Aboriginal community in order to determine a policy on the matter. The Aboriginal community has indicated during those discussions that the course of Mullering Brook should not be permanently disrupted by mining but that they are prepared to accept temporary disturbance provided that the watercourse is restored. A commitment has therefore been made to replace the watercourse during site rehabilitation and specific landscaping will be implemented to re-establish a natural appearance.

An application to disturb an Aboriginal site has been made to the Western Australian Museum under the provisions of the Aboriginal Heritage Act, 1972-1980 and permission has been granted by the Minister for Aboriginal Affairs.

The artefact scatter located near Mullering Brook will not be disturbed by the proposed mining activities.

6.2.2 Land Use

Mining at Cooljarloo is not expected to affect contemporary land use in the longer term. The disturbed areas will be rehabilitated and returned to natural vegetation in the case of the Vacant Crown Land and to agricultural production in the case of CG3906. Commercial picking of wildflowers and use by apiarists will be allowed to continue and may be facilitated through the provision of better tracks.

The mining will also not impinge negatively on current land use nearby as the mining activities, apart from the supply of electricity and transport, will be restricted to the tenement area.

However, parts of tenements M70/132 and M70/283 overlap with part of the proposed extension of Badgingarra National Park as described in Section 5.2.2. TIO2 Corporation NL recognises that mining could reduce the natural value of this area (notwithstanding successful rehabilitation) and that therefore a proposed land use could be affected. On the other hand, denial of access would seriously affect the available resource and would reduce the viability of the project. The company has therefore sought the opinion and direction of State Government on this matter.

The overlap area of some 678ha in extent could be up to 80% disturbed by mining on current knowledge of the mineral sands deposits. The vegetation associations present are typical of the tenement area generally and the conclusions about local significance in Section 6.1.3 apply. The extent of each vegetation association in the overlap area is:

- Banksia low woodland, 547ha
- Wetland heath, 71ha
- Xanthorrhoea reflexa low heath, 20ha
- Mixed low heath, 37ha
- Hakea obliqua scrub heath, 3ha.

A specific botanical survey of the overlap area has been made in order to locate any plants of particular interest.

Rye and Hopper (1981) list 16 gazetted rare species found in the Moora Wildlife District, which includes the Cooljarloo area. From the localities and recorded habitats of these 16 species held at the Western Australian Herbarium, it was concluded that possibly three could grow within the overlap area:

- Spirogardnera rubescens, recorded from lateritic heath in the Badgingarra area.
- Urocarpus phebalioides, recorded from a gravel pit in the Cataby area.

- Grevillea saccata recorded from an area of mixed low heath south of Cooljarloo Road during the 1986 Cooljarloo Vegetation Survey.

In the survey, special attention was given to the lateritic area and the areas of mixed low heath as it seemed possible that the above named species might grow there. The Banksia low woodland and the Hakea obliqua scrub heath were also examined for any species of interest. Low priority was given to wetland areas because none of the gazetted rare species have been recorded from wetland environments.

A large section of the south-east of the overlap area was burnt during April 1986. Regeneration is occurring but the overall biomass is much reduced here. Also, considerable sections of the northern part of the overlap area had been burnt more recently, presumably during March 1987. In places no new growth was apparent and species recognition was virtually impossible.

Two gazetted rare species were found:

- Grevillea saccata: Ten specimens are growing at five localities in the central area of mixed low heath. The association here includes scattered Banksia prionotes, B. attenuata and B. candolleana. Shrub species present include Conospermum stoechadis, Dasypogon bromeliifolius, Hakea costata, H. prostrata and Jacksonia spinosa. Grevillea saccata also grows outside the overlap area in the mixed low heath to the south of Cooljarloo Road.

- Stachystemon axillaris: Twenty-four specimens are growing at six localities in the Banksia low woodland in the unburnt northern part of the overlap area. Banksia species present are Banksia attenuata and B. menziesii; shrub species include Adenanthos cygnorum, Dasypogon bromeliifolius, and Leucopogon conostephioides. Stachystemon axillaris had not been found during the 1986 vegetation field work on the mining leases.

Marchant and Keighery (1979) have listed poorly collected and presumably rare vascular plants of Western Australia. None of the species in their list of those considered to be rare occurs in the overlap area.

Of those species which have a restricted distribution (those occurring between localities less than 100km apart), only one was found within the overlap area - Isopogon adenanthoides. This grows occasionally in the Xanthorrhoea reflexa low heath. It is a species typical of this association on laterite, and probably grows in similar localities on the Gingin scarp outside the overlap area.

Other species regarded as partially more or less restricted (known only to occur between localities less than 160km apart) were found growing in the overlap area. These are:

Verticordia grandis and Conostylis juncea, both growing in the Banksia low woodland, and relatively common inside and outside the overlap area; Banksia candolleana, growing in the mixed low heath and well represented in other areas of similar vegetation outside the overlap area; Banksia telmatiaea, growing in the wetlands and common in other wetlands outside the overlap area; and Isopogon linearis and Scholtzia teretifolia, both growing occasionally in the Xanthorrhoea reflexa low heath. The extent to which these latter two species occur outside the overlap area is not precisely known.

Some species are poorly known on the basis of having less than five herbarium collections. Rarity is not implied; it is likely many of the species in this category are widespread, although it is probable some will prove to be rare or restricted when more data are available. Two species from the overlap area fall into this category. Leucopogon leptanthus and Tetraria octandra both grow occasionally in the Xanthorrhoea reflexa low heath. The distribution of these two species on other lateritic areas outside the overlap area is not known.

TIO2 Corporation NL believes that it would be appropriate for the EPA to consider excising the overlap area from its recommended extension to Badgingarra National Park. The extension area is intended to provide:

- a link between existing reserves,
- a long continuous strip of roadside vegetation along the Brand Highway, and
- an addition to the existing local reserve system.

The first two of these features would not be affected by the suggested excision and the company believes that the potential loss to the local reserve system could and should be compensated for by an addition of a larger area of land to the proposed extension.

The biological surveys commissioned by TIO2 Corporation NL indicate that an addition involving Vacant Crown Land between the tenements and the proposed extension area could include the major vegetation associations in the overlap area except for the Xanthorrhoea reflexa low heath found on the Gingin Scarp. This association is very extensive in the Badgingarra National Park. It is reasonable to assume that the species of particular interest listed above may also occur in this area. The proponents are prepared to commission a survey to determine whether this is the case if requested.

6.2.3 Local Demography

It is generally recognised that the most important factor determining the social impact of a project is the size of the workforce which relocates into the local area close to the development site (Dames & Moore, 1985). The local area is usually defined as being within 60km (or 40 minutes commuting time) of the workplace. At Cooljarloo this 60km road distance includes Cataby, Dandaragan, Badgingarra, Cervantes and Jurien.

These towns and nearby farming properties can be expected to supply a certain proportion of the Cooljarloo workforce from present residents, but it is expected that some workers may come from outside the local district. The proportion of locals to non-locals employed on new projects in the south-west of Western Australia is assumed to be 60:40 (Dames & Moore, 1985). These proportions apply not only to the workforce directly employed by a project, but also to consequential employment generated by the general economic stimulation that a new project brings about.

Again, estimates of consequential employment in the south-west vary with the locality involved and the nature and scale of the development. Multiplier estimates range from 2.14 to 3.15, ie each job on a project will generate between 1.14 and 2.15 consequential jobs. The relatively small scale of employment at Cooljarloo suggests that a small multiplier is appropriate.

An estimated 42 people will be directly employed at the Cooljarloo minesite. Assuming a multiplier of 1.14, provides an estimate of 90 total jobs generated by this part of the project [42+(42x1.14)]. Of these, 54 (60%) are predicted to be taken by locals and 36 by non-locals. At the minesite itself, 25 (60%) of the 42 workers are expected to be locals and 17 non-locals.

The proportion of non-locals expected to take up long term residence in the local area is assumed to be 50% with the remaining 50% either employed in flow-on jobs outside the area or commuting from elsewhere. On this assumption 18 people will move into the local area and about 8 or 9 of these will be directly employed at Cooljarloo.

It is further assumed that the proportion of this labour force that will be married will be in the order of 65% (12 people) and that the average family size will be 3.3. Therefore, the total population inflow caused by the Cooljarloo project is predicted to be 45. No attempt has been made to allocate these people among the various local towns but it can be expected that Cervantes and Jurien may be favoured because of their coastal location, and Dandaragan because of its proximity.

The estimated number of migrants into the local area given above is not large. As a consequence, it is considered that no special provisions in terms of community needs (eg town planning, housing, service, educational and other facilities) will be required. A small accommodation facility will be built at Cataby for non-local and local workers who may wish to commute on a weekly rather than daily basis to the minesite. This is not expected to contain more than 20 units and it will be completely self-sufficient in terms of services.

6.3 THE DRY PROCESS PLANT (MUCHEA) - NATURAL ENVIRONMENT

6.3.1 Site Preparation

Site preparation at Muchea will involve little more than levelling. The actual amount of earthworks will be relatively small because of the general flatness of the site. It is intended that the plant itself and associated works such as the TIO2 Administration Centre, railway siding, storage facilities and workshops, will all be built in the western half of the property closest to the Brand Highway. Most of the older trees on the site are located in the eastern half and the development plan will enable most, if not all, of these to be retained. The eastern half will also act as a buffer between the plant and Ellen Brook which runs along the eastern boundary of the property.

6.3.2 Ground and Surface Waters

It is intended to obtain the Muchea plant water supplies from groundwater at the site. The predicted demand is 300kL/day. It is proposed to draw this from a bore tapping the sands low in the "Superficial Formations" or within the Osborne Formation. An assessment has been made of the interference drawdowns which might be expected to be induced in pre-existing neighbouring bores by adopting values for aquifer hydraulic properties and assuming radial flow to the pumping bore (Table 6.1). This assessment found that insignificantly small drawdown would be caused. At 200m the drawdown might be about 1.5m after six months, or about 0.9m at 1km radial distance. This suggests that:

- The abstraction rate envisaged would have minimal effect on other uses of the resources.
- There would be little or no appreciable effect on the overlying water table as the aquifers would not be in full hydraulic connection and induced leakage would be expected to be slight.
- The aquifer developed for supply would be remote from any risk of surface contamination whether accidental or malicious.

TABLE 6.1

EXAMPLES OF DISTANCE DRAWDOWN ESTIMATES FOR THE MUCHEA PLANT

ABSTRACTION RATE: 300kL/d
DURATION OF PUMPING 6 MONTHS

Aquifer Properties			Drawdown at Distance r	
Transmissivity (m^2/d)	Specific Yield (%)	Storage Co-efficient	r = 300m	r = 1km
75m^2/d	25%	-	0.10m	*
75m^2/d	-	10^{-4}	1.85m	1.10m
100m^2/d	25%	-	0.15m	*
100m^2/d	10%	-	0.35m	*
100m^2/d	-	10^{-4}	1.50m	0.90m
500m^2/d	-	10^{-4}	0.40m	0.25m
750m^2/d	-	10^{-4}	0.30m	0.20m
1,000m^2/d	-	10^{-4}	0.20m	0.15m

* negligible effect

It is proposed that wastewater and sewage would be disposed of via a septic tank with a leach drain system. It is estimated that sewage derived from plant operations would become 5 to 6kL/day, equivalent to the sewage production of about 10 or 11 domestic households. Leach drains are liable to release dissolved nutrients which would either be intercepted by the roots of plants, adsorbed by soil or would reach the water table and be incorporated into the groundwater beneath the site.

