EIS 152

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Environmental impact statement for extension of existing mineral sands mining operations in the Tomago sandbeds water supply catchment area

RZM

Rutile & Zircon Mines (Newcastle) Limited

EIS for Mineral Sands Mining in the Tomago Sandbeds

Environmental Impact Statement for Mineral Sands Mining in the Tomago Sandbeds Water Supply Catchment Area.

Prepared by Croft & Associates Pty Limited

Rutile & Zircon Mines (Newcastle) Limited

Environmental Impact Statement for Extension of Existing Mineral Sands Mining Operations in the Tomago Sandbeds Water Supply Catchment Area.

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Contents

TABLE OF CONTENTS

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

TABLE OF CONTENTS (cont'd)

LIST OF ABBREVIATIONS

a	annum
A.H.D.	Australian Height Datum
cm	centimetre
d	day
dB(A)	decibel ("A" weighted scale)
h	hour
ha	hectare
kg	kilogram
kL	kilolitre
km	kilometre
kW	kilowatt
Hz	Hertz
L	litre
M.L.A.	Mining Lease Application
m	metre
mm	millimetre
mg	milligram
ML	megalitre
PM	Permanent Mark
s	second
t	tonne
y	year

Section 1

Summary and Overview

1.1 PROPOSAL

Rutile & Zircon Mines (Newcastle) Limited has prepared this Environmental Impact Statement for the proposal to continue mineral sands mining within the Tomago Sandbeds Water Supply Catchment Area, north of Newcastle.

The Company has been mining this groundwater reserve for the past nine years employing up to three mining plants. The operations have been successfully carried out under controls imposed by State laws administered by the Department of Mineral Resources, the Hunter District Water Board (hereinafter referred to as 'The Board') and the State Pollution Control Commission.

1.2 SCOPE AND OBJECTIVES

Approval to continue mining will permit the annual extraction of approximately 25 000 t of rutile, 30 000 t of zircon and quantities of other heavy minerals over 15 to 20 years.

This yield represents 85 per cent of the Company's anticipated regional production.

1.3 MINING OPERATION

It is proposed that at the commencement of operations two mining plants, each comprising a dredge and a concentrator, will mine and separate the heavy mineral from unwanted siliceous material. The mineral sands will be further refined at the Company's mill at Tomago.

An additional plant may be introduced at a later date should such factors as technological change, production increases and/or market forces warrant such an amendment to the mining operation.

1.4 SAFEGUARDS AND CONTROLS

The existing mining operation is subject to rigorous controls with special emphasis on water quality and site restoration. These controls have been approved by the Department of Mineral Resources and the Board and are monitored by the Board and its consultants. The Company intends to implement similar safeguards and controls in this proposal, unless directed by the Board to vary any of the existing procedures.

With the continuation of the existing mining operation employing two plants, water used in the mining and concentration phase will be treated at the Company's wastwater treatment plant. Slime removed from this effluent will be pumped to the Company's settlement ponds outside the sandbeds catchment area for disposal in accordance with State laws. Water clarified at the treatment plant will be returned to the dredge ponds for recycling.

Any potential pollutant solids, including organic detritus, which settle to the bottom of the dredge pond will be removed by suction pump and piped to the wastewater plant for treatment. The Board is at liberty to vary these procedures should it be considered desirable to do so.

Before the introduction of a third mining plant, proposals will be submitted by the Company to the Board for approval and definition of the necessary safeguards and controls.

Heavy machinery working in conjunction with the electrically powered mining plant will be fitted with improved noise control abatement equipment when the mining operation is in close proximity to residences at Campvale.

The Company ascribes major importance to the comprehensive monitoring and ongoing assessment of the status of the natural environment. Prior to mining a topographic and vegetation survey will be undertaken to assist in formulating the rehabilitation programme.

Subsequent to the clearing of vegetation, the topsoil will be windrowed and later replaced on the recontoured tailings. Mined areas will then be subjected to an extensive revegetation programme to ensure a suitable

vegetation cover featuring a predominance of flora species indigenous to the surrounding habitat. Periodic surveys of the revegetated areas will be made to monitor species composition and growth rates.

1.5 IMPACT ASSESSMENT

The potential impact of the proposal has been assessed by studying the existing development in the context of the surrounding environment.

Physiography

In the short term the soils and terrain along the mining path will be significantly disturbed. Topography restoration safeguards will facilitate satisfactory replacement of the surface features.

Hydrology

Mining of low-lying swampy areas is considered likely to cause disturbance to any impermeable layers at the base of such wetlands. The restoration of topography after mining is unlikely to replace the conditions required for the re-establishment of a swamp.

Water Quality

Stringent operational safeguards adopted by the Company will ensure that no lubricants or effluents are permitted to come in contact with the highly porous sandbeds. The removal of any slime residues from the bottom of the dredge pond will prevent any long term deterioration in water quality.

Noise Levels

Residents nearest the proposed mining path at Campvale may experience an increase in noise levels due to the operation of earthmoving machinery.

Flora

Approximately 500 to 600 ha of sclerophyll forest, heath and wetland will be progressively cleared over a 15 to 20 year period. This disturbed area represents 5.7 per cent of the 106 km^2 covered by the Tomago Sandbeds Water Supply Catchment Area.

Regeneration practices will mitigate the long term effects of mining although the re-established vegetation, especially in the heath and wetland areas, is unlikely to replace the previously existing climax community, at least in the short term.

Fauna

The removal of habitat from the mined area will result in an unavoidable decrease in some existing fauna populations as a result of the loss of shelter and nesting sites for a period of up to 40 years. Sedentary birds, small non-avian fauna and arboreal species will be most affected.

Some small ground species appear able to utilise regenerating areas.

Visual Aspects

The sandbeds environment is of significant visual quality and the adopted rehabilitation safeguards and the screening of roadways will assist to lessen the visual impact.

Socio-economic Aspects

The proposed development encompassing two mining plants will serve to maintain the Company's existing employment levels and ensure that other socio-economic benefits continue to accrue to the region.

If a third mining plant is introduced an extra 23 employment positions will be created resulting in additional expenditure and income contributions to the regional economy.

Should the total proposal be refused the Company's long term future in the region will be placed in jeopardy. If the Company is forced to cease all

regional operations 188 employment positions together with indirect and induced employment levels will be lost. The local and regional economies will also be adversely affected.

1.6 CONCLUSION

This Environmental Impact Statement has been prepared for Rutile & Zircon Mines (Newcastle) Limited to support its proposal to continue mineral sands mining in the Tomago Sandbeds.

The findings of this study are that with the continued adoption of carefully monitored safeguards and controls, it will be possible for the proposal to be undertaken so as to not adversely effect the natural environment of the sandbeds nor interfere with the utilisation of the area by the Board.

This assessment is based on a careful analysis of detailed control and monitoring systems that have been in existence for a period of 14 years.

Section 2

Introduction

SUMMARY

Rutile & Zircon Mines (Newcastle) Limited has been mining the Tomago Sandbeds area for over nine years in order to produce heavy minerals. These operations have been carried out successfully under stringent controls imposed under State laws administered by the Department of Mineral Resources, the Board and the State Pollution Control Commission.

It is the Company's proposal to mine other areas within the sandbeds so as to maintain the present level of operations.

This section introduces the Company and its proposal. It reviews the relevant background to the proposal described in this environmental report and outlines the Company's mineral sands mining operations in the area. The significance of the Tomago Sandbeds as a domestic water supply is noted and an outline of previous investigations of mining in the sandbeds is provided.

2.1 THE PROPOSAL

Rutile & Zircon Mines (Newcastle) Limited proposes to continue its present heavy mineral mining operations in the Tomago Sandbeds Water Supply Catchment Area in accordance with the conditions stipulated by the Board and other government authorities.

This will permit the continued supply of raw materials to the Company's processing plant at Tomago about 20 km from the proposed mining area. This plant produces the final products of rutile, ilmenite, monazite and zircon. These minerals have a multitude of uses ranging from paint pigments, paper refractories, pottery, glass and other ceramics to optics, cosmetics and food preservatives. Some details of commercial uses are given in Appendix 1.

At present the Company's production in the Tomago area north of Newcastle yields approximately 2000 t of concentrate per week. This figure represents 85 per cent of the total heavy mineral concentrates refined at the Tomago processing plant.

Approval to continue heavy mineral mining operations in the sandbeds will permit the mining of known economic reserves in that area for another 15 to 20 years and provide the major component of the Company's future operations in the region by contributing 85 per cent (1500-1700 t per week) of the total projected production.

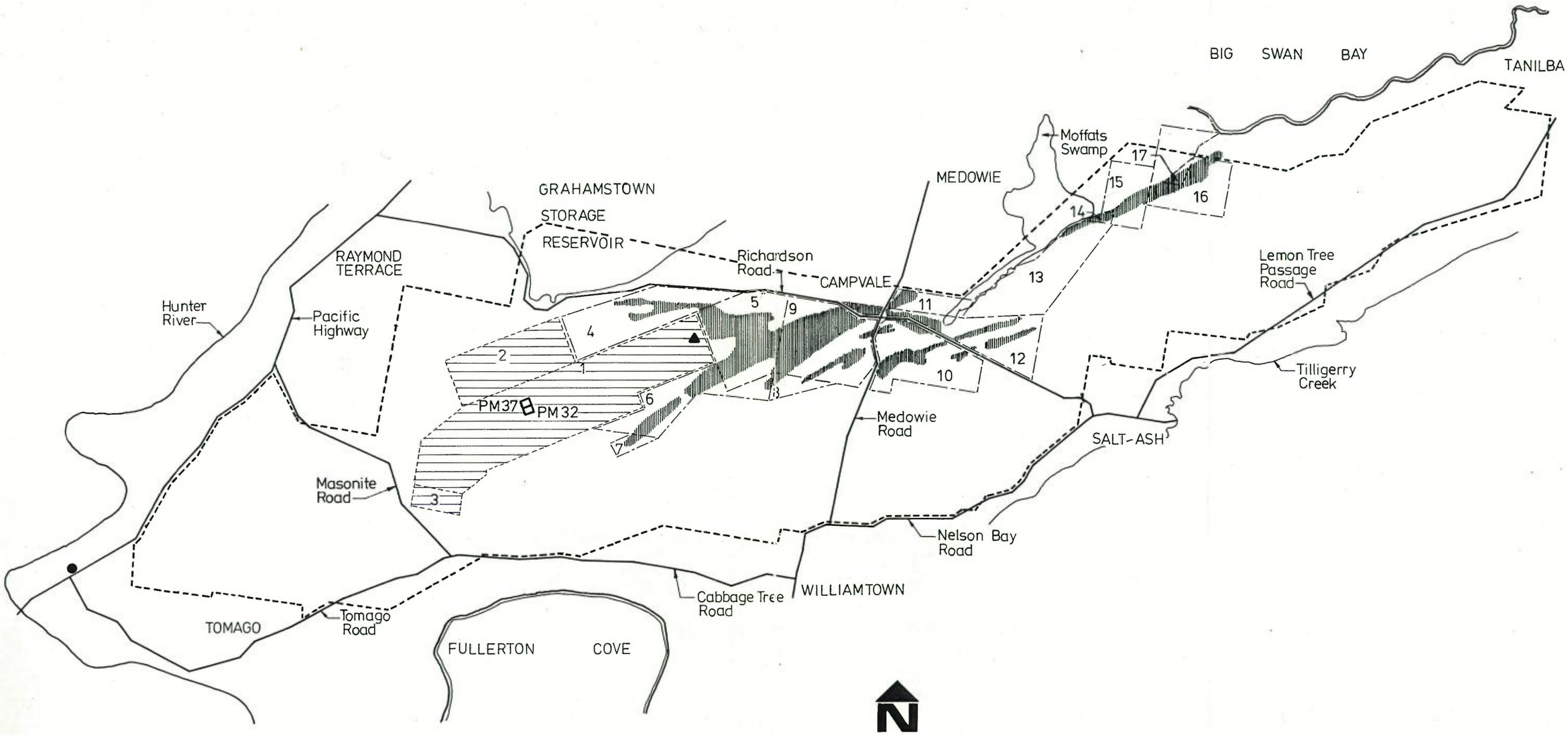
The proposed mining areas are presently gazetted as a number of Mining Lease Application (M.L.A's). Figure 1 shows the location of the relevant M.L.A's listed in Table 1. Details of the land tenure of the subject area is outlined in Appendix 2.

TABLE 1

MINING LEASE APPLICATIONS

Application No.	Date of Lodgement	Parish	Area in Hectares
256	12.5.69	Sutton	6.374
263	15.7.70	Stowell	259.0
1151	13.12.72	Sutton	12.14
1155	9.3.73	Stowell	32.2
1163	18.6.73	Eldon	223.0
1166	18.6.73	Eldon	155.2
1168	18.6.73	Eldon	220.2
1169	18.6.73	Stowell	198.5
1170	18.6.73	Stowell	207.2
1171	18.6.73	Stowell	227.1
1173	10.9.73	Stockton	19.22
1175	10.9.73	Stowell	57.42
34	31.5.78	Stowell	186.8
35	31.5.78	Stowell	108.4

This Environmental Impact Statement has been prepared as required under Section 77 (3) (d) of the Environmental Planning and Assessment Act (1979)



LEGEND

- Catchment Boundary
- Duckhole Trig Station
- MLA Boundaries
- Mining Leases Currently being Mined
- Mineralised Ore Bodies included in this Proposal
- Tomago Dry Mill

1 ML 594 (Act 1973)
2 ML 785 (Act 1973)
3 ML 744 (Act 1973)
4 MLA 1163 (Act 1906)
5 MLA 1168 (Act 1906)
6 MLA 1166 (Act 1906)
7 MLA 1173 (Act 1906)
8 MLA 1155 (Act 1906)
9 MLA 263 (Act 1906)
10 MLA 1170 (Act 1906)
11 MLA 1175 (Act 1906)
12 MLA 1169 (Act 1906)
13 MLA 1171 (Act 1906)
14 MLA 256 (Act 1906)
15 MLA 35 (Act 1973)
16 MLA 34 (Act 1973)
17 MLA 1151 (Act 1906)

LOCATION OF MINING LEASE APPLICATIONS HELD BY THE COMPANY

FIGURE 1

in support of an application to the Port Stephens Shire Council for development consent. The document also complies with the provisions of the Commonwealth Environment Protection (Impact of Proposals) Act 1974.

It forms the basis of applications for approval by other government departments and statutory authorities including the Department of Mineral Resources, the Board and the State Pollution Control Commission.

Further details on the respective roles of these local government, State government and statutory authorities are given in Appendix 3.

The Statement details the procedures proposed to safeguard the environment and assesses their effectivness. It also addresses the social and economic impacts of the proposal. Every attempt has been made to consider all potential environmental effects and report the results of all investigations.

No omissions are intended and the Company is most willing to provide supplementary information to clarify any aspect which may appear to be accounted for in insufficient detail.

2.2 CORPORATE BACKGROUND

Rutile & Zircon Mines (Newcastle) Limited is a Company owned by Peko-Wallsend Ltd. (50 per cent) and Coffs Harbour Rutile N.L. (50 per cent).

2.3 BACKGROUND TO THE PROPOSAL

In 1965 the mineral deposits under prospecting titles granted by the Department of Mineral Resources and approved by the Board were defined. The Company then sought and received approval from the Board to mine a non-productive portion of the aquifer at Tomago on a trial basis.

Located on the southern perimeter of the catchment area, operations commenced in July 1967 and ceased in June 1971. The Company engaged the Civil Engineering Department of the University of Newcastle and Water Science Laboratories of Melbourne as independent consultants to undertake an

investigation of the effects of mining operations on the yield and quality of the aquifer. The results of the investigations were presented to the Board and a request was made for permission to contine mining on a trial basis in areas within mining titles held by the Company in the Tomago Sandbeds.

On the basis of data supplied by the Company and intensive investigations undertaken by the Board's consultants, Ercon Australia Limited (Soil Mechanics Limited London), operational safeguards were formulated to permit mining to commence on a trial basis in the main orebody of the sandbeds.

The earlier investigations found that there was an increase in the iron content in the water approximately twelve months after mining, and this led to the Board requiring the Company to treat the dredge pond water for the removal of slimes which accumulate at the bottom of the pond. The increase in iron was considered to be related to either biological or chemical changes taking place and possibly associated with the slimes at the bottom of the dredge pond.

The original monitoring programme also considered the recharge and water retention characteristics of the mined areas together with water yields and the adequacy of the revegetation techniques.

In December, 1970, the Company applied to Port Stephens Shire Council for development consent in respect of its proposed mining operations within the Tomago Sandbeds Catchment Area, comprised in M.L.A's 1048 and 263. Council resolved to approve the Company's proposal on the 19th January, 1971, subject to the concurrence of the Board and the then Minister for Mines. The conditions approved by the Board relating to mining operations were included in the Minister's consent to mine, granted in January, 1972.

Mining operations commenced in December, 1972, and since that time the operation has been continually monitored by the Board and their consultants to assess conditions pertaining to water quality, ground water recharge, water retaining characteristics, ground strata conditions and the re-vegetation programme. Since 1972, the operations of the Company have fully complied with the mining requirements attached to the Board's approval.

Subsequently the Company sought the approval of the Board to extend its existing mining operations for orebodies outside the M.L.A. 1048 and approval was granted subject to compliance with further conditions which are now incorporated as the Conditions of Authority in Mining Leases 594, 744 and 785. After obtaining the respective approvals from the Board the Company made successive applications to Port Stephens Shire Council for development consent in respect of its existing use in February 1978 and October 1978. Council granted development approval with the concurrence of the then NSW Planning & Environment Commission in June 1978 and March 1979.

In addition, the Department of Mineral Resources referred the remaining M.L.A's within the Tomago Sandbeds Catchment Area to the Commission. As a result, the Commission recommended to the Company in February 1979 that it make only one application for development consent for all the remaining areas to be mined in the locality, rather than a series of extensions to mining leases granted with the approval of the Board. The Commission also recommended that the Company submit an Environmental Impact Statement covering such a submission.

The Company has proceeded, with the approval of the Board, to complete further field survey work and orebody definition in those areas of the sandbeds covered by the Company's M.L.A's.

In 1977 the Company also submitted proposals to the Board for mining operations to be undertaken outside of the main orebody within areas of Crown and privately owned lands situated north of Cabbage Tree Road at Williamtown. The orebodies were contained in sand dunes located along the southern boundary of the Board's catchment area, with mineralisation occurring above the groundwater table.

The Board's approval to undertake mining operations in this area was given subject to special conditions relating to depth of mining being restricted to a datum determined above the established groundwater table, with no treatment of processed slimes, and with conditions relating to the re-vegetation programme. Application for development approval was made to Port Stephens Shire Council in April 1977 and approval granted in December 1977.

2.4 OUTLINE OF THE COMPANY'S EXISTING MINERAL SANDS MINING OPERATIONS IN THE AREA

The Company has operated recently at Tomago, Bulahdelah and Harrington near Taree. The location of the Tomago mining area is shown in Figure 2 where two wet mining plants are dredging Pleistocene, Inner Barrier sands and secondary sand dunes within the Tomago Sandbeds. The nominal capacity for processing sand from these two plants is 500 t/h.

A mineral separation and processing mill located at Tomago is also operated by the Company. The Tomago mill receives concentrates from the two mining plants working in the sandbeds nearby. The average heavy mineral content of concentrates received from these plants during 1981 was 33 per cent rutile and 44 per cent zircon.

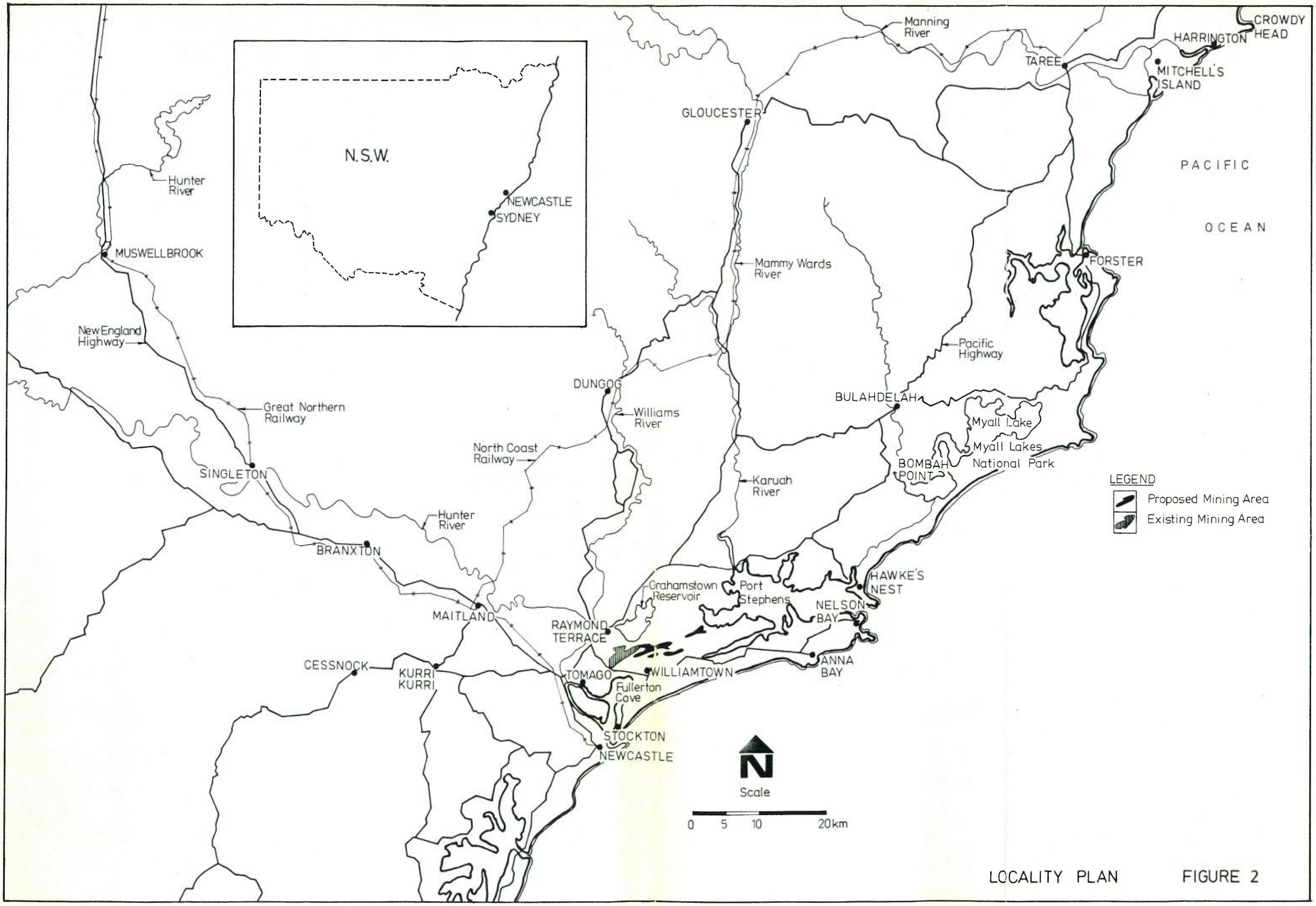
Other heavy minerals such as ilmenite, monazite, leucoxene, tourmaline, cassiterite and garnet represented a further 9 per cent of the material extracted.