Table 6.2 presents calculations estimating the nutrient load which might be released from the proposed sewage disposal system's leach drains. The contamination which might be expected to result would be largely diluted and dispersed so that insignificant levels of nutrient contaminants would be expected within a short distance of the point of discharge.

6.3.3 Vegetation

The existing natural vegetation at the Muchea site will be substantially unaffected by the development as it is the intention to retain as many of the remaining shade trees as possible. In this respect, the company intends to prepare a vegetation assessment of the site as a first step in detailed site planning.

The increased rainwater run-off from the buildings and vehicle areas will be absorbed to some extent by ornamental and screen plantings of trees and shrubs in the western section of the property. The balance of the surface run-off will be dispersed by surface drains.

6.3.4 Vertebrate Fauna

The value of the Muchea site to vertebrate fauna lies mainly in the large trees which are probably used by various bird species for roosting and nesting. As the site development plan aims at retaining these trees the vertebrate fauna values are not likely to be affected. Landscape plantings around the Administration centre and elsewhere are expected to increase the range of food items available to birds and therefore the number of species using the site is expected to increase.

TABLE 6.2

ESTIMATION OF THE NUTRIENT CONTRIBUTION TO GROUNDWATER FROM THE PROPOSED SEWAGE DISPOSAL SYSTEM

(a) NITROGEN

Estimated annual production at the site: 100kg.

This is equivalent to 443kg of nitrate since it may be anticipated that the nitrogen would be oxidised (ammoniacal nitrogen would be oxidised to nitrate oxygen).

Some of the nutrient would be retained in the septic tank sludge, whilst say 75% would be discharged to the ground.

Plant roots could intercept some of the nitrogen, however, should all this 75% reach the shallow groundwater together with rainwater and run-off infiltrating into the 40ha site (estimated to be some 100mm/yr) then the dilution of nitrate would produce on average a nitrate concentration in the recharging water of about 8mg/L.

(b) PHOSPHORUS

Estimated annual production at the site: 30kg.

Phosphates would tend to be adsorbed by the soil, especially by the more clayey soil to be met with at the site, and some would be taken up by plants via their roots.

In the very long term it may be that some phosphorus would contaminate the shallow groundwater.

Estimating in a similar manner to that used above for nitrate, this might result in some 0.76mg/L phosphates on average in the recharging water.

6.4 THE DRY PROCESS PLANT (MUCHEA) - SOCIAL ENVIRONMENT

6.4.1 Aboriginal Sites

The Muchea site has no known archaeological sites and is not considered to be of significance to contemporary Aboriginal peoples (Section 5.4.1).

6.4.2 Land Use

It is the intention of the Shire of Chittering to zone the Muchea site and adjacent properties for industrial purposes. This intention pre-dates and is not motivated by the TIO2 proposal, but is part of the long-term Shire development plan. One of these properties is currently being used for industrial purposes by Black Granite. The TIO2 project will not affect industrial use of other properties nearby and will not restrict future use of the site itself for industrial purposes after the dry process plant has been decommissioned.

Agricultural properties occur immediately to the north and west of the Muchea site. These are used predominantly for the grazing of cattle and there is absolutely no reason why this use should not continue during operation of the dry process plant.

6.4.3 Local Demography

The Muchea plant and administration centre are expected to employ 66 people. Therefore, assuming a conservative multiplier of 1.14 (see Section 6.2.3), a total of about 141 jobs will be created by this part of the project and associated economic stimulation. It is expected that all of these permanent positions will be filled by local people as the northern part of the Perth Metropolitan area is within the 60km commuting distance generally used to define the local area (Section 6.2.3). The TIO2 construction workforce is also expected to come from this area.

The project however, can be expected to cause some relocation of residents within the local area given the availability of land in the Chittering Valley and at estates such as Brigadoon which offer the attractions of a premium rural environment. These and other similar locations are relatively close to Muchea and employment nearby is likely to be a further inducement for people to move from the Metropolitan area.

Urban housing and allotments could also be available in Muchea and Gingin, and especially in Bullsbrook. At present, Bullsbrook is virtually dependent on the presence of the RAAF at Pearce. The town's Structure Plan however, regards it as essential that this dependence be removed by broadening the area's economic base through the introduction of new employment industries. The TIO2 project would enable this objective to be at least partly achieved.

Nevertheless, a significant number of persons are expected to commute from the Metropolitan area each day despite the opportunities to relocate. Also some of the consequential employment is likely to be within the Metropolitan area rather than close to Muchea.

The availability of land in the Shires of Chittering and Swan and the relatively small scale of relocation to the district suggests that no special planning requirements will need to be implemented.

The Shires of Chittering and Swan have been informed of the project and are keen to see it proceed.

6.4.4 Aesthetics

The dry process plant will constitute a significant change to the existing rural landscape of the Muchea site. The main building of the plant will be some 40m in height and there will be various storage bins, a railway siding and other features which will all be evident from the Brand Highway next to the site and, to some extent, from further afield. The plant will however, be clean and there will not be large open mineral stockpiles or any of the debris sometimes associated with industrial sites. Overall, the proponents consider that the Muchea plant, while having a different aesthetic to a rural landscape, will not be unattractive and it is their intention to operate it as a model mineral sands facility. The retention of mature trees on the site and some landscaping will help to moderate the visual impact of the plant.

6.4.5 Transport

Transport of wet concentrate from Cooljarloo to Muchea and the return of wastes will require one road train per hour in each direction on a continuous basis. The Brand Highway is the major route to Geraldton, Carnarvon, the Pilbara and the far north of Western Australia. It carries large numbers of road trains at all times of the day and night as a consequence. The section between Muchea and Cooljarloo also does not pass through any towns. The relatively small increase in traffic associated with the present project will not therefore have any adverse social impact.

6.5 THE PORT (KWINANA)

The Kwinana site will be used for temporary storage of minerals prior to shipment. It is developed and much of the necessary infrastructure such as railway lines, jetty and conveyor belts are in place and were used previously for the receival of iron ore from Koolyanobbing. The area is zoned industrial and is relatively remote from urban areas. Only one person will be permanently employed at the site.

The previous development of the Kwinana site indicates that its use by TIO2 for the Cooljarloo Project will have no impact on the existing natural or social environment.

7. ENVIRONMENTAL MANAGEMENT AND MONITORING PROGRAMME

7.1 INTRODUCTION

The principal concerns of environmental management for the Cooljarloo Project are the rehabilitation of mined areas, fire management in the tenement area, and radiation protection in the production, handling and transport of monazite. These matters are discussed in detail below.

A large number of other issues related to environmental management will also have to be addressed during the detailed design, development and operational phases of the project. The majority of these however will be matters of standard practice or of a minor nature, such as general site housekeeping to maintain efficient and tidy operations at Cooljarloo and at Muchea, the design of roads, landscape plantings at the Muchea site, and so on. These are not addressed here but will be the subject of discussions with, and reports to, State Government authorities as the project evolves.

7.2 MINESITE REHABILITATION

7.2.1 Objectives

A general rehabilitation model has been developed which allows for variations according to the terrain being mined and the objectives of the rehabilitation programme. The principal terrain distinctions are:

- The comparatively well drained soils and slopes of the Banksia low woodland association.
- The poorly drained soils and drainage areas of the wetland heath association.

The general objectives of the rehabilitation programme are:

- The duplication as near as possible of the original native vegetation associations.
- The creation of a functional pasture where pasture existed before mining.
- The possible modification of some rehabilitated wetland heath areas so as to include permanent bodies of water suitable for waterbirds.

Approximately 80% of the total area to be mined over the full term of the project will be rehabilitated to native vegetation. Within such areas, further objectives will be to:

- Fill and contour the mined areas to similar topography and soil conditions to those which existed in the natural state prior to mining.
- Ensure the establishment of the pre-mining drainage system after the completion of mining.
- Stabilise all new land surfaces against water and wind erosion using both physical and biological methods.
- Establish an indigenous native plant succession designed to produce an ecosystem as close as possible to that which existed under pre-mining conditions.
- Reduce all roads and tracks to the minimum required for ongoing rehabilitation work and monitoring programmes.

The general rehabilitation model will also be adapted to suit the different mining methods used for:

- The upper level strands such as Zone 13000, where the mining pit will vary in width to cover the whole strand and be of shallow depth ranging from 6-13m.
- Mining mid-level strands and basement deposits. For the mid-level Zone 27000 and probably most of the others, this will require deeper pits (averaging 30m depth) of fixed width and parallel mine paths. This will present scope for the direct lateral movement of plant material and topsoil.

The rehabilitation programme for the upper level Zone 13,000 has been defined in some detail and is presented below. This programme will cover the first 2-3 years of mining.

The programme for the mid-level Zone 27000 and the later mid-level strands and basement deposits will conform to the same basic model with respect to the rehabilitation aims and the final landform results. However, the methods adopted will vary according to the future improved definition of the deposits and the mining methods considered necessary. Future rehabilitation programmes will also be influenced by the application of results from field monitoring studies and trials.

7.2.2 Pre-Mining Plans

The general approach to mining and site restoration prior to rehabilitation has been described in Section 4.1.7. In practice, this basic model will be adapted so as to achieve a variety of landform and soil conditions similar to those in the pre-mining landscape. In order to achieve this a detailed study of each of the ore deposits will be made prior to mining. This will include:

- A soil profile analysis.
- A large-scale topographical map extending to areas next to the orebody.
- A detailed vegetation map of the orebody including vegetation boundaries and densities and information on the presence of any unusual species.

This information will be used for detailed rehabilitation planning and in particular to determine respectively:

- Tailings disposal and the placement of slimes (post mining soil profile).
- Post mining contours and surface drainage.
- The ultimate vegetation types and species composition intended for each site after mining.

7.2.3 Topsoil Removal and Storage

Over Zone 13000, topsoil will be removed in front of the mine path with two separate cuts using a conventional earth scraper. The first of these will remove about the first 5cm of soil and most of the vegetation and leaf litter etc. Only the trees and large shrubs will be removed separately as these are beyond the capacity of scrapers (see Section 7.2.8). The depth of the second cut will depend on the soil profile, but is expected to generally be about 20cm. The first and second cut material will be stored separately in the topsoil stockpile areas beyond the vegetation buffer adjacent to the mine path. As Zone 13000 will be mined relatively rapidly, topsoil storage times will be short.

7.2.4 Topsoil Replacement

Site restoration behind the dredge pond will typically involve the disposal of slimes into pits where they will be allowed to dry thoroughly before being covered with at least 1m of sand (Section 4.1.7). This approach is designed to provide reasonable sub-soil conditions for the development of deep-rooted plants. In situations where wetlands are to be created however, a slimes layer may be retained closer to the final soil surface to provide a relatively impermeable stratum which will promote waterlogging. A schematic plan of such a wetland, but with the addition of permanent water, is shown in Figure 7.1.

Dried and broken-up slimes material may also be placed on top of the sand layer in non-wetland areas, to increase the clay content in the subsoil. This technique has been found to increase the survival rate of seedlings in rehabilitation areas at Eneaaba due to improved sub-soil moisture retention during summer.