Final product destined for export is transported by road from the separation mill to the Port of Newcastle whilst the Australian market is serviced by the road and rail network.

The mining leases held by the Company in the Tomago Sandbeds Water Supply Catchment Area relevant to this proposal are listed in Appendix 4.

2.5 WATER SUPPLY FROM THE TOMAGO SANDBEDS

The Tomago Sandbeds area represents one of three major sources of domestic water for the Newcastle region and was first brought into use in 1939. The Tomago Sandbeds Water Supply Catchment Area was proclaimed under the Hunter District Water, Sewerage and Drainage Act 1938 by notification in New South Wales Government Gazette No. 89 of 11th July, 1941. Together with later amendments and additions thereto, the catchment area now comprises an area of approximately 106 km^2.



LOCALITY PLAN FIGURE 2

LEGEND

--- Catchment Boundary

---H.D.W.B. Roads

• Primary Pumping Stations

▲ Duckhole Trig Station

■ R&Z Mines Waste Water Treatment Plant

2 Water Table Contours (A.H.D) from 14th June 1977 to 16th June 1977 (no Stations Pumping) Average Water Level by Weighted Mean = 4·974m

Existing Settlement Ponds

Proposed Settlement Ponds

Big Swan Bay

MEDOWIE

Moffats Swamp

Grahamstown Reservoir

Campvale Swamp

Medowie Road

Lemon Tree Passage Road

Pacific Highway

Richardson Road

Hunter River

SALT ASH

Nelson Bay Road

Tilligerry Creek

Masonite Road

WILLIAMTOWN

Dawsons Drain

Cabbage Tree Road

TOMAGO

Nelson Bay Road

Fullerton Cove

Hunter River

Newcastle Bight

N

Scale 1:70 000

0 1 2 3km

GROUNDWATER CONTOURS AND WATER BOARD PUMPING STATIONS

FIGURE 3

The 21 deep and shallow pumping stations extract water from most of the catchment as shown in Figure 3. Water is supplied to a central treatment plant at Tomago before being pumped to reservoirs for distribution.

The quantity of water stored in the sandbeds is variable and generally related to rainfall patterns, recharge and use. The storage potential of the sandbeds has been estimated to be between 110 and 160 x 10^9 L.

In 1977-78, a total of 13.57 x 10^9 L of water was delivered to the Newcastle area from the Tomago Sandbeds. This figure represented 16 per cent of the total domestic water requirements at that time.

In 1980 during a prolonged dry spell up to 40 per cent of the Board's domestic supply was being extracted from the sandbeds. The peak volume of water that has been extracted in any one year is approximately 26 x 10^9 L.

The other main sources of domestic water are Chichester Dam and Grahamstown Reservoir which jointly delivered 71 x 10^9 L of water in 1977-78.

Greater demands are placed on the sandbeds water supply during the summer months. The number of pumping stations delivering water to the treatment plant at any one time is dependent on demand, water quality and the storage situation with regard to other sources.

The operations over a twelve months period at any one pumping station follow no particular pattern. Stations with consistently better water quality tend to be used more frequently, but when demand is high, water from other stations augments the supply.

The Board is investigating the feasibility of upgrading and increasing the capacity of existing pumping stations. Studies are also being carried out to determine the possibility of placing additional stations within the sandbeds to increase supplies.

There has been no evidence to date to suggest that the present rate of water extraction has caused a decline in the groundwater supply or quality.

2.6 PAST AND PRESENT ENVIRONMENTAL INVESTIGATION AND REPORTS

The Company, the Board and their respective consultants have periodically produced reports on mineral sand mining in the Tomago Sandbeds. Aspects of the mining development that have been studied include:

i. The procedures adopted in preparing the site for mining.
ii. The phases and techniques of post-mining rehabilitation.
iii. The treatment of waste water.

The four year trial operation conducted on the southern fringe of the sandbeds (referred to in Section 2.3) provided the opportunity for monitoring and assessing the environmental impact under actual mining conditions. Prior to, during and after mining, the soil structure and stratigraphic character was monitored carefully. Permeability, pH, presence of dissolved salts, distribution of fine solids as well as the pollution from machinery and the operations in general were assessed. Extensive trials were initiated with respect to vegetation rehabilitation procedures.

As a result of this trial, the Board formulated conditions under which the Company would be permitted to mine within the sandbeds catchment area. The Company has adhered to such 'Special Conditions of Authority' as listed in Appendix 5 since that time.

As a matter of policy, the Company undertakes extensive investigations and monitoring of all mining operations within the Tomago Sandbeds. Studies are initiated throughout all phases of heavy mineral extraction.

Pre-mined areas are examined for topographic and botanic characteristics. Post-mining aspects of the projects are also monitored.

To facilitate the comprehensive monitoring of mining operations the Company maintains a N.A.T.A* registered laboratory with a staff of five chemists and technicians.

The direct consequences of the mining operation are reviewed every second week and on alternate weeks a field inspection is carried out.

* *National Association of Testing Authorities, Australia*

Every four weeks, a drilling rig is positioned immediately behind the dredging plant on the levelled tailings. A grid of 10 holes is drilled and undisturbed samples from the former pond bottom are extracted. These 6 to 10 m deep cores are examined for the presence of fine slimes, which are limited by the Board's specifications to 50 mm total slime in 10 holes or an average of 5 mm per hole. In any single hole the thickness of slime may not exceed 30 mm.

Every six months the rehabilitation areas are inspected and a technical session on plant growth is held. The total mining operation is reviewed annually by the Company, the Board, both parties' consultants and the Department of Mineral Resources. These procedures are additional to the normal inspection and control procedures carried out by the Department.

Reports that have been presented concerning mineral sands mining in the Tomago Sandbeds are listed in Appendix 6.

2.7 INVESTIGATIONS FOR THE PROPOSAL

The environmental investigations considered in this document are outlined as follows:

i. Examination of the Company's proposal

ii. A study of the components of the existing environment of the Tomago Sandbeds and other criteria likely to be affected by the proposal.

iii. An assessment of the Company's management of the constraints imposed on the existing mining operations with particular reference to water quality control and rehabiliation procedures.

iv. Identification of the significant aspects of the development which require safeguards.

v. An analysis of the potential impacts.

2.8 MANAGEMENT OF THE PROJECT

The environmental investigations for the project have been undertaken by

personnel from Croft & Associates Pty Limited. The study team assisting the Company officers included:

J.B. CROFT, B.E., Ph.D. (NSW)	Management of the Study.
W.B. GIBLIN, B.Sc. Dip.Ed. (UNE) Dip.Env.Stud. (Macq)	Project Co-ordinator, bio-physical studies, design of safeguards, interaction analysis and final report writing.
D.T. LACEY, B.Sc. Ph.D. (NSW)	Engineering investigations and design of safeguards.
P. RAY, B.E. (Swin., Vic)	Engineering investigations.
G. BARTRIM, B.Sc. Dip.Ed (UNE)	Fauna, flora studies.
A. MARTIN, B.Sc. (UNE)	Ecological studies, impact analysis.
S. GARLICK, B.A. (Econ.) (N'cle)	Socio-economic aspects.
L. PASLAWSKYJ, B.Sc. (N'cle)	Land use studies.
D. CLARK, B.E. (James Cook)	Noise studies.
J. WIGGERS, B.A. Dip.Ed. (N'cle)	Socio-economic aspects.

Section 3

Description of the Proposal

SUMMARY

This section delineates the objectives and scope of the proposal and describes the general features of the mining operation. A full description of the basic engineering, pollution control and rehabilitation features is also presented.

3.1 OBJECTIVES

Rutile & Zircon Mines (Newcastle) Limited seeks development approval to mine heavy mineral from the M.L.A's listed in Table 1 and shown in Figure 1. The proposal will enable the Company to maintain its present level of mining operations in the sandbeds once the ore in existing leases has been extracted.

The granting of mining approval will facilitate the continuity of development by the Company and guarantee employment within the Company and in associated industries such as road haulage contractors.

The Company has worked closely with the Board for the past 15 years to ensure the maximal development of mineral resources compatible with the optimum utilisation of water resources. The Company also liaises with the Port Stephens Shire Council to ensure that benefits accrue to the area.

3.2 SCOPE

The operations to which the Company seeks consent involve the gradual progression of existing mining operations to adjacent areas of the Tomago Sandbeds. Integral components of these operations are the refining and processing mill at Tomago, a wastewater treatment plant within Mining Lease 594 and slime disposal ponds at Williamtown. These are approved and licensed operations and do not form part of the proposed development.

They are, however, described in some detail in this Statement because of the importance of their role in the operation as a whole.

The Company proposes to mine reserves of heavy minerals located discontinuously in orebodies of varying width over 25 km of the sandbeds as shown in Figure 1.

It is estimated that an average of 25 000 t of rutile and 30 000 t of zircon will be extracted annually from the areas within this proposal during the complete mining operation. It is proposed that mineral will first be extracted from the main orebodies southwest of the Richardson Road/Medowie Road intersection area over a 14 year period. The reserves east of Medowie Road will be mined by a third plant as and when market conditions permit, and subject to the approval of the Board.

The proposed main orebody operation up to the Richardson Road/Medowie Road intersection will comprise two mining plants, one land-based and one floating in a 3.5 m deep dredge pond. Both plants will have a throughput capacity of 250 t/h. The area to be mined by these two plants will be at a maximum of 30 ha/y in accordance with the present constraints imposed by the Board.

Winning of the sand will be achieved by floating suction cutter dredges which will deliver a slurry to a concentrator plant. The heavy mineral concentrates will then be pumped to a stockpile and dewatered before being transported to the existing processing and refining mill at Tomago. Dewatered tailings will be discharged to the rear of the pond.

Periodically, small isolated pockets of heavy mineral which cannot be extracted using conventional dredging methods will be recovered by earth-moving equipment and transferred to the mining operation for processing.

All effluents from the two plants will be collected and pumped to a common clarifier/thickener with the clarified water being returned to the dredge ponds. Settled slime from the thickener will be pumped to ponds at Williamtown which, when filled and dry, will be grassed and used for flood-free grazing or turf production purposes.

The third mining plant to be located east of Medowie Road will be land-based and have a throughput capacity of 250 t/h. The mining procedures

to be adopted by this plant will be in accordance with conditions stipulated by the Board.

The procedures to be adopted for restoration and rehabilitation of the mine site are discussed in Sections 3.5.6 and 3.5.7.

The final products of rutile, zircon, ilmenite and monazite destined for export will be delivered by road from the mill at Tomago to the Port of Newcastle. Domestic supplies will be delivered to other parts of the country by road or rail transport.

The workforce directly associated with the two mining plants will be 79. Should approval be granted by the Board for the introduction of a third mining plant an additional 23 personnel would be employed on site. The Company is employing a further 109 personnel off site to support this operation and its other activities in the region. It is intended to operate the two mining plants on a continuous basis, with the third plant operating as required to supplement the economic production levels of the Company's dry processing mill at Tomago. The proposed operation has a life expectancy of 15 to 20 years.

Appropriate safeguards to minimise pollution and sources of potential impact have been designed and are detailed in Sections 3.5.4 and 5.1 to 5.5.

3.3 AREAS TO BE MINED

Those areas which the Company wishes to mine are represented by the M.L.A's delineated in Figure 1.

All proposed mining operations will be undertaken subject to the approval of the Board. Proposed mining paths, including direction and location of mining, will be submitted to the Minister for Mineral Resources and the Board for approval on an annual basis in addition to a five year forward plan.

The two mining plants now working on Mining Leases 594 and 785 are expected to complete these operations by 1986. One of the mining plants having previously mined the southwestern flank of the sand dunes denoted by Duckhole Trig. Station in Mining Lease 594 will progress in an east-north-easterly direction into the areas denoted by M.L.A's 1168 and 263. It is expected that, under the present constraints imposed by the Board, the total mining time in this area will be approximately 14 years. During this same period the second mining plant will mine the satellite orebodies within M.L.A's 1163, 263, 1155, 1168, 1166 and 1173.

It is proposed that a third land-based plant will extract heavy minerals from M.L.A's 1175, 1169 and 1170 to the north and east of the Medowie Road/ Richardson Road intersection over a total period of approximately four to five years. The orebodies located in M.L.A's 1171, 256, 35, 1151 and 34 near Moffats Swamp at Salt Ash are remote from the other orebodies and will also be mined by this plant over a two year period.

It is anticipated that the third plant will only operate beyond the main orebody area, but for reasons of logistics or market economics, the second plant referred to above may also move to areas outside of the main orebody from time to time.

3.4 GEOLOGICAL FRAMEWORK

3.4.1 Site Geology

The mining proposals are designed to win heavy minerals from placer deposits found in dunes and undulating sand plains. These features are part of the Inner Barrier Dune System which extends along the coast from the Lower Hunter River Estuary to the southern side of Port Stephens.

Commonly called the Tomago Sandbeds, these unconsolidated sands, approximately 10 km inland, were deposited in the recent geological past during the Pleistocene period.

The Inner Barrier sands contain heavy mineral deposits formed as a consequence of wind and wave sorting action. This has resulted in the concentration of rutile, ilmenite, zircon, magnetite, monazite, tourmaline, garnet and other silicates into locally discrete bodies called heavy mineral placers. The zones of concentration were preserved by subsequent burial as lens-shaped horizons of varying thickness.

Between this Inner Barrier and the present shoreline is a more recent (Holocene) Outer Barrier Dune System and extensive estuarine swamps and flats.

3.4.2 Exploration

Rutile & Zircon Mines (Newcastle) Limited began lodging M.L.A.'s for the Tomago Sandbeds in 1965. Since that time the Company has undertaken, with the permission of the Board, extensive field survey work, orebody definition and plan preparation. The Company proposed that certain groups of M.L.A's be considered together for the granting of a Mining Lease as contiguous areas separated by public or main roads which act as logical boundaries.

Drill hole exploration has revealed stratiform deposits of beach placers preserved in succession, each dipping at a shallow angle towards the original stormwave transects.

The extent of mineralised zones was ascertained following detailed analysis of core samples taken above and below the water table.

3.4.3 Reserves

Reserves held by the Company lie along a former beachline approximately 10 km inland from the present shoreline of Newcastle Bight. The orebodies are considered to be of average grade with the sands containing between 1.5 and 2 per cent heavy minerals. The economic reserves stretch in a narrow band for some 25 km. Exploration activities indicate that the heavy mineral deposits are of higher grade in the southwest of the proposed mining area and decrease in grade northwards along the orebody. It is estimated that approximately 1 million tonnes of economically extractable heavy mineral

ore lie in the reserves.

3.5 MINING OPERATIONS

3.5.1 Pre-Mining Assessment

Before any action involving the clearing of the mining path is initiated, a topographical and vegetation survey will be undertaken.

Contour Surveys

A 1:4000 map with contour intervals of 1.5 m indicating the topography will be drawn together with a map delineating the groundwater levels.

Vegetation Survey

A 6 m wide continuous transect for seed collection and identification purposes along the mining path will provide a pre-mining assessment of the vegetation. Existing plant associations will be determined from aerial photographic interpretation together with subsequent verification by ground survey. The diversity and density of species will then be identified using three nested quadrats of 1m, 10m and 100m square as required by condition 160 of Mining Lease 594.

Table 2 indicates the heights that will be adopted for defining the various vegetation zones when undertaking the species count.

TABLE 2

HEIGHT SPECIFICATIONS FOR VEGETATION SURVEY

Vegetation		Height (m)
Overstorey:		
Trees	exceeding	8
Understorey:		
Trees		5-8
Shrubs		1-5
Ground cover		0-1

All records will be filed in the Company's herbarium.

Collection of Native Seeds

Prior to clearing, seeds of all the tree species and some of the shrub species will be collected from the area to be disturbed by mining. The quantity of seed collected will be sufficient to satisfy the anticipated direct planting and nursery requirements of each species.

The seeds of most species are available only at certain times of the year. To ensure that an adequate supply of seeds is kept on hand throughout the year, mature seeds may be collected from other parts of the mining path yet to be cleared or from areas adjacent to the mining path. If seeds of some species are still unavailable (for example, a particular tree species), supplies will be purchased from the New South Wales Forestry Commission.

Hunter District Water Board Installations and Mining Operations

In any area where installations of the Board overlie the orebody, the Company will undertake a comprehensive economic analysis to determine the mineral value and the cost of replacement or relocation of the facilities.

In the event of the results indicating that mining is warranted, the Company will submit a proposal to the Board suggesting relocation or replacement of the installation. If approved, as was the case with the relocation of Number 6 Pumping Station, all associated costs will be borne by the Company in accordance with conditions 143, 144 and 178 listed in Appendix 5.

3.5.2 Site Preparation

Clearing of Vegetation

After the mining path has been surveyed and mined, the vegetation cover up to 120 m in advance of the dredge pond will be cleared. The width of the mining path will vary from 60 m to 150 m, depending on the type of plant and method of mining employed.

Trees will be cleared by bulldozer from the surveyed mining path and minimal adjacent areas to allow for topsoil stacking and provision of services to the mining operation. The fallen timber will then be stacked on the mining path and burnt as permitted. The understorey species will be removed with the tospoil.

In areas within the orebody where mineral values are considered too low to warrant extraction, and to comply with the specific requirements of the Board, islands of native vegetation will be left between mining runs to:-

i. provide a source from which the natural propogation of new vegetation will take place,

ii. avoid any significant uninterrupted views across the mining area, and

iii. dissipate prevailing winds.

In areas of high grade minerals, artificial islands of vegetation will be created by the concentrated planting of native species to comply with the Board's requirements as outlined in the mining lease conditions.

Access across the islands will be restricted to an absolute minimum. While mining is in progress, adjacent islands will be clearly marked to protect them from unnecessary incursions.

Topsoil Removal

The topsoil will be stripped to a depth of 300 mm and stockpiled in windrows one on either side of the mining path.

The understorey and ground cover vegetation left after the initial clearing operation will be removed with the topsoil and stockpiled in the windrows.

This procedure ensures that plant propagules of many of the smaller species are not destroyed by burning, but are returned to the site with the topsoil after mining.

After reinstatement of the mined area, topsoil will be replaced by mechanical means to a position approximating its original location.

Root combing to a depth of 300 mm will be undertaken after topsoil removal in those areas considered to have heavy root concentrations.

3.5.3 Extraction of Heavy Minerals

The specifications of the two mining plants which will operate on the main orebody as described in Section 3.2 are outlined in Table 3. (Both these plants are now operating within mining leases held in the Tomago Sandbeds.)

Should a third plant be introduced it will have the same capacity as the land-based plant and will be equipped with pollution controls which meet the requirements of the Board.

TABLE 3

MINING PLANT SPECIFICATIONS

Plant	Dimensions (m)	Weight (Deadweight Tonnes)
Floating Plant:		
Dredge	21 x 9	130
Concentrator	60 x 20	500
Land-based Plant:		
Dredge	21 x 9	130
Concentrator	50 x 20	400

It is proposed that the floating plant will work on orebodies which permit continuous mining whilst the land-based plant will mine on orebodies where continuity is not possible.

Both plants will extract the sand using electrically powered suction cutter dredges fitted with 300/250 mm centrifugal gravel pumps. The sand will be mined to a depth of 6 to 10 m but generally not below R.L. -1.0 A.H.D. The resulting sand slurry will be pumped to the floating or land-based concentrator via 250 mm delivery lines. The mined material will then be passed over a primary screen to remove trash before entering the surge bin. The

trash will be delivered to the top of the tailings pile.

The two plants feature autogenous grinding drum scrubbers to reduce recoverable primary screen oversize which is then fed back into the surge bin.

After passing through the surge bin, the sand is fed through a three stage concentrator with the final concentrate being pumped to a dewatering cone close by. Details of the primary concentrating equipment are discussed in Appendix 7.

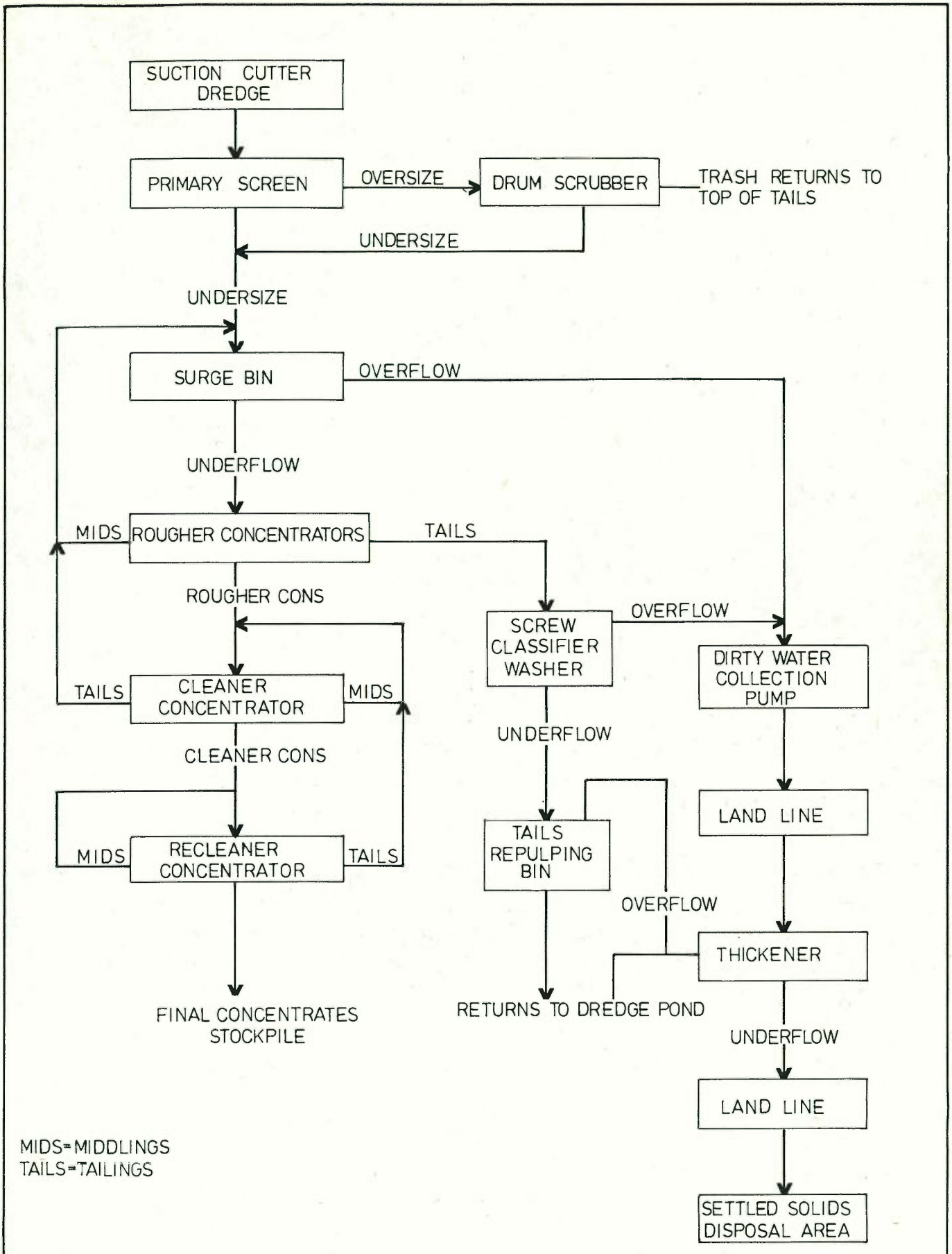
Road haulage trucks will transport the concentrate to the separation mill at Tomago.