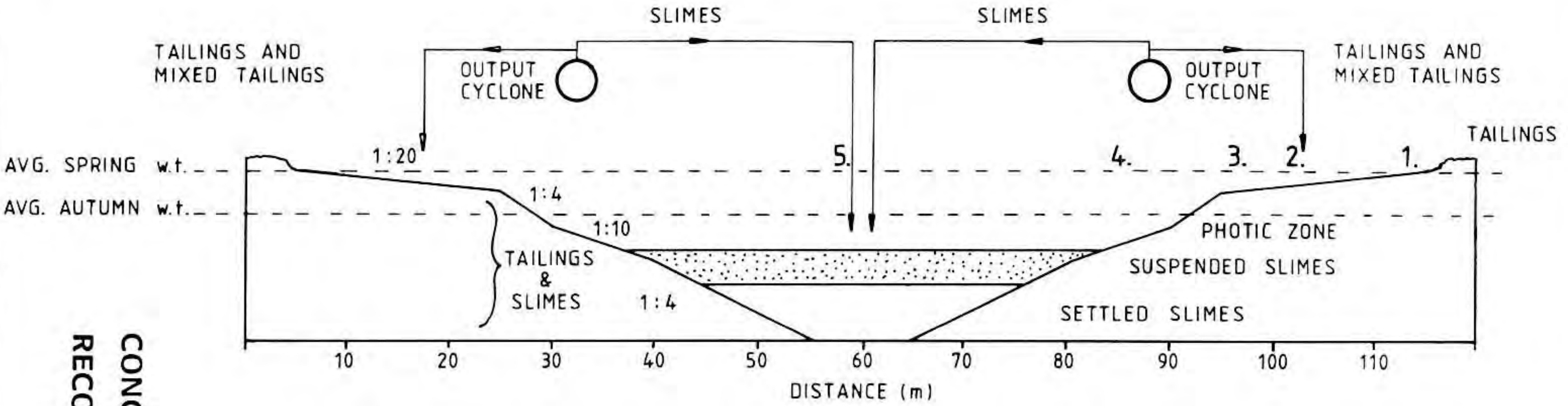
Once the sub-soil conditions are considered to be satisfactory, a second-cut topsoil layer will be replaced using stockpiled materials spread by scraper and then the final first-cut topsoil will be laid. This double-cut method of topsoil removal and replacement has been shown in Western Australian conditions to give a much higher level of plant productivity during rehabilitation than the removal and replacement of the top 25cm of soil as a single unit. This is because seed material and organic matter which occur in the first 5cm or so of soil, are replaced close to the surface rather than being mixed into a deeper soil profile. The method also produces less drying out or crusting of the soil surface and reduces soil losses due to wind erosion.

Replacement of the final topsoil will occur only between early November and late June when the later conditions for germination and seedling survival are optimal.

7.2.5 Cultivation

In normal circumstances all cultivation will occur after final topsoil replacement and in the period from January to June. The only exception may be on sloping sites where some treatment is required to prevent soil erosion due to surface run-off. The actual nature of cultivation treatment will depend on soil type, soil condition, and prevailing weather, but could include:

- Ripping or chisel ploughing through second cut topsoil to break up underlying slimes layers.
- Light cultivation through both layers of topsoil using chisel pointed tines.



LEGEND

1. EUCALYPTUS RUDIS, MELALEUCA SPP.
2. WETLAND HEATH
3. SEDGE ZONE
4. ROOTED AQUATICS
5. PHYTOPLANKTON

CONCEPTUAL DESIGN OF RECONSTRUCTED WETLAND

FIGURE 7.1

- Levelling using a tractor towed grader or offset disc harrows.
- Light discing and harrowing inherent in the use of a trash disc seeder.

7.2.6 Seeding

Although the replaced topsoil will contain a reservoir of seeds and other plant propagules, it will be necessary to supplement this with a direct seeding programme in order to quickly stabilise the topsoils and to improve levels of native plant growth. Therefore, after cultivation, direct seeding and fertilising will occur aimed at:

- The establishment of a cereal cover crop to protect the topsoil for the first two years.
- Initiating the spread of quick-growing native shrubs and ground covers.
- Encouraging a diverse flora.

The cover crop will consist of Sudax applied at a rate of 2kg per hectare from January to March and cereal rye (Secale cereale) applied at a rate of 1kg per hectare maximum from April to June. Sufficient irrigation of the former will be supplied to establish the crop to a height sufficient for soil protection.

The native plant seed mix will be collected on site and especially from areas to be cleared for mining. As mining and monitoring of rehabilitation progress, special emphasis will be given to the collection of seed from any species which are showing reduced abundance in the rehabilitation areas. Development of seed production plantings is also being considered to facilitate seed collection, and seed cleaning and treatment facilities will be established.

7.2.7 Nursery Stock Planting

Nursery stock production for use on the rehabilitation blocks will use seed or other propagules collected from the site. Regular production will principally be of trees and larger shrubs. There will also be a research phase concerned with any rarer species that were shown by the monitoring programme to be deficient in numbers in the rehabilitation blocks. Field planting will generally be in the May-June period.

The planting requirements at Cooljarloo will be:

- Small trees and large shrubs (eg, banksia and eucalypts) to make up plant densities to those commonly encountered in low woodlands and scrubs.
- To mark block boundaries with quick-growing shrub and tree plantings, At some borders, where wind exposure is marked, such planting could be supplemented with a wind break fence.
- Windbreaks, screen trees and some ornamental shrubs.
- Rare native plants and others that might not propagate from field practices.

7.2.8 Brush Matting and Chop Mulching

Both treatments of rehabilitation areas will be used in addition to direct seeding and planting to promote regeneration of native plants. Apart from providing a further seed source, these techniques also reduce the potential for wind and water erosion, increase the available nutrients, and provide some shelter and habitat for fauna.

Brush matting involves the placement of entire branches of larger shrubs and trees directly onto the rehabilitation areas. At Cooljarloo, this will be the preferred method for treating larger plants from areas directly in the mine path. Alternatives are to burn the felled material prior to topsoil removal, or to chip it prior to respreading. These alternatives however, are less likely to promote recolonisation by fauna. After the trees and large shrubs are removed, the remaining vegetation can be harvested together with the first-cut topsoil using a conventional scraper.

The vegetation may also be stripped and collected for respreading using a heavy duty forage harvester. In this case, the process is known as chop mulching. The technique is very suitable for heath vegetation but is less applicable where plant stems exceed 5cm in diameter such as the banksia woodlands at Cooljarloo. However, it may have application in the collection of plant material from firebreaks where the topsoil is to be left in place and where earthmoving equipment could cause unnecessary impact. This would provide a useful source of mulch for the retreatment of any rehabilitation sites showing evidence of uneven regrowth.

7.2.9 Treatment of Weeds

Low density occurrences of many agricultural weeds in the early stages of the rehabilitation succession can be ignored. These succumb to competition from the native plants as the latter establish and grow, and the plant nutrients supplied in the initial fertilising diffuse through the soil profile.

However, there sometimes remains a "hard core" of persistent weeds such as Veldt grass (Ehrharta calycina) or Doublegee (Emex australis) that have to be removed by hand or spot-sprayed. If present, these weeds require a labour intensive effort for their removal during late winter and early spring prior to flowering.

7.2.10 Monitoring Studies

Long term monitoring studies will be established to measure vegetation and fauna recovery. The sampling design for these studies will be determined after discussion with State Government agencies but it is envisaged that the vegetation assessment would be based on quadrat sampling of areas before and after mining and of unmined areas, and that the following variables at least will be measured on a periodic basis:

- total plant cover
- plant density for all plants and for selected individual species
- species number

The vertebrate fauna studies will include the establishment of a grid of pit traps on the rehabilitation area and an unmined control site. The traps will be uncovered and drift fences erected for four consecutive days and nights each season and will be checked on a four hourly schedule. The species and number of all animals trapped will be recorded and individuals will be marked prior to release.

Assessments of the bird communities of rehabilitation and unmined areas will also be made using standard fixed transect census methods. Studies of the niche requirements or of food items (such as invertebrates) may also be made for individual species which fail to recolonise the rehabilitation areas. The objective will be to find methods of improving the suitability of such areas as fauna habitats.

The results of these ecological studies will be presented as regular reports to the Environmental Protection Authority, Department of Conservation and Land Management and the Department of Mines (Rehabilitation Section).

In addition to the above monitoring studies, TIO2 Corporation NL will also encourage research at Cooljarloo by academic institutions and others with interests in the site restoration and rehabilitation methods.

7.3 FIRE MANAGEMENT AT COOLJARLOO

The frequency of bushfires in the Cooljarloo area and the probable negative effects that this has had on flora and fauna have been described in Section 5. The Cooljarloo Mineral Sands Project will enable this pattern of frequent fires to be replaced by a comprehensive fire management plan for the entire tenement area designed to promote ecological diversity and stability and to protect rehabilitation areas.

The fundamental objective of this management programme will be to exclude fire from as much as possible of the natural vegetation on the tenement area during at least the first 15 years of mine operation. To achieve this, the area will be divided into blocks each of which will be surrounded by a firebreak system. Each firebreak will incorporate a track flanked by strips of land from which the low shrub vegetation has been harvested (Section 7.2.8). As far as possible these breaks will be based on survey lines installed for mineral exploration and other purposes, so as to restrict environmental damage.

Should a fire exclusion policy prove difficult to apply in practice to such a large area, the system will be modified to include fuel reduction burning of selected areas. Again however, the objective will be to protect as much of the area as possible from fire.

Certain minesite personnel will be trained in fire fighting techniques and a fire-truck and other firefighting equipment will be maintained on-site. This crew will carry out any fuel reduction burns and will endeavour to put out any spot fires due to lightning strike or other event, or to contain any fire within the boundary of a single management block. It will also be available to fight bushfires elsewhere in the district and to assist in the implementation of fire management plans in the nearby reserve system.

7.4 RADIATION PROTECTION

7.4.1 The Need for Radiation Protection

The principal sources of radiation in minerals sands derive from natural thorium which is associated with monazite mineralisation.

Natural uranium also occurs within the mineral sands but at low concentrations. While it is necessary to note the potential contribution from the uranium source, it is generally so low as not to warrant routine inclusion in effective radiation dose equivalent calculations. Thoron and radon gases emitted as a result of the decay of both thorium and uranium are also generally insignificant contributors, because of their relatively short half life in the case of Rn-220 (thorium derived) and the low concentration in the case of Rn-222 (uranium derived). However, build up of thoron and radon gases and their daughters needs to be prevented by the provision of good ventilation particularly in monazite bulk storage areas.

Workers in the mineral sands industry may be exposed to ionising radiation from outside and inside the body. The dose received is determined, among other things, by its duration and the activity of the material being mined or processed. External exposure results from beta or gamma radiation, the dose being influenced by distance from the source. Internal exposure from alpha particle emissions and beta and gamma rays will occur if radioactive material is inhaled or ingested, the dose depending upon the method of intake and its retention in the body.

Inhalation is affected by the nature of the dust aerosol and ingestion is affected by the occurrence of surface contamination. Retention is governed by the half life of the radioactive species and by physiological and metabolic processes. Workers may therefore be exposed to ionising radiation in various ways and to various degrees and it is essential to afford them an appropriate standard of protection against exposure.

7.4.2 Standards and Guidelines

Effective protection from harmful radiation in the mineral sands industry can be achieved by specific plant and process design measures, through dust control and work practices, and the strict maintenance of standards designed to limit exposure levels. In Western Australia, such matters are currently defined under the Mines Regulations Act Regulations through the Code of Practice on Radiation Protection in the Mining & Processing of Mineral Sands (1982). The Mines Regulations Act Regulations allows individual standards within this Code of Practice to be amended from time to time. As an example, the standards applying to Th-232 concentrations in airborne dust have been made more stringent.

It is anticipated that by 1988, the Western Australian Code will be replaced by the Commonwealth Code of Practice on Radiation Protection in the Mining & Milling of Radioactive Ores which has recently (1986) been issued in revised draft form. This Commonwealth Code has been used as the basis for planning for the present project as it is expected that its standards will apply well into the production period. The proponent will also be required to comply with formal variations to standards as they arise during the life of the project.

The philosophy of radiation protection from which the Commonwealth Code of Practice is derived is based on the recommendations of the International Commission on Radiological Protection and endorsed by the National Health and Medical Research Council of Australia. The Commonwealth Code sets different limits of annual exposure arising from project operations for employees and the public. These are expressed as an annual committed effective dose equivalent of 50mSv (milli-sievert) and 1mSv respectively. In addition the Code of Practice requires that all exposures shall be kept as low as reasonably achievable, with economic and social factors taken into account.

These considerations are firstly designed to ensure that the risk of employee mortality associated with an average exposure from radiation is commensurate with that experienced in other occupations having high safety standards (a rate of 1 in 10,000 per year is adopted). Secondly the limit for members of the public addresses a corresponding average risk of between 1 in 100,000 and 1 in 1,000,000, the consequences being in practice virtually undetectable in small populations.

Two other sets of draft Guidelines have also been used in developing the radiation protection programme described below. These are the Assessment of Doses and Control of Exposure to Meet the Radiation Protection Standards, and Implementation of Dust Control Strategies in the Mineral Sands Industry.

7.4.3 Regulatory Responsibilities

The Western Australian Environmental Protection Authority will be responsible for providing initial advice to the Western Australian Government on radiation protection measures in the Cooljarloo Project, through the ERMP process. The Department of Mines will then place conditions on the production licence prior to the actual commencement of operations.

These conditions will require adherence to the Mines Regulations Act Regulations, which in turn are likely to require adherence to the Commonwealth Code of Practice. The Department of Mines will then become the formal regulatory body to which the proponent must report. Representatives from the Department will as a matter of routine, conduct their own surveys of the operations as well as reviewing data provided by the proponent.

In addition the Mines Radiation Safety Board, comprising representatives of employees, operators and radiation protection specialists will be responsible for providing advice on radiation safety matters directly to the Western Australian Minister for Minerals and Energy.

For its part, TIO2 Corporation NL will appoint a Radiation Safety Officer who will be responsible to the Operations Manager for the conduct of day to day radiation protection. The Operations Manager carries the formal responsibility to the Department of Mines for the proper conduct of the operations.

7.4.4 Classification of Employees and Working Areas

The Commonwealth Code of Practice, together with its guidelines, provides for a system of employee classification which influences both the work practices set in specific operations areas and radiation and dose assessment procedures. In summary the Commonwealth Code defines employees as either designated or non-designated, the latter being confined to those unlikely to be directly involved with significant radiation sources. Designated employees are further sub-divided into Working Conditions A (where their exposure might exceed three-tenths of the annual effective dose equivalent limit) and Working Conditions B (those where the exposure might exceed one-tenth of the annual limit).

In the Cooljarloo Project, operations areas will be designated as 'Controlled' where access is strictly limited on the basis of functional requirements, and 'Supervised' where controls to limit public access will be in place. Generally controlled areas will correspond to Working Conditions A and supervised areas to Working Conditions B of the Commonwealth Code. During the initial production stage, before a substantial suite of monitoring results is available, it will be necessary to make assumptions in regard to classifications and working areas. It is proposed that all employees in the dry plant itself be considered as designated employees, and at the mine and wet concentration plant as non-designated. The dry plant buildings will be regarded as controlled areas. Finalisation of these classifications will be the subject of review with the Department of Mines.

7.4.5 Radiation Protection Measures

Experience in the mineral sands industry ,suggests that due to the dilution of radioactive constituents within the ore deposits and the natural dust suppression inherent in dredge mining and wet processing, there will be little difficulty in maintaining radiation exposure levels at the minesite at less than one-tenth of the limits set by the Commonwealth Code of Practice. In the dry process plant various radiation protection measures will be adopted as described below.

Prior to dry processing the ore will be cleaned by:

- The abrasion and washing associated with dredge operations.
- Attritioning of total concentrates.
- Elutriation (the separation of finer particles via a slow stream of water moving upwards through the feed).

This programme of progressive cleaning will reduce the level of dust particles in the minus 85 micron range. Various measures will then be taken to reduce airborne dust arising from the residual fines and as a result of abrasion of the feed as it progresses through the dry plant. In developing these measures, reference has been made by the proponent to the suggestions outlined in the Department of Mines draft guideline, "Implementation of Dust Control Strategies in the Mineral Sands Industry".

Fully enclosed air conditioned control and work rooms would be routinely provided for employees in the dry plant.

In addition, the non-conductor magnetics will be directed to a separate building for monazite extraction. Special attention will be given to dust hygiene measures in this building, including the provision of floor washdown facilities free of external dust contamination sources. Access to this separate building will also be controlled to authorised persons for limited periods associated with operation of the semi-automatic process.

Special commitments made in regard to dust management are as follows:

- Provision of solid plate flooring with side kickers on all stairways and elevated walkways.
- Continuation of this flooring beneath and outwards from process equipment, to a distance to be determined by detailed study. These solid floor areas will be serviced by a vented dustproof chute connecting to enclosed collection bins at ground level and will be used in manual cleaning.
- Provision of an engineered vacuum cleaning system to service discrete locations on each floor.
- The use of steel support structural elements having dust shedding characteristics, eg inverted angles and enclosed box sections.
- The use of rotary screens having proprietary hooding and venting.
- Hooding and dust extraction of monazite and possibly zircon air tables. Every attempt will be made to employ alternative equipment to air tables.

- Enclosure and dust extraction of vertical feed elevator systems.

- Provision of induced draft low velocity ventilation in the general area .

- Thermal insulation of heaters and heating zones on hot ore handling equipment to reduce convection currents carrying dust between and across floors.

- Hooding and venting of major feed transfer points.

- Care in design to reduce conveyor spillage through overload or high speed operation.

- Semi-automatic bagging of the monazite product without the need for close operator attendance during filling.

In addition to these commitments the proponent undertakes, prior to final plant design, to consider the feasibility of fully enclosing the high tension and magnetic drum separators and electrostatic plate and screen separators. At this stage, given the other commitments to reduce and manage dust, it is considered that this may not be warranted due to cost and maintenance implications.

7.4.6 Gamma Ray Exposure

The following precautions will be adopted in order to reduce external gamma ray irradiation of employees:

- Provision of an inert material shield at the base of the monazite bulk storage bin.

- The use of steel plate shields between the bag and forklift driver and between the bagger and weighing machine (if automatic weighing is not used).

- Provision of a well ventilated lock-up shed for the storage of bagged monazite, with access strictly controlled.

- The use of pre-marked bags to avoid the need for on-site marking.

- Off-site transportation of bagged monazite within 20 tonne steel containers to provide shielding from gamma rays and to reduce the risk of spillage.

7.4.7 Other Measures Designed to Minimise Exposure

The proponent recognises that radiation protection should primarily be based on making the workplace intrinsically safe and that managerial procedures designed to reduce exposure to radiation and personal protective devices should be regarded as supplementary measures.

Other things being equal, the most cost-effective way of minimising exposure is for workers to withdraw from the source of radiation as frequently as operational requirements permit. Thus, automation of as many process controls as is feasible will be targeted when detailed engineering design proceeds. A number of ancillary actions will also be taken, as follows:

- Approved respirator protection will be available for workers to use during any event involving high dust concentrations.
- A positive attitude to workplace cleanliness will be fostered by management, with the facilities described earlier in this section designed to enable routine clean up of accumulated fines without resort to blowing down or excessive sweeping.
- Gloves and overalls will be provided to designated workers as well as adequate washing and changing facilities. Disposable handkerchiefs will be available. Eating, drinking and smoking will not be permitted in designated controlled areas elsewhere in the plant.
- The Radiation Safety Officer will arrange instruction for all new workers on the precautions and routines necessary to minimise exposure. The proponent will prepare specific project brochures to assist in the worker education programme.

7.4.8 Radiation Monitoring

Monitoring programmes will address firstly existing pre-operational background radiation levels and secondly radiation levels arising from the project operations.

The pre-operational radiation monitoring programme has two prime objectives:

(i) To provide a basis for checking that rehabilitation both at the mine and the dry processing plant (upon closure) is effective in eliminating residual incremental radiation.

(ii) To assist in confirming that the incremental radiation exposure of members of the public as a result of the operations will be within limits set by the Commonwealth Code of Practice.

In regard to (ii) some comparative figures in natural background radiation are relevant. Worldwide surveys conducted on behalf of the United Nations concluded that the average limit for natural background radiation, expressed as an annual effective dose equivalent, is 2mSv. However doses received by members of the public can actually rise to an order of magnitude higher than the average limit quoted under otherwise quite normal circumstances.

The limit on the additional or incremental dose which a member of the public can receive as a result of project operations, is set by the Commonwealth Code of Practice at 1mSv . This relativity does not in any way invalidate the need to ensure that incremental doses are minimised, but merely puts the current regulatory limit in perspective with naturally occurring circumstances.

For this project pre-operational monitoring for gamma will consist of grid surveys at the mine and dry process plant sites.

Gamma readings have already been taken over the northern section of the minesite on a 400mx200m grid, supplemented by some additional readings. The absorbed gamma dose rate in air measured was 0.08 micro-grays per hour with a standard deviation of 0.018. This corresponds to an annual effective dose equivalent of less than 1mSv.

At the Muchea dry process plant gamma readings will be taken over a 100m grid with the option to halve this grid in the event of significant variations to the readings.

At both the mine and dry process plant sites, airborne dust will be collected by high volume dust samplers with micropore glass fibre filters. Concurrent dust sizing impactors will not be used because of the low concentrations of airborne activity anticipated, but this can be reviewed. For reasons of security and ease of operation the samplers will be located where they can be readily reached and protected and near to power.

In Muchea one sampler will be located at or as close to the site boundary as the above considerations permit and one at the townsite. At Cooljarloo a sampler will be located at an occupied farm dwelling in reasonable proximity to the mine.

Monitoring for any groundwater quality changes will be carried out at both the minesite and dry processing plant site. Five sites up-gradient and five down-gradient will be selected at the minesite and three at each for the dry process plant site. Monthly sampling over a year will be carried out in the pre-operational period, with minimal sampling thereafter. Samples will be checked for gross alpha and gross beta activity.

The pre-operational programme described above will take into account summer and winter conditions prior to start up and will be carried forward into the operational period. Sampling periods will be reviewed with the appropriate authority prior to the commencement of the programme. The further analysis of data obtained during the operational period will also be the subject of review with the appropriate authority.

Details of the radiation monitoring and reporting procedures to be conducted during the operational period, will be the subject of consultation with the Department of Mines prior to commissioning. Some important principles associated with these procedures are listed below:

- Designated employees will be subject to personal dose assessment procedures, including individual (personal) monitoring.

- Key workplace locations will be surveyed monthly in both controlled and supervised areas, with more frequent monitoring likely during commissioning.

- Operational monitoring to assess particular production aspects will be conducted on an 'as needs' basis.