Figure 4 showing the operations of the mining process, indicates that tailings (i.e., the unwanted portion of the solids) are discharged from the concentrators and are passed to a screw classifier and washer. This is a plant commonly used in the mining industry for the continuous separation of coarse particles (sands) from a slurry of fine particles called 'slimes'.

The tailings slurry is fed at an intermediate point along an inclined trough and is continuously raked upwards by large, slowly revolving screws.

The heavier particles are raked towards the top end and in so doing are scrubbed and washed clean. These solids will be returned to the rear of the dredge pond (that section already worked) via stackerbooms on the floating plant and a pipe from the land-based plant. The lighter fraction in the washer moves upwards and is removed with the bulk of the entering water as a muddy effluent.

In essence, the combination of mining plant concentrators and screw-classifier will produce three products from the sandbed soils - heavy mineral concentrates (further refined at Tomago mill), cleaned tailings stripped of heavy minerals (returned to the dredge pond) and muddy water. The treatment of this latter stream is described in Section 3.5.4.



MINING PLANT FLOWSHEET FIGURE 4

3.5.4 Pollution Control Plant

i. Water Quality Control

Process Effluents

The operations presently being undertaken and those proposed and described in this Statement are not generators of water pollutants in the traditional sense. No chemical changes occur and no contaminants are produced that cannot be readily removed by conventional water treatment practice to protect the quality of ground and surface waters.

In essence the operations cause disturbance of the soil layers, create changes to the physical characteristics of those soils and generate liquid effluents containing finely divided silt and clay particles.

For the two dredges operating on the main orebody, it is proposed to treat these liquid effluents in plant that is in existence and that has been used successfully for this purpose for the past nine years. The proposed relocation of mining operations, for which approval is sought, will not create additional volumes of effluents but will simply extend by a period of 15 to 20 years the generation of effluents of almost identical volumes and characteristics.

The muddy water leaving the screw classifier as overflow will flow by gravity to a collection sump from where it will be pumped to the Company's wastewater treatment plant located near the Board's main access road west of pumping station No. 5 (Figure 3 shows this location). It is anticipated that the water will contain finely divided suspended silt and clay at concentrations of around 4000 mg/L (99.6 per cent water, 0.4 per cent solids by weight). The flow rate of this influent to the treatment plant is presently 400 L/s (35 ML/d) and is constant over 24 hours each operating day. A similar flow rate is anticipated for the two mining plants phase of this proposal.

The treatment plant consists of a Warman-Envirotech clarifier/ thickener 46 m in diameter equipped with a flash-mixing tank for effluent collection and settled slime storage of 32 hours capacity.

Upon arrival at the thickener, the influent will be dosed with a potable polyelectrolyte coagulant of types approved by the Board. Depending on soil conditions at the mine site, the polyelectrolyte will be either ionic or non-ionic. (The type and dosage rate will be chosen to achieve optimum conditions for coagulation and flocculation of the suspended matter.)

The flocculated water will enter a stilling well and thence the main settling compartment. The unit is sized to allow the coalesced flocs of solids to settle rapidly to the bottom where they are mechanically raked continuously to a central draw-off mechanism and discharged to the slime holding tank.

The clarified supernatant overflows circular weirs to a launder and thence to a clearwell from where it will be pumped back to the dredge pond. This overflow contains, on average, 100 mg/L of suspended solids, representing an overall treatment efficiency of approximately 97.5 per cent. (The monitoring of the effect of this recycling operation on the quality of the sandbeds aquifers is discussed in Section 5.2.)

Settled slime may be pumped daily, over a period ranging between 8 and 24 hours as required, to slime ponds 5 km away at Williamtown. Extended pumping hours may be necessary when the mining plants are in areas of high silt and clay content. This slime will contain solids ranging from 140 000 to 450 000 mg/L (14.45 per cent by weight, approximately).

The ponds located outside the sandbeds catchment area as shown in Figure 3, have a total surface area of 30 ha. (The Company has recently received consents to develop a further 50 ha of ponds on its own freehold lands at Williamtown.)

The average volume delivered daily will be about 0.67 ML containing (on a dry weight basis) about 93 t of solids.

To assist in the drainage of the swampy areas surrounding Fullerton Cove, all local landholders are members of an organisation entitled *"The Longbight and Williamtown Drainage Union"*. The union oversees maintenance of communal drains in the area under the auspices of the Department of Public Works. One such drain is Dawsons Drain which is shown on Figure 3. The Company has a licence (issued by the State Pollution Control Commission under the Clean Waters Act) to discharge high clarity water from the surface of the ponds into this drain.

A copy of this licence is given in Appendix 8 and in Section 5.2 the results of operation of these ponds and compliance with the licence conditions during past years are discussed.

The quality of the effluent discharged from the slime ponds into Dawsons Drain is monitored weekly and these results are shown in Appendix 9.

The solids in these ponds will dry out to yield a soil suitable for sustaining pasture growth and when a pond reaches maximum capacity it is the Company's intention to utilise the area for the flood-free grazing of livestock or for turf production purposes.

Oil Spillages and Sanitary Wastes

Oil spillage will be controlled by imposing a strict maintenance standard and by the employment of personnel to clean down the decks of the dredges. Oil dispersants will not be deposited in the pond. Oil and the material used to trap any spillage (such as sand or sawdust) will be placed in bins and removed from the site. Within the dredge a detergent is to be used for cleaning purposes and the effluent will be mopped up and removed in sealed bins. All garbage will be removed from the site in bins.

In the event of contamination, soil from the affected area will be removed and the groundwater tested.

Toilets will be of the flushing type. All effluent will be held in

tanks, the contents of which will be removed from the site periodically by a sanitary contractor.

Shower and meal room effluents will also be pumped ashore to holding bins which will similarly be emptied by the sanitary contractor.

ii. Air Quality Control

The operation as described above entails wet processing from the beginning to the end. No specific air pollution control plant is proposed although (as discussed in Section 5.3) road watering will be employed if dust emissions from unsealed roads become significant at any time.

Heavy earthmoving equipment used in the mining operation will be equipped with spark arrestors to eliminate the possibility of fire hazard.

iii. Noise Control

The mining and separation plants are electrically operated and no specific acoustic treatment is proposed. These plants will operate 24 hours per day and their effects on the noise climate are discussed in Section 5.4. Studies of the Company's existing operations show that the plants generate a sound pressure level of 49 dB(A) at 50 m; this is equivalent to a point source noise level of 83 dB(A) at 1 m.

The bulldozers used to clear the mining path and reshape the tailings generate measured exhaust and engine noise levels of 105 dB(A). Except in emergencies these dozers will operate during daylight hours only. It is proposed to equip the dozers with high performance silencers, engine enclosures and modified cooling fans to achieve an additional reduction of both engine and exhaust noise emissions of around 15 dB(A).

This equipment will be fitted when mining operations are in close proximity to residences at Campvale.

The reasons for this and the resultant diminution in impacts are discussed in Sections 5.4 and 6.5. Haul trucks will be fitted with exhaust mufflers and will be maintained in accordance with the manufacturer's specifications to ensure that the rated noise levels are not exceeded.

3.5.5 Separation and Refinement of Heavy Minerals

The existing 20 t/h heavy mineral separation plant at Tomago will receive the concentrates from the mining operations.

The average rutile and zircon content of all the heavy mineral received by the Tomago plant in 1981 was 33 per cent and 44 per cent respectively.

Appendix 10 outlines the separation process employed at the Tomago refining plant.

3.5.6 Site Restoration

The tailings in the mined area will be contoured to a profile approximating that which existed before mining.

The topsoil which will be stored for an average period of three months will be replaced in the area from which it was removed. A front-end loader will collect the soil from the stockpile area and distribute it in dumplings at or near its final location and the spreading of the residual stockpiles and dumplings will be carried out by dozers. Care will be taken to ensure that the replacement conditions, with respect to topography, are similar to the original conditions. (For instance, every attempt will be made to ensure that topsoil from low-lying areas is replaced in low-lying restored areas.)

In the edge-zone bordering the disturbed and undisturbed areas, any residual topsoil and sand stockpiles will be spread back over the area to be restored.

Where access corridors have been cut through unmined areas, those parts affected will be replanted after use.

To assist in the planning of site restoration, a sketch plan will be prepared each fortnight showing the location of:

* area stripped for mining
* topsoil stacks
* mining plant
* recontoured tailings
* respread topsoil
* irrigation plant (if used)
* replantings.

A list of species and the quantities planted out during the period will also be attached. This report will then be tabled to the Board's representatives at regular fortnightly meetings.

3.5.7 Revegetation

Nursery

The Company has developed an extensive nursery to establish seedlings to be used later in the revegetation programmes. Seedlings will be established from seeds collected in the areas to be mined. Upper storey species will be raised in the nursery in sufficient quantities to achieve the revegetation standard required by the Board and the Department of Mineral Resources.

Subject to the prior approval of the Board, seedlings may be raised from seeds of regionally indigenous species obtained outside the proposed mining area.

Nursery procedures are set out in Appendix 11.

Trial Plots

Trial plots have been established in previously mined areas in the Tomago Sandbeds to determine the relative performance of selected species of seedlings under varying topographical conditions. The results from these experiments have provided information useful in the revegetation programme.

Cover Crops and Brush Matting

Cover crops will not be used unless such a procedure is considered necessary to prevent soil erosion. The disadvantages of cover cropping are that it deprives the naturally recurring species of nutrients and is an avenue for the introduction of exotic weeds and grasses.

Cover crop seed, if used, will be sown sparingly at a maximum rate of 4.5 kg/ha. Seeding will be by drilling or rolling immediately after topsoil has been replaced. The application will be sufficient to achieve the objective of providing stabilisation of the soil on an interim basis.

Permitted cover crops include Japanese Millet in summer, Cereal Rye in winter and a mixture of both in autumn. Sorghum may also be used with Japanese Millet in summer. Seeds from species such as Melaleuca and Leptospermum collected from the area may be mixed in with the cover crop. The latter species will not be used in areas where natural regeneration from seeds contained in the topsoil may occur, for example in the higher elevation areas. Sally Wattle *(Acacia sauveolens)* and Coastal Wattle *(Acacia sophorae)* seeds may also be included in the cover crop seeding in very small quantities. The average seeding rate will be 250 seeds per hectare.