- Any mechanisms of exposure that contribute less than 10% of the total, will in general not be the subject of routine monitoring but rather confirmatory monitoring.

- Recording and investigation levels will be established for individual monitoring, and where appropriate to workplace monitoring. In addition authorised limits on concentrations of radioactive contaminants and emissions may also be specified by either the State Mining Engineer or the Operations Manager, as a further indirect means of controlling radiation dose.

- Visual inspection will be used for monitoring surface contamination.

- A quality assurance programme will be put in place to verify the suitability of instrumentation methods and procedures, calibration, maintenance of measuring equipment, analysis and recording.

Particular attention will be paid to the maintenance of proper records, using an in-house data recording and retrieval system. Annual reports on radiation protection will be prepared for the Department of Mines.

The results of workplace monitoring for dust will also be used to test compliance with the regulations limiting total dust concentrations in air.

Table 7.1 sets out in detail the type of radiation monitoring programmes that the proponent expects to implement on this project.

TABLE 7.1

SAMPLE RADIATION MONITORING PROGRAMME

Note: This programme will be reviewed following the issue of guidelines by the State Mining Engineer

Radiation Parameter	Site/Item Monitored	Frequency of Measurement	Method/Equipment and/or Radiation Measure
Absorbed dose rate in air	Designated employees	Continuous with one month integration time Area monitoring required	Personal and passive integrating TLDs. Dose rate meter (eg Berthold LB 1200)
	Other employees	Monthly surveys on workers category representatives	Integrating electronic dosimeter
	Controlled areas	Quarterly surveys to identify trends	Area monitoring using dose rate meter
	Environmental/ lease boundary	Bi-annual surveys	Dose rate meter (held 1m above ground)
	Mining pits	Monthly survey of mining pits	Dose rate meter used to delineate any controlled areas
	Pre-and post mining areas	Once-off gridded survey to confirm success of rehabilitation	Dose rate meter (held 1m above ground)
	Radiation Gauges	Quarterly	Dose rate meter at 1m and at surface
Radio-nuclides in air	Designated employees	Employees not likely to exceed 1/10th annual limit. 12 representative samples/year	Positional sampling
		Employees not likely to exceed 3/10th's annual limit. 18 representative samples/year	Personal air sampling. Determination of gross alpha activity and some statistical analysis of concentration distribution
		Employees likely to exceed 3/10th's annual limit. Each employee 8 samples/year	
	Other employees	12 samples per year on worker category representatives or monthly surveys of occupied workplaces	Personal air sampling. Determination of alpha activity etc. Positional air sampling and employee time and motion studies
	Controlled areas	Monthly surveys to identify trends	Positional air sampling. Determination of gross alpha
	Storage sheds/ ship loading operations	Annual survey to confirm levels ok	Positional air sampling inside sheds/ breathing zone sampling inside enclosed cabins
	Environmental locations outside operations area boundaries	Quarterly surveys at selected downwind locations	High volume air sampling. Determination of gross alpha activity. Radionuclide analysis if indicated
Radio-nuclides in water	Potable Water	Annual survey of bores used for potable water	Gross alpha and gross beta determination on soluble and insoluble components. Other radionuclide analysis if indicated
	Groundwater bores/ monitoring bores	Annual survey Seepage surveys	
Surface contamin-ation	Crib/change rooms/ ablutions	Daily	Visual inspection by supervisory staff
	Fixed and mobile plant in controlled areas	Weekly	Visual inspection by site RSO
		Spot measurements monthly on a random basis	Alpha contamination by alpha probe or wipe test technique
	Designated employees	Random quarterly surveys before crib break	Alpha contamination by alpha probe/auditing
Thoron/ Radon Daughters	Controlled areas	Initially an annual survey with intervals to be determined thereafter	Random spot measurements using method of Rolle, Rock or similar

7.4.9 Transportation of Monazite

Monazite will be packaged in 2 tonne bagged lots and loaded into 20 tonne capacity steel containers at Muchea. From there it will be loaded onto trucks and transported to the Port of Fremantle for direct offloading onto ships. The requirements for packaging, labelling, transport and storage in transit are set out in the Code of Practice for the Safe Transport of Radioactive Substances. This Code of Practice gives standards for the strength and security of packaging to guard against spillage or leakage of monazite. Radiation emission limits at the surfaces of the package are set out to provide protection to persons involved in its transport and loading. Labelling requirements are designed to make absolutely clear the nature of the material being carried (monazite is defined as a low specific activity material).

Routine visual and gamma surveys will be carried out at not more than six monthly intervals on product transportation units. These will be directed at the detection and removal of any residual contamination. Routine area sampling for dust in air will also be conducted during bulk loadout of product from wharf storage areas.

8. CONCLUSIONS

8.1 REVIEW OF COMMITMENTS

The Cooljarloo Project presents an opportunity for the establishment of a new mining and mineral processing venture in Western Australia with consequential benefits in terms of expenditures, employment, revenue and royalties. These benefits will occur at the national, State and local level.

Against these benefits the potential costs, in the view of the proponent, consist mainly of site impacts due to mining. It is considered that these will be offset by rehabilitation which will restore the landform, vegetation and current use potential. TIO2 Corporation NL is committed to achieve a very high standard of rehabilitation and in particular to:

- carry out detailed soil profile analyses, and flora and vegetation studies in front of the mine path to provide site specific information for rehabilitation planning
- supplement rehabilitation measures by seeding and planting using local indigenous species
- consult closely with Government agencies and especially the Rehabilitation Section of the Department of Mines
- establish long-term monitoring studies to assess revegetation and recolonisation by fauna
- encourage independent research programmes into rehabilitation methods

TIO2 Corporation NL will develop, in consultation with the Department of Conservation & Land Management, a comprehensive fire management plan for the Cooljarloo tenements. This will have the objectives of providing protection to rehabilitation and of encouraging ecological diversity and vigour generally. A fully equipped fire truck and trained personnel will be maintained on site for this purpose.

A commitment is also made to monitor the shallow groundwater levels (ie the water table) since mining-induced drawdowns, should they occur, might be expected to adversely stress vegetation. Should monitoring detect significant drawdowns induced away from the immediate mine area, then the proponents will take action to restore groundwater levels. Surface hydrological features will also be maintained by the reconstruction of Mullering Brook after mining and by incorporating wet depressions in the rehabilitation in appropriate places.

As monazite is radioactive, strict adherence to all Western Australian regulations and the Commonwealth Code of Practice relating to radiation protection will be adopted as described in Section 7.4. This will include specifically:

- a comprehensive radiation level monitoring programme at both the minesite and dry process plant and their environs and of monazite transport units
- isolation of the monazite process circuit into a separate building
- comprehensive dust suppression measures
- specific precautions in the handling, storage and transport of monazite product

TIO2 Corporation is therefore committed to a high level of environmental management and monitoring as an integral part of the Cooljarloo project. It intends to conduct its operations with the highest level of corporate social responsibility and is firmly committed to the principle that mining should involve a transient impact on the environment. On this basis, TIO2 Corporation NL believes that the proposal warrants approval.

9. REFERENCES

Australian Groundwater Consultants (1986).
Hydrological and Geotechnical Studies. Volume V of the Cooljarloo Heavy Mineral Sands Deposits Feasibility Study. Unpublished Report to TIO2 Corporation NL.

Briese, E.H. (1978).
The Geology and Hydrogeology of the Moora Borehole Line. Geological Survey of Western Australia Annual Report.

Dames & Moore (1985).
A Socio-economic and Social Impact Assessment of the Proposed Kemerton Aluminium Smelter. WA Department of Resources Development.

Dunlop, J. & Bamford, M.J. (1987).
An Assessment of the Vertebrate Fauna of the Cooljarloo Project Area 1986/87. Unpublished Report to TIO2 Corporation NL.

Elkington, J. (1986).
Report on the Proposed Extension of the Badgingarra National Park and Overlap onto Mining Leases 70/132 and 70/283. Unpublished Report to TIO2 Corporation NL.

Elkington, J. (1987).
Report on the Vegetation of Cooljarloo. Unpublished Report to TIO2 Corporation NL.

Environmental Protection Authority (1987).
A Guide to the Environmental Protection Act 1986.

Marchant, N.G. and Keighery, G.J. (1979).
Poorly collected and presumably rare vascular plants of Western Australia. Kings Park Research Notes - No. 5.

O'Connor, R. & Quartermaine, G. (1987a).
Report on the Survey for Aboriginal Sites in the Vicinity of the Cooljarloo Mineral Sands Project. Unpublished Report to TIO2 Corporation NL.

O'Connor, R. and Quartermaine, G. (1987b).
Report of a Survey for Aboriginal Sites at the Proposed TIO2 Dry Plant Sites, Muchea.

Playford Work Party (1987).
Conservation and Rehabilitation in the Mineral Sands Mining Industry. Western Australian Department of Mines.

Rye, B.L. and Hopper, S.D. (1981). A guide to the gazetted rare flora of Western Australia. Fisheries & Wildlife Report No. 42.

TIO2 Corporation NL (1986).
Annual Report.

TIO2 Corporation NL (1987).
Dry Separation Plant: Review of the Effects of Location at Geraldton in Lieu of Muchea. Unpublished Report.

APPENDIX 1
EPA GUIDELINES

PROPOSED TiO_2 MINERAL SANDS PROJECT

EPA GUIDELINES* FOR AN ENVIRONMENTAL REVIEW AND MANAGEMENT PROGRAMME (ERMP)

SUMMARY

This section should contain a clear and concise summary of the salient features of the proposal, site location alternatives, existing environment, the magnitude and extent of environmental impacts and environmental safeguards and management.

1. INTRODUCTION

This section would include:

. background and objectives of the proposal;

. details of the proponent;

. why the document has been prepared;

. scope and timing of the proposal;

. other existing mineral sand mining operations; and

. relevant legislative requirements and approval processes (State and Commonwealth)

2. NEED FOR PROPOSAL

This section presents an opportunity for the proponent to describe in a general way the broad costs and benefits of the project to the Company and community. These should be described at local, State and National levels.

3. EVALUATION OF ALTERNATIVES

The evaluation of alternatives is considered to be one of the more important parts of the document. It should demonstrate to the reader how choices on location, technology, techniques, etc, have been proposed 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.

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.

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

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

. mining and mineral processing techniques;
. rates of production and project development;
. mine site rehabilitation, in particular end land use;
. water supply;
. ore transportation;
. port site facilities; and
. land tenure

When alternatives are rejected, the factors which led to their rejection should be clearly identified.

Rehabilitation options should be considered with regard to achieving initial stability of recontoured mined areas and then examining longer term land use options including progressively replacing the initial function of the vegetation in this area. Development of some wetland areas could also be considered where desirable.

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.

4. THE PROPOSAL

The document should provide descriptions of 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 supply, should also be described. Matters to discuss would include:

. description of mineral deposits and exploration;

. the mineral deposits mineral exploration review;

. the mining operation including rehabilitation;

. on-site mineral concentration;

. secondary concentration;

. project infrastructure;

. project transport;

. water supply; and

. sewage treatment.

A discussion of a progression to the Jurien ore bodies should only be referred to in the introduction as being the subject of a future proposal.

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 environmental management discussion.

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

5. 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, but 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.

A discussion of the regional situation within which the project site is situated should be provided before discussing the project site. Perhaps conceptual models or diagrams could be provided to illustrate and synthesize the interactions between the physical and biological aspects of the habitats and resources discussed.