In addition sorghum may be used as a screen planting in order to provide wind breaks.

In areas where cover cropping has failed to prevent soil erosion due to blowouts or mechanical disturbances, brush matting or branches cut from vegetation on the mining path, will be employed.

Fertiliser Application

The option to use fertilisers on restored areas is available. Present practice however is to use no fertilisers as past trials have indicated an insignificant vegetation response.

Should fertilisers be used, applications will be in accordance with the Board's constraints as outlined below:

* Upper total limit of phosphorus permitted - 41 kg/ha.

* Amount of phosphorus per application - 3.5 to 6.8 kg/ha.

* The first application should be immediately after topsoil replacement. The maximum number of applications permitted in any twelve months is four and there should be not less than two months between successive applications.

Planting Out of Seedlings

Seedlings will be planted out immediately after site restoration (in association with irrigation) if no cover crop is used. If a cover crop is sown and suitable conditions exist, seedlings will be planted out as soon as practicable after the cover crop is able to afford reasonable protection.

The planting of species will be in the proportions indicated by the species count prior to clearing, subject to such aspects as elevation and water table level.

The upper storey species considered most suitable to be planted out as seedlings under specific conditions are listed in Appendix 12.

The selection of indigenous taller shrub and small tree species will be at the discretion of the Company, subject to the conditions of the area concerned and the availability of seedlings.

Where initial wind breaks are established with sorghum plantings consideration will also be given to supplementing these with denser plantings of seedlings on the lee side of the sorghum.

When seedling losses are severe, replacement planting will be pursued.

The islands of native vegetation left after site clearing will encourage the revegetation of adjacent disturbed areas by providing shade and seed from mature trees.

Irrigation

The Company's planting programmes are subject to adequacy of rainfall.

In the event of extended dry spells occurring, the areas to be planted will be irrigated prior to and after planting. Approval for such procedures will first be obtained from the Board.

Control of Troublesome Flora and Fauna

Measures will be taken to control vegetation species which may hamper regeneration if left unchecked. Species such as Rhodes Grass, Pampas, Red Natal and Wild Tobacco will be controlled by the herbicide "Roundup", subject to controls imposed by the Board.

In the Company's experience there has been only a minor occurrence of Bitou Bush on isolated parts of the mined area. It is proposed that any seedlings encountered will be either controlled as above, be removed manually by the field services crew and burnt, or transported to an area outside of the catchment area for destruction. Care will be taken to avoid contamination of unaffected areas.

Feral pigs inhabit the area and have the potential to frustrate the revegetation programme. Action may be taken by the Board to trap the pigs in corrals and to remove them from the catchment area if considered necessary.

3.5.8 Post-Mining Assessment

On the completion of each mining run the restored area will be surveyed to provide a contour map comparable in detail with the pre-mining survey.

Assessment will commence after the physical completion of the mining operations and restoration of the topography.

Periodic surveys of the revegetated areas will be made to assess and record the species composition and frequency of occurrence of individual woody species and the extent of cover by grass species. Findings from such surveys will assist in the establishment of a basis for future revegetation techniques. (For instance it may be necessary to plant out additional seedlings or to sow seeds of different varieties.)

Permanent Marks (PM's) which represent one month's mining advance, will be established by survey prior to mining, for future reference during the post-mining revegetation assessment.

Those areas eligible for assessment will have had at least two post-restoration growing seasons. The interval between assessments will be of two years' duration.

These surveys will enable decisions to be made concerning the time at which the Company's responsibilities may be terminated within the conditions of the mining lease. Based on past experience, the Company expects to maintain rehabilitation of vegetation until the flora has reached a self-sustaining state.

Specific reviews of the progress of the revegetation programme will be made at six monthly intervals. At these meetings the parties specified in Section 2.6 will discuss the relevant issues following a field inspection.

3.6 TRANSPORT OF PRODUCTS

The concentrate produced by the mining plants will be hauled up to 31 km by road to the separation mill at Tomago. Vehicles will traverse public roads as well as those constructed by the Board and the Company.

A company road located on the southern side of the mined orebody in Mining Lease 594 will provide access to the proposed mining areas southwest of the intersection of Richardson and Medowie Roads at Campvale.

Concentrate mined to the west of Medowie Road will be hauled a distance of 18 km to the mill at Tomago via the Company's and the Board's access roads, Masonite Road and the Pacific Highway. (Public roads will represent 8.8 km of the journey, mining access roads up to 7 km, and the remainder will be roads constructed by the Board.)

When mining operations are undertaken on the orebodies to the east of the

Richardson Road/Medowie Road intersection, the use of public roads is likely to increase resulting in a trip of some 30 km. The Company is examining three options for the most suitable transport route to the mill from Campvale, namely:

i. via Richardson Road and the Pacific Highway

ii. via Medowie Road, Williamtown Road, Cabbage Tree Road and Tomago Road

iii. a combination of the Board's roads, extended mining access roads and public roads.

At this stage no decision has been made on the most suitable route.

Over a 12 month period up to 3 km of road will be laid by the Company to gain access to the changing locations of the mining plant.

In consultation with the Board, the Company may seal those roads within the Tomago Sandbeds Water Supply Catchment Area considered likely to carry certain volumes of traffic for a number of years.

Company-constructed roads no longer in use will be removed at the Board's request. The Company will restore the condition of any road or track upon completion of the mining operations if required by the Board.

It is estimated that between 75 and 100 loads of heavy mineral will be transported per week from the mine sites to the separation mill. The weight of each truck load will range from 15 to 20 t.

In addition, about 20 other trips would be made each day in Company-owned cars and utilities.

Cartage of heavy mineral concentrate will be undertaken on weekdays during the hours of 7 a.m. to 3 p.m. with the occasional trip to 6 p.m. On average, the mined concentrate will be transported on only three or four days of the week.

The final product will be transported from the separation mill at Tomago to the Port of Newcastle along the Pacific Highway via Hexham, a distance of 17.6 km.

3.7 WATER SUPPLY

Water required for the mining and irrigation operations will be extracted from the sandbeds by a series of Company-owned pumping stations, the location and capacity of which are matters for determination by the Board.

Under terms and conditions imposed by the Board, the Company pays a rate of charge on the water abstracted from the sandbeds for use in connection with its mining operations.

Water is used within the mining operations, as make-up for the dredge ponds (when necessary) and for irrigation. The daily water balance for all purposes can be as high as 45.5 ML but the bulk of this water is actually returned to the sandbeds via percolation from the irrigation areas and recycling of clarified water from the wastewater treatment plant. In actual fact, the only losses that will occur include the quantities pumped with thickened slime to the drying ponds and evaporative losses (about 0.6 ML/d or 219 ML/y). This is approximately equivalent to the volume of water consumed by a town having a population of 1000. Such a population represents only 0.4 per cent of a city the size of Newcastle (population 251 120 [1976]).

The quality of the water recycled to the sandbeds will be no less than that of the groundwater in the same locality.

Factors to be considered in determining the location of the Company's pumping stations include:

i. The need for a satisfactory supply of water within close proximity to the mining plant.

ii. The need to minimise the draw-down effect on the water table.

iii. The priority of the Board's own pumping stations.

3.8 POWER SUPPLY

Approximately 8 132420 kW hours of electrical energy will be required per annum by the proposed mining operation. To maximise power usage the Company will install power factor correction equipment on the mining plants. Power will be provided by the Shortland County Council and the mobile nature of the development will require the erection of at least 35 spans of line per annum.

All electrical work will comply with the requirements of the Shortland County Council and the Standards Association of Australia (SAA).

Similarly all electrical machinery and equipment to be used in the project will comply with the current SAA Standards and in accordance with the provisions of the Mines Inspection Act, 1901, as amended.

3.9 ON-SITE OPERATIONS

3.9.1 Equipment

The equipment proposed to be used on-site for the extension of the existing operations on the main orebody and for general site works maintenance and supervision is listed below in Table 4. The mining plants will be in continuous operation seven days per week.

TABLE 4

EQUIPMENT LIST

Item	Number
Caterpillar D5 Bulldozer	2
Caterpillar D7 Bulldozer	1
Caterpillar 930 Front-end Loader	1
Hough Front-end Loader (3.8 m^3)	1

If a third mining plant is introduced an additional Caterpillar D5 Bulldozer will be necessary.

3.9.2 Personnel

The number of employees required for the proposed two-plant mining operation on the main orebody is shown in Table 5.

An additional 23 personnel will be required on the introduction of a third mining plant. A further 109 personnel are currently employed by the Company in the Newcastle Region.

TABLE 5

PERSONNEL REQUIREMENTS

Operation	Number
Mining Plants	45
Water Quality Monitoring (includes Water Laboratory, Thickener and Drillers)	9
Field Services	25

3.10 ALTERNATIVES TO THE PROPOSAL

Rutile & Zircon Mines (Newcastle) Limited believes the proposal to extend its mining operations in the Tomago Sandbeds Water Supply Catchment area will permit it to continue operations in the region.

The Company's longterm future in the region and the employment of approximately 200 personnel will be placed in jeopardy however, should it be denied access to these orebodies which are predicted to supply 85 per cent (1980 figures) of the Company's local concentrate production.

For over a decade the Company has demonstrated through the results monitored from its environmental controls that heavy mineral extraction from the sandbeds area can be undertaken with minimal adverse effect on the aquifer, water quality and the local environment.

Conditions imposed by the Board with respect to environmental matters have restricted that area of the sandbeds affected by this proposal to 5.7 per cent. The Company considers that the Board's constraints are comprehensive and adequate in terms of the environmental sensitivity of the area and hence is of the view that alternatives to the current proposal are unnecessary.

Section 4

The Existing Environment & Potential Constraints

SUMMARY

This section of the Statement presents the component characteristics of the existing environment of the proposed mining area likely to be affected by the Company's mining operation.

The important features and any potential constraints imposed by the environment are outlined as follows:-

TOPOGRAPHY

The proposed mining area is flat to gently undulating. Attention will be required to ensure that the mined surface is restored to contours similar to those which existed prior to mining.

GEOMORPHOLOGY

The site features an unconsolidated coastal sand mass known as the Inner Barrier Dune System. This geomorphic form (commonly called the Tomago Sandbeds) is approximately 5 km wide and is separated from the coast 11 km away by a more recent Outer Barrier sand deposit and Barrier Swamp Systems.

SITE GEOLOGY

An impermeable bedrock of sandstone and siltstone underlies 15 to 18 m of sand. The sandbeds contain commercially viable leads of heavy minerals within 7 m of the surface.

Leached horizons of clean quartz sand offer potential for extraction as glass sands.

SOILS

Sandy humus podzols have developed on the sand sheets and dunes. In lower lying areas, iron-humus podzols occur.

Both soil types tend to be acidic and of low fertility. On exposed sites procedures will be required to control wind erosion.

DRAINAGE

Due to the high porosity of the sand, rainfall rapidly infiltrates to the water table. This characteristic poses a potential constraint and safeguards will be required to preclude access of spilled contaminants to the groundwater.

GROUNDWATER

The sand mass forms an extensive water bearing aquifer with the water table usually lying 1.5 to 5 m below ground level.

The aquifer has been developed as a major source of domestic water for the Newcastle district by the Board. Ferrous iron is an important parameter influencing the water quality.

Attention to the design of safeguards to protect this water source has been of principal concern in this Statement.