In particular, the aspects of the environment relevant to, or impacted by mining, transport links, mineral processing and the project work force 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 should be demonstrated for the mine, work force accommodation, new transport corridor and port. It is important to consider the conservation status of flora, and fauna.

Discuss the physical and biological processes which maintain the various habitats and resources. Assess the resilience of these habitats and resources to natural and man-made pressures. Cover such phenomena as bush fires and drought.

The discussion of the human environment should include information on demography, land-use and planning, features and sites of cultural and scientific interests including any historical, archeological or ethnographic sites. Also, infrastructure and public and private utilities and facilities, should be considered.

6. ENVIRONMENTAL IMPACTS

The proposal will impact on some aspects of the environment, and it is necessary to discuss the individual impacts and then synthesize 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 proposed is environmentally acceptable, and secondly, to show that operative management, ameliorative and monitoring programmes can be devised to manage potential impacts.

Consideration should be given to both the long and short term effects of the project development and operation at the various locations where the project and associated activities may significantly impact on the environment.

A thorough evaluation of the hydrological and botanical impacts of the proposal should be provided. Discuss effects of project and associated

Discuss the mechanism proposed to ensure that environmental management commitments are met through fluctuating economic conditions.

Emphasis should be given as to how the environmental management programme will be adapted in response to results from the monitoring programme.

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

8. CONCLUSION

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

9. REFERENCES (BIBLIOGRAPHY/ABBREVIATIONS)

. 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.

. APPENDICES

These may be produced as separate volumes or incorporated in the back of the document.

NOTE: The guidelines should be read in conjunction with the attached document, "Notes for the preparation of an ERMP".

population on the existing environment, including any archaeological, enthnographic and heritage aspects, existing population, and proposed or existing nature conservation reserves.

As the area proposed to be mined impinges on a proposed nature conservation reserve an assessment of the area's conservation status will be required. This is to ensure that conservation values which may be lost through mining are adequately represented and preserved outside the area to be mined. Proposals should be made with respect to the inclusion of suitable areas of vacant crown land and/or other land into existing reserves to replace lost conservation values. Details of the following would be required to adequately determine the relative values of the area to be proposed for reservation as well as proposed reserve areas that may be affected by mining:

- distribution and description of vegetation types;
- conservation status of vegetation;
- physical description of land eg relief and soil type;
- land tenure; and
- relevent details on native fauna and landscape.

This section should show the overall effect 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. The synthesis should also include an assessment of the significance and timing of the various impacts identified. For example:

- it may be useful to examine construction impacts separately from operational and decommissioning impacts; and

- some of the infrastructure elements (such as the power supply) will have little or no ongoing interaction with the environment once they are established.

A brief and general land capability analysis of the affected land after mining for the range of uses considered should be provided.

7. ENVIRONMENTAL MANAGEMENT

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

It will be essential to discuss the proposed managment programme in relation to current practice elsewhere in WA and Australia for various aspects of the proposal. The approach for trials that would either provide information on the best means of rehabilitation using native plant species or, if relevant assist in determining the land capability for various alternate end land-uses under consideration should also be discussed.

APPENDIX 2
LIST OF PLANT SPECIES RECORDED AT COOLJARLOO

(Elkington, 1987)

	Banksia Low Woodland N	Banksia Low Woodland Cen	Banksia Low Woodland S	Hakea obliqua Scrub Heath	Xanthorrhoea reflexa Low Heath	Mixed Low Heath	Wetland Heath/ Scrub Heath
Acacia auronitens Lindley						S	
Acacia pulchella R.Br.							P
Acacia saligna (Labill.) H.L.Wendl.*							
Acacia sphacelata Benth.			P		P	P	
Acacia stenoptera Benth.	P		S	P		P	
Actinotus sp *							
Adenanthos cygnorum Diels	P	P	P	P			S
Alexgeorgea arenicola Carlquist	P	P	P	P	S	P	P
Allocasuarina humilis (Otto & Dietr.) L.Johnson			P	P	P	P	
Allocasuarina microstachya (Miq)					P	P	
Allocasuarina thuyoides (Miq.) L. Johnson *							
Amphipogon turbinatus R.Br.	P	P	P	P	P	P	
Anagallis arvensis L. var *caerulea* *							
Anigozanthos pulcherrimus Hook.*							
Anigozanthos humilis Lindley	P	P	P	P	P	P	
Andersonia heterophylla Sond.		P	P	P	P	P	
Andersonia lehmanniana Sond. *							
Arctotheca calendula (L.) Levyns *							
Arnocrinum preissii Lindl.	P	P		S			S
Astroloma pallidum R.Br.			P		P	P	
Astroloma cf *pallidum* R.Br.				P	P		
Astroloma prostratum R.Br.			P	P	P		
Astroloma xerophyllum (D.C.) Sond.	P	P	P	P			
Baeckea grandiflora Benth.			P	P	P	P	
Banksia attenuata R.Br.	P	P	P	P			
Banksia candolleana Meisn.				P			
Banksia grandis Willd. *							
Banksia ilicifolia R.Br.	S						
Banksia incana A.S. George						S	
Banksia littoralis R.Br. var *littoralis* *							
Banksia menziesii A.S.George	P	P					P
Banksia prionotes Lindley *							
Banksia telmatiaea A.S. George				P			P
Baumea juncea (R.Br.) Palla							P
Burchardia umbellata R.Br.	P	P	P	P	P	P	
Beaufortia elegans Schau.			P	P	P	S	
Beaufortia squarrosa Schauer *							
Billardiera erubescens (Putterl.) E.M.Bennett *							
Blancoa canescens Lindley	P	P	P	P			
Boronia ramosa (Lindley) Benth.	P	S	P	P	S		
Borya nitida Labill.			P				
Bossiaea eriocarpa Benth.	P	P	P	P		P	
Byblis gigantea Lindley *							
Caladenia deformis R.Br.			S				
Calectasia cyanea R.Br.	P		P		P	P	
Calothamnus quadrifidus R.Br.*							
Calothamnus sanguineus Labill.			P	P	P	P	
Calothamnus villosus R.Br.							P
Calytrix aurea Lindley				P			P
Calytrix depressa (Turcz) Benth. *							
Calytrix flavescens A.Cunn.	P	P	P	P		P	
Calytrix leschenaultii (Schauer) Benth.	P		P		P	P	
Calytrix sapphirina Lindley		P	P	P		P	
Cassytha flava Nees	P			P		P	P
Cassytha glabella R.Br.	P	P	P	P	P		P
Cassytha pomiformis Nees				P			
Cassytha sp							P
Caustis dioica R.Br.			P	P	P	P	
Chamaescilla corymbosa (R.Br.) F.Muell. ex Benth.					P		
Comesperma acerosum Steetz			P	P	P	P	
Comesperma drummondii Steetz							P
Conospermum acerosum Lindley *							
Conospermum nervosum Meissner *							
Conospermum crassinervium Meissner	P	P		S	S	P	
Conospermum incurvum Lindl.		P					
Conospermum stoechadis Endl.	P		P	P	P	P	S
Conospermum triplinervium R.Br.*							
Conostephium pendulum Benth.	P	P	P	P		P	
Conostylis androstemma F. Muell.					P		
Conostylis aculeata R.Br.							P

	Banksia Low Woodland N	Banksia Low Woodland Cen	Banksia Low Woodland S	Hakea obliqua Scrub Heath	Xanthorrhoea reflexa Low Heath	Mixed Low Heath	Wetland Heath/ Scrub Heath
Conostylis aculeata R.Br. ssp breviflora *							
Conostylis aurea Lindley	P		P				
Conostylis aff aurea Lindley	P	P	P	P	P	P	P
Conostylis dielsii W.Fitzg.			P			P	
Conostylis festucacea Endl.					P		
Conostylis juncea Endl.	P	P	P				
Conostylis teretifolia J.W. Green.	P	P	P	P	P	P	
Conothamnus trinervis Lindley					P		
Cryptandra glabriflora C. Gardner			P	P	P	P	
Cryptandra humilis (Benth.) F. Muell.				P			
Dampiera juncea Benth.	S				P		
Dampiera linearis R. Br.	P	P					
Dampiera spicigera Benth.				P		P	
Darwinia sanguinea (Meissner) Benth.				P			
Dasypogon bromeliifolius R.Br.	P	P	P	P	P	P	P
Daviesia divaricata Benth.		P					
Daviesia gracilis M.D.Crisp		P	P	P		P	
Daviesia aff incrassata Smith			P	P		P	
Daviesia nudiflora Meissner				P	P	P	
Daviesia pectinata Lindley						P	
Daviesia quadrilatera Benth. ex Lindl.		P	P			P	
Drosera erythrorhiza Lindley		P	P	P	P	P	
Drosera gigantea Lindley		P	P	P	P	P	
Drosera menziesii R. Br.		P	P	P	P	P	
Drosera paleacea DC.		P	P		P		
Drosera pallida Lindl.		P	P	P	P	P	
Drosera microphylla Endl.		P					
Dryandra bipinnatifida R. Br.					P		
Dryandra nivea (Labill.) R.Br.	P		P	S		P	P
Dryandra shuttleworthiana Meisn.				P	P	P	
Dryandra tortifolia Kipp. ex Meissner			P	P	P	P	
Dryandra sp C63							P
Ecdeiocolea monostachya F.Muell.					P		
Eremaea asterocarpa R.Hnatiuk	P	P	P	P		P	
Eremaea fimbriata Lindley *							
Eremaea beaufortioides Benth.*							
Eremaea pauciflora (Endl.) Druce	S	P	P	P	P	P	
Eriostemon spicatus A. Rich.	P	P	P	P		P	
Eucalyptus calophylla Lindley *							
Eucalyptus camaldulensis Dehnh. *							
Eucalyptus drummondii Benth. *							
Eucalyptus rudis Endl. *							
Eucalyptus tetragona (R.Br.) F.Muell. *							
Eucalyptus todtiana F. Muell.	S	S					
Gahnia trifida Labill.							P
Gastrolobium bidens Meissner *							
Gastrolobium pauciflorum C. Gardner			P		P		
Gastrolobium spinosum Benth. *							
Glischrocaryon aureum (Lindley) Orch.*							
Gompholobium knightianum Lindley *							
Gompholobium tomentosum Labill.	S	P	S			P	
Conocarpus pithyoides Nees							P
Goodenia caerulea R.Br.		P	P	P	P	P	
Grevillea saccata Benth. *							
Grevillea shuttleworthiana Meissner					P		
Grevillea synapheae R.Br.					S		
Haemodorum paniculatum Lindley					P	P	
Hakea candolleana Meissner					S		
Hakea conchifolia Hook.			S		P		
Hakea costata Meisn.		P	S	P	P	P	
Hakea erinacea Meissner					P		
Hakea incrassata R.Br.					P		
Hakea lissocarpha R. Br. *							
Hakea obliqua R.Br.				P			
Hakea aff obliqua R.Br.							P
						S	

	Banksia Low Woodland N	Banksia Low Woodland Cen	Banksia Low Woodland S	Hakea obliqua Scrub Heath	Xanthorrhoea reflexa Low Heath	Mixed Low Heath	Wetland Heath/ Scrub Heath
Hakea prostrata R.Br.				P	P		
Hakea ruscifolia Labill. *							
Hakea stenocarpa R.Br.					P		
Hakea ?sulcata R.Br. *							
Hakea trifurcata (Sm.) R.Br.			P			P	
Hakea varia R. Br.							S
Hemiandra pungens R.Br.	P	P	S			P	
Hensmania turbinata (Endl.) W.Fitzg.	P	P					
Hibbertia crassifolia (Turcz.) Benth.	P	P	P	P	P	P	P
Hibbertia glaberrima F.Muell.		P	P				
Hibbertia huegelii (Endl.) F. Muell.	P	P	P	P	P	P	
Hibbertia hypericoides (D.C.)	P	P	P	P	P		
Hibbertia pachyrrhiza Steud.	P	P	P	P			
Hibbertia stellaris Endl.							P
Hovea stricta Meissner *							
Hovea trisperma Benth.				S			
Hypocalymma angustifolium Endl.							P
Hypocalymma xanthopetalum F.Muell.	P	P	P	P	P	P	
Hypocalymma xanthopetalum F.Muell. var linifolium			S				
Isopogon adenanthoides Meissner *							
Isopogon asper R.Br					S		
Isopogon divergens R.Br. *							
Isopogon linearis Meissner					S		
Isopogon teretifolius R.Br.					S		
Isotropis cuneifolia (Smith) Benth.		P	P	P	P	P	
Jacksonia floribunda Endl.	P	P	P	P	P	P	
Jacksonia restioides Meissner					P		
Jacksonia spinosa (Labill) R.Br.	P	P	S			P	P
Jacksonia sternbergiana Huegel *							
Jacksonia ulicina Meisn. *							
Johnsonia pubescens Lindley	P	P	P	P	P	P	P
Kingia australis R.Br.							P
Kunzea recurva Schauer							P
Lambertia multiflora Lindley					P		
Lasiopetalum lineare S.Paust	S						
Laxmannia omnifertilis J.Keighery (in edit)			P		P		
Laxmannia ramosa Lindley							P
Laxmannia squarrosa Lindley			P		P		
Lechenaultia linarioides D.C. *							
Lechenaultia ?stenosepala E.Pritzel			P			P	
Lepidobolus chaetocephalus F.Muell.	P	P		P	P	P	
?Lepidobolus sp C62							P
Leporella fimbriata (Lindley) A.S.George			P				
Lepidosperma angustatum R.Br	P	P	P	P	P	P	P
Lepidosperma tenue Benth.	P	P		P	P	P	
Leptocarpus ?coangustatus Nees							P
Leptocarpus tenax (Labill.) R. Br.	P			S			P
Leptospermum erubescens Schau.				S			
Leptospermum spinescens Endl.		P	P	P	P	P	
Leucopogon allittii F. Muell. *,							
Leucopogon conostephioides D.C.	P	P	P	P			P
Leucopogon leptanthus Benth.					P		
Leucopogon polymorphus Sonder	P			P	P		
Leucopogon striatus Sond.		P	P	P	P	P	P
Leucopogon sp 30.					P		
Logania campanulata R. Br. *							
Logania spermacocea F. Muell.			P		P	P	
Lomandra caespitosa (Benth.) Ewart						S	
Lomandra hastilis (R. Br.) Ewart	P	S	P	P	P	P	
Lomandra preissii (Endl.) Ewart.		P	P		P	S	
Lomandra sp		P	P	P	S	P	
Loxocarya flexuosa (R.Br.) Benth.			P				
Loxocarya sp C51 *							
Lyginia barbata R.Br.	P	P	P	P		P	P
Lysinema ciliatum R. Br.	P	P	P	P	P		
Macropidia fuliginosa (Hook.) Druce *							
Macrozamia reidlei (Fisch. ex Gaud.) C.A.Gardn. *							
Melaleuca ciliosa Turcz. *							
Melaleuca hamulosa Turcz.							P
Melaleuca incana R.Br							P

	Banksia Low Woodland N	Banksia Low Woodland Cen	Banksia Low Woodland S	Hakea obliqua Scrub Heath	Xanthorrhoea reflexa Low Heath	Mixed Low Heath	Wetland heath/ scrub heath
Melaleuca preissiana Schauer *							
Melaleuca scabra R. Br.	P	P	P	P	S	P	
Melaleuca teretifolia Endl.							P
Melaleuca C28					P		
Melaleuca C47				S			
Melaleuca 454							S
Mesomelaena stygia (R.Br.) Nees	P	P	P	P	P	P	
Mesomelaena tetragona (R.Br.) Benth.			P		P	P	
Mirbelia spinosa Benth.					P		
Monotaxis grandiflora Endl.		P		P			
Neurachne alopecuroidea R. Br.			P	P	P	P	P
Nuytsia floribunda (Labill.) R.Br.	S					S	
Olax benthamiana Miq.			P				
Onycosepalum laxiflorum Steudel							P
Opercularia spermacocea Labill.			P		P	P	S
Patersonia occidentalis R. Br.	P	P	P	P		P	P
Patersonia sp C32					P		
Persoonia angustiflora Benth.					P		
Petrophile ericifolia R.Br.				P	P	S	
Petrophile machrostachya R. Br.	P	P		P		P	
Petrophile media R.Br.			P	P	P	P	P
Petrophile seminuda Lindley *							
Petrophile striata R. Br					P		
Petrophile sp C45	P	P	P	P			
Phlebocarya filifolia (F. Muell.) Benth.	P	P		P			
Pileanthus filifolius Meisn.		P	P	P	P	S	
Pimelea angustifolia R. Br.	P					P	
Pimelea sulphurea Meissner.		P	S			P	
Pityrodia bartlingii (Lehm.) Benth.	S	S		P	S	S	
Pityrodia verbascina (F.Muell.) Benth. *							
Platysace ? teres (Bunge) Norman		S	S				
Platysace juncea (Bunge) Norman							P
Platysace xerophila (E. Pritzel) L. Johnson	S	S	P			P	
Prasophyllum sp			P				
Pterostylis vittata Lindley			S	S		S	
Regelia ciliata Schauer							P
Restio sphacelatus R.Br.	P	P	P	P	P	P	P
Restio megalotheca F.Muell.				P			
Scaevola canescens Benth				P	P	P	
Scaevola paludosa R. Br.	P		P	P	S	P	P
Schoenus brevisetis (R. Br.) Benth.	S		P	P	P	P	
Schoenus aff brevisetis (R. Br.) Benth.	P	P	P		P	P	
Schoenus caespititus W. Fitzg.		P		S			
Schoenus curvifolius (R.Br.) Benth.	P	P	P	P	S	P	P
Schoenus subflavus Kuek	P	P	P	P	P	P	
Schoenus unispiculatus F. Muell ex Benth.					P		
Schoenus aff unispiculatus F.Muell. ex Benth.		P	P	P			
Schoenus sp C33					P		
Schoenus sp C61							P
Scholtzia aff involucrata (Endl.) Druce		P	P	P		P	
Scholtzia involucrata (Endl.) Druce	S						
Scholtzia parviflora F. Muell. *							
Scholtzia teretifolia Benth.					S		
Sphaerolobium macranthum Meissner *							
Spyridium tridentatum (Steud.)					P	P	
Stackhousia dielsii Pampanini		P	S			P	
Stirlingia latifolia (R. Br.) Steud.	P	P	P	P			
Stirlingia simplex Lindley *							
Stylidium adpressum Benth.	P				P		
Stylidium brunonianum Benth.	S	P	P	S			
Stylidium carnosum Benth.			P	S	P	S	
Stylidium crossocephalum F.Muell.	P	P	P	P	P	P	
Stylidium ?dichotomum DC.							P
Stylidium luteum R. Br.	P				P		
Stylidium maitlandianum E. Pritzel				S	P		

	Banksia Low Woodland N	Banksia Low Woodland Cen	Banksia Low Woodland S	Hakea obliqua Scrub Heath	Xanthorrhoea reflexa Low Heath	Mixed Low Heath	Wetland heath/ Scrub Heath
Stylidium miniatum Mildbr.		P	P				
Stylidium piliferum R.Br.		P	P	P	P	P	
Stylidium repens R.Br.	P	P	P	P	P	P	P
Synaphaea petiolaris R. Br.	P	P	P	P	P	P	
Synaphaea polymorpha R. Br.					P		
Templetonia biloba (Benth.) Polh.					P		
Tetraria octandra (Nees) Kuek.					P		
Tetratheca sp *							
Thelymitra spiralis (Lindley) F.Muell.					S		
Thomasia grandiflora Lindley *							
Thysanotus multiflorus R.Br. *							
Thysanotus patersonii R. Br.		S		P	P	P	
Thysanotus sparteus R. Br.	P	P	S		P	P	S
Thysanotus triandrus (Labill.) R.Br.						P	
Trachymene pilosa Smith			P			P	
Tribonanthes uniflora Lindley *							
Tricoryne elatior		S				P	
Tricoryne sp 296						P	
Tripterococcus brunonis Endl.		P					
Ursinia anthemoides (L.) Poiret *							
Verrauxia reinwardtii (Vriese) Benth.						P	
Verticordia densiflora Lindley							P
Verticordia drummondii Schauer							P
Verticordia grandiflora Endl.					P		
Verticordia grandis J. Drumm. ex Meissner *							
Verticordia patens A.S. George *							
Verticordia pennigera Endl.			S		S		
Verticordia ?picta Endl.		S					
Wurmbea dioica (R. Br.) F. Muell. *							
Xanthorrhoea reflexa Herbert	P		P		P	P	
Xanthosia huegelii (Benth.) Steud.	P	P	P	P	P	P	
Unidentified sp C57							P
Unidentified sp C59 (Cyperaceae)							P
Unidentified orchid sp					S	S	
Unidentified sp C66							P

A total of 245 species were observed in the belt transects in the Cooljarloo area.

A further 60 species were noted in the area but did not occur in the transects; they are marked "*".

Species noted only from a single individual in a sampling area are marked "S".

Species noted by two or more specimens in a sampling area are marked "P".

APPENDIX 3

LIST OF VERTBERATE FAUNA RECORDED AT COOLJARLOO

(Dunlop & Bamford, 1987)

1 Mammals

MACROPODIDAE

Macropus fuliginosus - Western Grey Kangaroo.

Common in the lease area especially adjacent to farm land and on recently burnt areas.

Macropus irma - Western Brush Wallaby.

Two sightings within the lease area during the February survey.

TARSIPEDIDAE

Tarsipes rostratus - Honey Possum.

A sub-adult male was pitfall trapped near flowering *Banksia telmatiaea* at trapping location 5 in August. Sub-adult males were captured at localities 1 & 2 in February (Figure 1). *Tarsipes* is an abundant small mammal at nearby Badgingarra (Murray 1980) but is very scarce at Cooljarloo.

MURIDAE

Mus musculus - House Mouse.

Twenty-six (26) *Mus* were captured in pitfall and box traps from localities 1 (3 individuals), 2 (1), 3 (1) and 5 (21). The specimens from the wet heath (locality 5) included juveniles, gravid and lactating females and sexually active males. There was no evidence of breeding in specimens taken from dry heathland and woodland.

Pseudomys albocinereus - Ashy-grey Mouse.

Four (4) individuals, two males and two females, were pitfall trapped in August at location 4 in Banksia woodland. One male had scrotal testes whilst the other three specimens were not reproductively active. This was consistent with the later spring/summer breeding season recorded at Mooliabeenae.

VESPERTILIONIDAE

Chalinolobus gouldii - Gould's Wattle Bat.

One was observed flying at dusk at a gravel pit. There was little bat activity because of the low temperatures. This species was again observed over Banksia woodland in February. No bats were captured or collected.