RAINFALL

Most of the annual precipitation of 1134 mm falls in summer as a result of thunderstorm activity. Early spring tends to be the driest time of the year. The lack of rainfall may pose a constraint on the revegetation programme.

WINDS

The mining area is exposed to northeasterly and easterly winds in summer and west to northwest winds in winter. Wind funnels may be experienced along the southwest to northeast orientated mining path. Safeguards will be required to minimise erosion potential.

AMBIENT SOUND LEVELS

The average background noise level in the proposed mining area is 43 dB(A) during the day and 30 dB(A) at night. The main noise source contributing to these readings is traffic movement along Richardson Road and Medowie Road which is more pronounced during the day. The heavy machinery operating in conjunction with the electrically powered mining plant is the main source of noise generated by the proposal.

Attention to safeguards to minimise this noise when the plant is in proximity to residents at Campvale will be required.

FLORA

The vegetation on the sandbeds is dense and relatively undisturbed. Mixed eucalypt forest and woodland dominate the landscape. Wetlands are common in the low-lying sectors. A number of plants specified in the New South Wales Protected Plants list occur in the area but most are adequately reserved elsewhere in the State.

Attention to safeguards to minimise the effects of vegetation clearing is necessary. Similarly, due consideration is given to rehabilitation and revegetation procedures.

FAUNA

Macropods and avifauna are common residents of this habitat. The absence of hollow trees and logs in the mined area will have an adverse effect on the colonisation of such species as koalas, possums, and gliders for a period of up to 40 years. Satisfactory rehabilitation and revegetation plans are considered necessary to ensure the longterm viability of that part of the ecosystem disturbed by mining.

ECOLOGICAL RELATIONSHIPS

The proposed mining path passes by Moffats Swamp Nature Reserve. The Company recognises the need to preserve this wetland and accordingly has excised from the proposed mining area a valuable section of the orebody formerly comprised within M.L.A. 1150.

LAND USE AND ZONING

The mining proposal is located on land zoned "Special Uses (5A)" and managed by the Board for the purposes of groundwater extraction. Any development permitted within the Tomago Sandbeds Water Supply Catchment Area is subject to strict controls imposed by the Board. This factor is considered a constraint on the mining operations.

AGRICULTURAL LAND USE

A variety of agricultural activities are undertaken on the perimeter of the sandbeds including beef cattle grazing, horse breeding and poultry farming. Hobby farming is becoming more common.

URBAN LAND USE

A number of small urban settlements occur on the fringe of the Tomago Sandbeds Reserve, namely Williamtown, Salt Ash, Lemon Tree Passage, Campvale and Medowie.

Raymond Terrace, 7 km to the west, is the largest town in the district with a population of 7000 people.

RECREATIONAL LAND USE

Formal recreation facilities within the area are limited. The beach at Newcastle Bight, 10 km to the east, offers the greatest recreational potential.

EXTRACTIVE INDUSTRIES

Rutile & Zircon Mines (Newcastle) Limited is the only company which mines within the Tomago Sandbeds Catchment Area.

VISUAL ASPECTS

The sandbeds which form part of the coastal lowland landscape are of significant visual quality. Thus attention is required to ensure adequate rehabilitation of the mined areas and for the provision of screening along roads.

POPULATION

Approximately 2000 people live in the surrounding areas of Tomago, Williamtown, Campvale and Medowie.

INDUSTRY AND EMPLOYMENT

Port Stephens Shire has a well diversified rural base with poultry, dairying, beef cattle, fruit and vegetable farming, the principal activities. The expansion of such industries as manufacturing and tourism have broadened the economic base.

Industry in the Shire employs approximately 8000 people with 10 per cent based in the local area.

4.1 TOPOGRAPHY

The proposed mining area and its environs consist of undulating sand dunes, interdune sand flats and swamps. These landforms tend to form a linear arrangement running southwest to northeast and parallel to the coastline, some 11 km away to the east.

Most of the area is less than 8 m above sea level with isolated dunes rising to 27 m above sea level.

This extensive low-lying area extends along the coast from the Lower Hunter River estuary to the southern side of Port Stephens.

Sandy rises at the southwest end are flanked by extensive estuarine flats and the alluvial floodplain of the Hunter River.

4.2 GEOMORPHOLOGY

The area features a mass of unconsolidated coastal sand deposited during the recent geological past (approximately 2.5 million years ago).

During the late Pleistocene period, the last ice age waned, raising the sea level by 90 m and submerging the land surface to form the Tomago Basin. Sedimentation from stream and seaborne deposits caused a sand bar to close off the Basin. Subsequent re-entry of the sea deposited sand and heavy minerals on the ocean beachfront.

A slight return to ice-age conditions caused the sea level to fall 4 to 6 m. The deposit of windblown (aeolian) sand then formed dunes as the beach retreated to the southeast. Figure 5 shows the geomorphology of the subregion. The aeolian sand mass is known as the Inner Barrier, referred to locally as to the Tomago Sandbeds.

This geomorphic feature, which extends from Tomago in the southwest to Tanilba Bay in the northeast, has an average width of 5 km and is separated from the coast by a more recent Outer Barrier Dune System.

The second sand beach ridge was formed approximately 10 000 years ago when the sea level attained its present level. This system of dunes gives rise to sand dunes 15 to 30 m high and forms a long continuous barrier 2 to 3 km wide from Stockton in the south to Anna Bay in the north.

A flat low-lying area separates the Inner and Outer Barrier systems and extends from Fullerton Cove in the southwest to Tilligerry Creek in the northeast. Essentially a shallow strait of swamps, this 1 to 3 km wide zone is covered with alluvial soils deposited by floodwaters from the Hunter River seeking an outlet to Port Stephens via Tilligerry Creek.

To the northwest, the sandbeds give way to bedrock belonging to the Tomago Stage of the Upper Coal Measures.

4.3 GEOLOGY

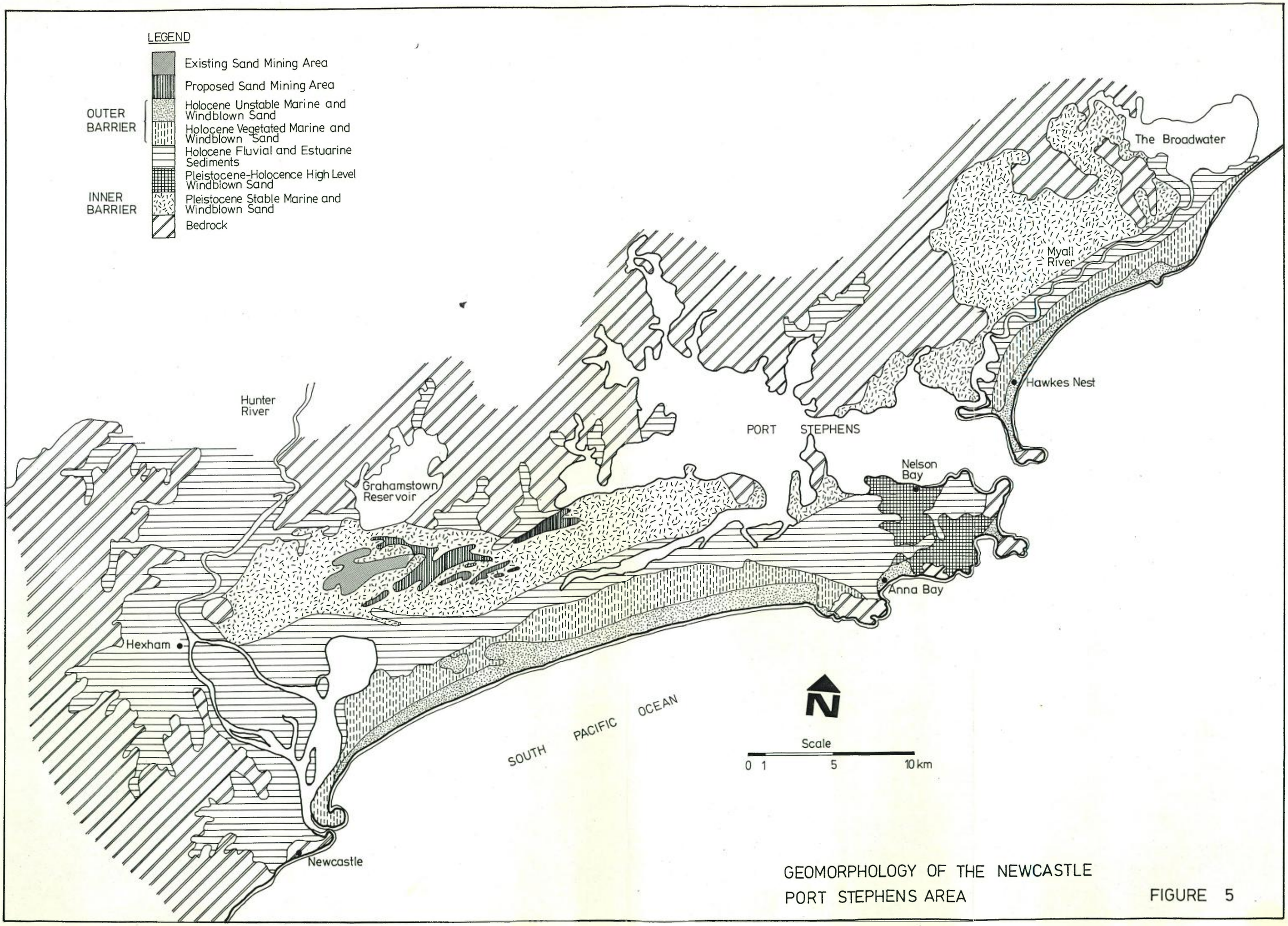
The Tomago Sandbeds rarely exceed 18 m in thickness and overlie an impermeable bedrock of sandstone, siltstone and mudstone. The sorting action of wind and wave during the Pleistocene era has concentrated the heavy mineral grains of rutile, ilmenite, zircon, magnetite, monazite, tourmaline, garnet and other silicates into lens-shaped horizons (1 to 2 m thick) or as linear horizontal beds, many metres in length. These zones of concentration have been preserved by subsequent burial.

Known heavy mineral reserves located in the sandbeds indicate deposits are of medium to low grade (approximately 2 per cent heavy mineral).

Natural sorting processes have also yielded leached horizons of clean quartz sand which offer potential for extraction as glass sands.

4.4 SOILS

The two main soils found on these ancient aeolian sands are the sandy



GEOMORPHOLOGY OF THE NEWCASTLE PORT STEPHENS AREA

FIGURE 5


R.Z. MINES (NEWCASTLE) PTY. LTD.
SPEARPOINT LOCATION PLAN.
-TOMAGO SANDBEDS AREA.
SHOWING MINING, REMINING AND PROPOSED REMINING.
1 : 10,000
C.V.M.
15-3-89
Revised
DJS
10-3-92
CM-581/3A
NOTE: See P. Judge Memo No. 7598.
LEGEND
Boundary of M.L. 594 (Act 1973)
5955
Location of Spearpoint No. 5955
Area mined
Area remined
Proposed remining
Pump Station No. 6 (New)
Pump Station No. 6 (Old)
M.L.A. 129
M.L. 1071
M.L. 785
M.L.A. 130
Pt M.L. 594
M.L. 1066
M.L.A. 131
M.L. 1170
M.L. 1104
M.L. 1103
M.L. 1077
M.L. 1036
M.L. 650
M.L. 573
M.L. 572
M.L. 574
M.L. 1008
M.L.A. 53
PARISH OF ELDON
PARISH OF STOCKTON
PARISH OF STOWELL
WILLIAMTOWN R.A.A.F. BASE
Finnan Drive
Grahamstown Road
Richardson Road
Tomago Road
Cabbage Tree Road
Barrie Close
Moscow Road
Pump Stn. 3
Pump Stn. 4
Pump Stn. 5
Pump Stn. 7
Pump Stn. 8
Pump Stn. 10
Pump Stn. 19
FOR ADJOINING INFO. SEE PLAN CM-581/4A
1 370 000 N
374 000 E
377 000 E

humus podzol and the iron-humus podzol. Both soils tend to show a strongly differentiated profile with a distinct subsurface horizon overlying a zone rich in sesquioxides relative to those above and below it.