LEPORIDAE

Oryctolagus cuniculus - European Rabbit.

There was evidence of summer occupation of wet heathland areas. No rabbits were sighted in the lease area.

FELIDAE

Felis catus - Feral Cat.

Several feral cats were recorded in the lease area and at the Wongonderrah Springs Reserve.

CANIDAE

Vulpes vulpes - Red Fox.

Fox tracks were frequently observed in the lease area.

2 Reptiles

GEKKONIDAE

Diplodactylus spinigerus - Spiny-tailed Gecko.

One drowned specimen collected in *Kunzea* wet heath in the main wetland area. One trapped at location 2 and one at location 7 in February.

Phyllodactylus marmoratus.

One collected from under *Banksia* bark.

PYGOPODIDAE

Pletholax gracilis

One sub-adult trapped at location 2 in February.

Pygopus lepidopodus.

One individual captured and released in the Wongonderrah Springs Reserve.

VARANIDAE

Varanus gouldii

One sighting of a sub-adult in the area in February.

AGAMIDAE

Pogona minor - Bearded Dragon.

This reptile became active in the warmer second week of the winter survey when there were several sightings. Adults were pit-trapped at locations 2, 3 and 7 in August and young of the year (2 individuals) at location 4 in February.

Tympanocryptis adelaidensis.

One drowned specimen was collected in wet heath.

Observed active in *Banksia* woodland in February.

SCINCIDAE

Ctenotus fallens

Two adults trapped at location 1 and one young of the year (o+) at location 7 in February.

Ctenotus gemmula

One o+ age specimen collected in February at location 8 in *Banksia* woodland.

Ctenotus impar

Individuals trapped at locations 4 and 8 in February.

Morethia obscura.

One individual pitfall trapped at location 1.

Tiligua rugosa.

One individual observed near location 7.

ELAPIDAE

Rhinopocephalus gouldii.

One captured from decaying blackboy stump on Wongonderrah Springs Reserve and immediately released.

3 Frogs

LEPTODACTYLIDAE

Heleioporus eyrei.

One individual pitfall trapped at location 5.

Limnodynastes dorsalis - Banjo frog.

Individuals pitfall trapped at locations 2, 5 and 6. Frequently heard calling in wetlands. Spawn found in main wetland.

Neobatrachus pelobatoides.

Three individuals were pit-trapped at location 5 and one at location 4. Occassionally heard calling in the main wetland.

Pseudophryne guentheri.

This frog was pitfall trapped at location 2(1 specimen), 3(1), 4(1), 5(8) and 7 (2).

Ranidella pseudinsignifera.

This frog was frequently heard calling in the wetland areas. One specimen collected. Metamorphosing larvae present in main wetland.

HYLIDAE

Litoria adelaidensis.

This species was heard calling in the main wetland.

4 Birds

Dromaius novaehollandiae - Emu.

A number of sightings were noted in the lease area.

Anas gibberifrons - Grey Teal.

Small numbers were using the main wetland.

Anas superciliosa - Pacific Black Duck.

Small numbers were using the main wetland and other small areas of open water.

Aquila audax - Wedge-tailed Eagle.

The home range of at least one individual overlaps the lease area.

Circus assimilis - Spotted Harrier.

One sighting from the lease area.

<u>Circus aeruginosus</u> - Marsh Harrier

One observed over wet heath in February. Also sighted at Wongonderrah salt pan.

<u>Falco longipennis</u> - Australian Hobby.

Sighted in the lease area in February.

<u>Falco berigora</u> - Brown Falcon.

This is the common raptore of the lease area. One was visiting an old nest in a <u>Banksia</u> tree near location 1.

<u>Falco cenchroides</u> - Australian Kestrel.

Only one sighting from within the lease area.

<u>Porzana tabuensis</u> - Spotless Crake.

Heard calling in dense <u>Kunzea</u> thickets in main wetlands. Call used was that associated with breeding (Jaensch. pers. comm.).

<u>Ardeotis australis</u> - Australian Bustard.

Two sightings on the lease area probably of the same individual.

<u>Ocyphaps lophotes</u> - Crested Pigeon.

Uncommon in the lease area.

<u>Phaps elegans</u> - Brush Bronze-wing.

One sighting in <u>Banksia</u> woodland in February.

<u>Phaps chalcoptera</u> - Common Bronzewing.

Uncommon in the lease area.

<u>Cacatua roseicapilla</u> - Galah.

One sighting from the lease area.

<u>Calyptorhynchus baudinii</u> - White-tailed Black-Cockatoo.

Several sightings of individuals and flocks within the lease area. Largest flock seen contained ca. 200 individuals.

Polytelis anthopeplus - Regent Parrot.

Several small flocks present in the lease area in February.

Chrysococcyx basalis - Horsfield's Bronze-Cuckoo.

Moderately common in the lease area.

Chrysococcyx lucidus - Shining Bronze-Cuckoo.

Several sightings in the lease area.

Cuculus pallidus - Pallid Cuckoo.

Moderately common in the lease area.

Podargus strigoides - Tawny Frogmouth.

One found dead on Brand Highway adjacent to the mineral lease.

Caprimulgus guttatus - Spotted Nightjar.

One sighting during spotlight traverse of the lease area.

Dacelo gigas - Laughing Kookaburra.

Present in Melaleuca woodland fringing the main wetland area.

Merops ornatus - Rainbow Bee-eater.

Present in the lease area during February.

Cecropis nigricans - Tree Martin.

Uncommon in the lease area.

Cheramoeca leucosternum - Richard's Pipit.

Several sightings in lease area.

Coracina novaehollandiae - Black-faced Cuckoo-Shrike.

Moderately common in the lease area.

Colluricincla harmonica - Grey Shrike Thrush.

Scarce in the area. Restricted to thicket vegetation fringing the wetlands.

Melanodryas cucullata - Hooded Robin.

Scarce inhabitant of the *Banksia* woodland.

Microeca leucophaea - Jacky Winter.

One sighting from *Banksia* woodland.

Oreoica gutturalis - Crested Bellbird.

Uncommon inhabitant of *Banksia* woodland.

Pachycephala rufiventris - Rufous Whistler.

Uncommon in *Banksia* woodland and fringing scrub.

Petroica multicolor - Scarlet Robin.

One sighted in *Eucalyptus rudis* woodland.

Eopsaltria georgina - White-breasted Robin.

Observed and mist-netted in *Eucalyptus* woodland in February.

Petroica goodenovii - Red-capped Robin.

Uncommon inhabitant of *Banksia* woodland. One pair found nesting during the survey.

Rhipidura fuliginosa - Grey Fantail.

Scarce in the lease area only observed in fringing scrub and *Banksia* woodland.

Rhipidura leucophrys - Willy Wagtail.

Uncommon inhabitant of *Banksia* woodland.

Cinclorhamphus mathewsi - Rufous Songbark.

Several sightings in the lease area.

Malurus leucopterus - White-winged Fairy-wren.

Uncommon inhabitant of low heath mostly on the lateritic scarp.

Malurus splendens - Splendid Fairy-wren.

Uncommon inhabitant of the wet heath and fringing scrub.

Gerygone fusca - Western Gerygone.

Recorded from Eucalyptus rudis woodland.

Acanthiza apicalis - Inland Thornbill.

Only observed in Kunzea heath and thicket in the main wetland.

Acanthiza chrysorrhoa - Yellow-rumped Thornbill.

Observed in Eucalyptus rudis woodland.

Acanthiza inornata - Western Thornbill.

Moderately common in Banksia woodland and fringing scrub.

Sericornis frontalis - White-browed Scrubwren.

(as above for A. apicalis)

Sericornis fuliginosus - Calamanthus

One sighting in February.

Daphoenositta chrysoptera - Varied Sittella.

Moderately common in the Banksia woodland.

Acanthorhynchus superciliosus - Western Spinebill.

Scarce, a few sightings in Banksia woodland.

Anthochaera carunculata - Red Wattlebird.

Uncommon in Banksia woodland and fringing scrub in August. Common in Eucalyptus rudis woodland in February.

Anthochaera chrysoptera - Little Wattlebird.

One sighting in B. prionotes woodland in August.

Common in Eucalyptus rudis woodland in February.

Lichenostomus virescens - Singing Honeyeater.

Abundant and widespread in the lease area.

Lichmera indistincta - Brown Honeyeater.

Abundant and widespread in the lease area. Large numbers near clumps of flowering Adenanthos cygnorum. Less common in the area in February.

Manorina flavigula - Yellow-throated Miner.

Moderately common in the Banksia woodland.

Melithreptus brevirostris - Brown-headed Honeyeater.

Scarce inhabitant of Banksia woodland.

Phylidonyris melanops - Tawny-crowned Honeyeater.

Moderately common in low blackboy heath on laterite and in Kunzea heath in the main wetland. Scarce in other habitats. One breeding record from the wetland heath.

Phylidonyris nigra - White-cheeked Honeyeater.

Moderately common with similar habitat preferences as P. melanops. Absent from the lease area in February.

Zosterops lateralis - Silvereye.

Moderately common in wetland heath and fringing scrub, scarce in other habitats.

Artamus cinereus - Black-faced Woodswallow.

Common in the Banksia woodland.

Cracticus torquatus - Grey Butcherbird.

Moderately common in the Banksia woodland.

Gymnorhina tibicen - Australian Magpie.

One group sighted on the edge of the lease close to farmland.

Corvus coronoides - Australian Raven.

Moderately common in the lease area.

APPENDIX 4

COMMITMENTS

COMMITMENTS

TIO2 Corporation NL will undertake the following commitments with respect to the Cooljarloo Mineral Sands Project.

TIO2 Corporation NL is committed to achieve a very high standard of mine-site rehabilitation and in particular to:

- carry out detailed soil profile analyses, and flora and vegetation studies in front of the mine path to provide site specific information for rehabilitation planning

- supplement rehabilitation measures by seeding and planting using local indigenous species

- consult closely with Government agencies and especially the Rehabilitation Section of the Department of Mines

- establish long-term monitoring studies to assess revegetation and recolonisation by fauna

- encourage independent research programmes into rehabilitation methods

TIO2 Corporation NL will develop, in consultation with the Department of Conservation & Land Management, a comprehensive fire management plan for the Cooljarloo tenements. This will have the objectives of providing protection to rehabilitation and of encouraging ecological diversity and vigour generally. A fully equipped fire truck and trained personnel will be maintained on site for this purpose.

A commitment is also made to maintain groundwater levels at Cooljarloo within naturally occurring seasonal levels so as to reduce risks of adverse impact on vegetation due to drawdown. Should monitoring detect indications of drawdown, the proponents will take action to restore groundwater levels. Surface hydrological features will also be maintained by the reconstruction of Mullering Brook after mining and by incorporating wet depressions in the rehabilitation in appropriate places.

As monazite is radioactive, strict adherence to all Western Australian regulations and the Commonwealth Code of Practice relating to radiation protection will be adopted as described in Section 7.4. This will include specifically:

- a comprehensive radiation level monitoring programme at both the minesite and dry process plant and their environs and of monazite transport units

- isolation of the monazite process circuit into a separate building

- comprehensive dust suppression measures

- specific precautions in the handling, storage and transport of monazite product

TIO2 Corporation is therefore committed to a high level of environmental management and monitoring as an integral part of the Cooljarloo project. It intends to conduct its operations with the highest level of corporate social responsibility and is firmly committed to the principle that mining should involve a transient impact on the environment.