The sandy humus podzols are developed on the sand sheets and dunes. A typical profile reveals a grey, 0.5 m thick A_1 horizon with variable amounts of organic matter. This overlies a leached A_2 horizon consisting of white fine to medium grained sand up to 3 m thick. Dark brown, humate-impregnated sand forms the B_2 horizon. The remainder of the B horizon tends to be undifferentiated sands.

The iron-humus podzols associated with the low-lying areas feature a dark A_1 horizon of organic accumulation 30 cm thick overlying a moist leached whitish A_2 horizon.

In the brown to black B horizon, the accumulation of both humus and iron oxide occurs. This overlies a water-saturated and weakly mottled mineral sand.

Aeolian sand underlies both soil types to a depth of approximately 18 m. Fertility of both soils is low and characteristically acid. The erosion potential of the podzols is minimal.

In 1962, the New South Wales Department of Agriculture undertook a soil analysis for the R.A.A.F. Base at Williamtown. This information, shown in Table 6, is considered representative of the soils found in the Tomago Sandbeds.

TABLE 6

WILLIAMTOWN R.A.A.F. BASE SOIL ANALYSIS

Soil Description	Texture	pH	Organic Carbon	Organic Matter	Per cent Total Nitrogen	Water Holding Capacity per cent
Topsoil (0-15 cm)	sand	4.9	1.4	2.48	0.5	25
Subsoil (15-61 cm)	sand	4.8	0.25	0.5	0.1	20

Source: *Soil Conservation Service.*

4.5 HYDROLOGY

4.5.1 Surface Drainage

Precipitation on the sandbeds rapidly infiltrates to the groundwater table due to the high porosity of the soil. Sustained rainfall may result in the water table rising to the surface, temporarily increasing the extent of swamps or lagoons. Tilligerry Creek to the northeast of Williamtown drains the inter-Barrier depression into Port Stephens.

4.5.2 Groundwater

Aquifer Definition

The Tomago Sandbeds extend to an impervious clay bottom 9 to 18 m below the surface. The fine grained sand forms an extensive water bearing aquifer with the water table usually lying 1.5 to 5 m below the ground level.

The exact limits of the aquifer have not been precisely defined, but the proclaimed boundary of the Tomago Sandbeds Water Supply Catchment Area shown on Figure 1 is considered the approximate limit of the aquifer suitable for water supply. This boundary encompasses an area of 106 km^2.

Aquifer Characteristics

The water stored in the sandbeds is derived entirely from rainfall infiltrating through the pervious sands. The quantity of water held in the interstices of the sand grains is that portion of precipitation not lost by evapotranspiration, underground flow or runoff.

The permeability and storage capacity of the sandbeds are related to soil type, particle size distribution, density of the soils and the presence of impervious layers in the aquifer formation.

The estimated peremability of the sandbeds is between 1.5 and 2.5 x 10^{-2}cm/s.

Groundwater contours determined by the Board are shown in Figure 3. The contours represent the level of the water table when no pumping stations were operating. Figure 3 indicates a sloping of the water table (called the hydraulic gradient) towards the Hunter River, Pacific Ocean and Port Stephens.

Between 20 and 25 per cent of all rainfall reaches the water table. A pumping rate of 625 kL/d.km^2 has been estimated by the Board to be the safe yield of the aquifer. This figure represents 25 per cent of the average annual rainfall for the area.

The Hunter District Water Board (1957) has conducted experiments which indicate that the incidence and character of rainfall are significant factors in determining the amount of water that infiltrates the soil.

After a dry period, good rains only wet the dry surface sands and have little or no effect on the level of the water table. Heavy concentrated rains make the greatest contribution to storage. Thus although the sandbeds have an annual average rainfall of 1134 mm per annum, it is not this yearly rainfall that is critical for storage, but rather the individual weather sequences.

Groundwater Losses

The Hunter District Water Board (1957) and *McGrath (1967)* consider that evaporation and transpiration account for the major water losses from the sandbeds.

Experiments initiated by the Board have determined that 1.2 m of sand cover is sufficient to prevent evaporation from the water table. Thus water losses from storage by evaporation are greatest after periods of heavy rain when low-lying areas have less than 1.2 m of sand above the water table.

The Board has also attempted to measure the evapotranspiration losses by assuming that all salt present in the groundwater comes from the rainfall, as any salt originally in the sand would have been leached out in past geological ages.

The average chloride content of the groundwater was found to be 40 mg/L as against 10 mg/L in rainwater. This indicated that 75 per cent of the rainfall had been lost by evaporation and transpiration. As earlier experiments had ruled out that direct evaporation from the water table was a major factor, it was concluded that transpiration losses were high.

McGrath (1967) calculated that in an average year, actual evapotranspiration accounted for over 86 per cent of the rainfall.

4.5.3 Groundwater Quality

The characteristics of the groundwater (based on a recent analysis by James B. Croft & Associates Pty. Limited) indicates that the water is acidic (pH 6) with the soluble salt content averaging 135 mg/L. Fluoride, chloride and sulphate levels are low. Hardness of the water is well below the maximum level recommended by the World Health Organisation (500 mg $CaCO_3$/L) and alkalinity levels are within the acceptable range of 30 to 500 mg $CaCO_3$/L. Carbon dioxide levels are considered high with an average of 100 mg/L.

Past studies by the Board have revealed an average iron content of 6 mg/L and colour up to 200 parts on the platinum-cobalt scale. Hydrogen sulphide is commonly found with a concentration ranging between 0.5 and 1.0 mg/L.

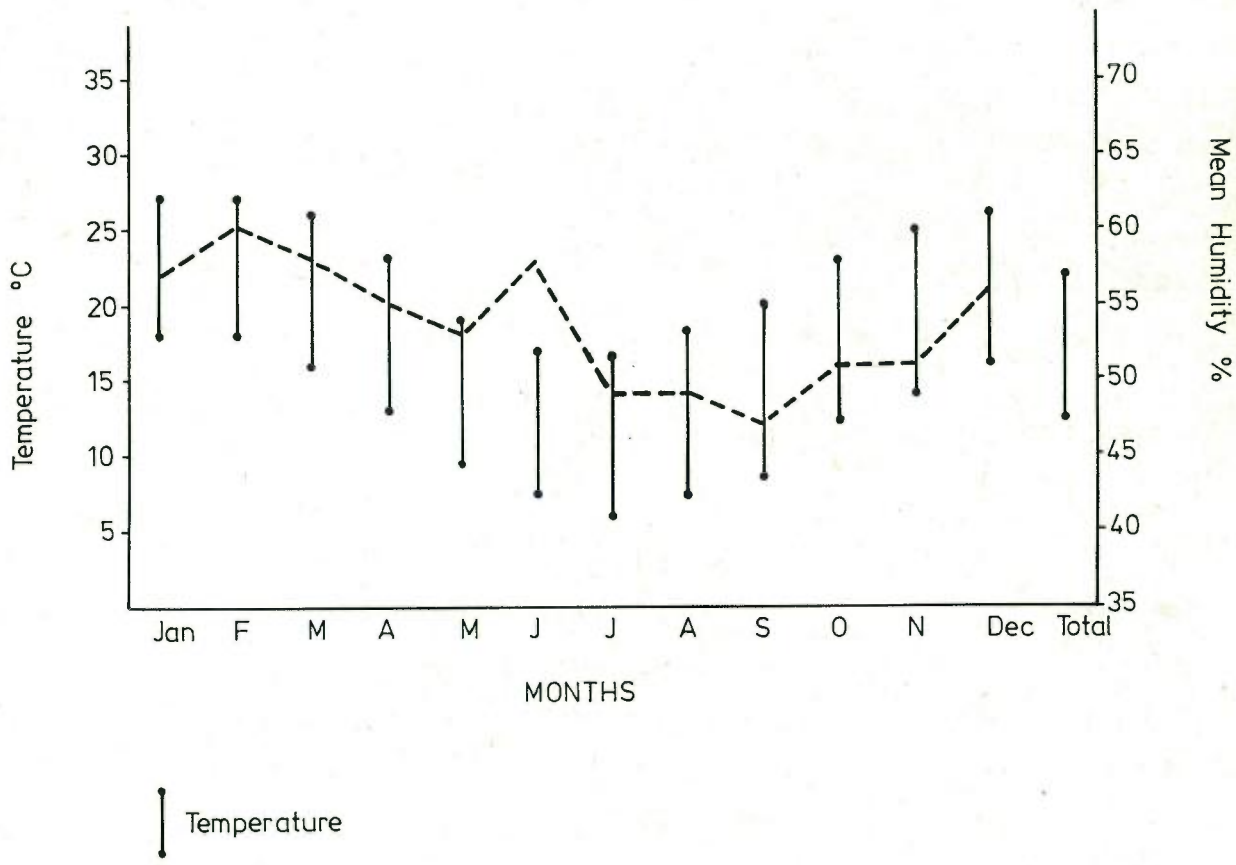
4.6 METEOROLOGY

4.6.1 Source of Data

The climatic characteristics have been assessed from the official meteorological station at Williamtown located immediately adjacent to the proposed mining areas.

4.6.2 Temperature and Humidity

The average daily maximum and minimum temperatures are shown in Figure 6 along with the average daily minimum (3 p.m.) relative humidity readings.



Temperature

--- Humidity

Location: Williamtown

Source : Bureau of Meteorology

MEAN DAILY MAXIMUM AND MINIMUM TEMPERATURE AND MEAN DAILY MINIMUM RELATIVE HUMIDITY

FIGURE 6

The hottest month is January with an average daily maximum temperature of 27.2°C and an average minimum reading of 17.9°C. July is the coldest month with an average maximum temperature of 16.8°C and an average minimum of 6°C.

The relative humidity readings show a similar pattern, with peaks in February and June of 60 per cent and 58 per cent respectively. The yearly average is approximately 54 per cent.

4.6.3 Rainfall

The average monthly rainfall and the average number of raindays per month are shown in Figure 7.

The average annual rainfall of 1134 mm falls on 132 days per year. Most of the rain falls in summer when the northeasterly winds bring thunderstorm activity.

January is the wettest month, receiving 125 mm of rain. The driest period is from late winter to early spring when dry westerly winds prevail.

The driest month is September which receives 59 mm. The average number of raindays is evenly distributed throughout the year with a trough from July to September.

4.6.4 Winds

The wind roses illustrated in Figure 8 represent seasonal readings taken at 9 a.m. and 9 p.m. each day. The summer wind rose indicates a predominance of winds from the northeast and southeast, reflecting the maritime influence. Wind speeds vary from 11 to 30 km/h with the occasional 'southerly buster' reaching 51 km/h.

In autumn the winds are more evenly distributed, blowing from the west and northwest in the morning and from the south and southeast in the afternoon. Wind speeds range from 11 to 50 km/h.

The continental influence in winter is borne out by the predominance of quite strong west and northwest winds.

Spring shows an even distribution of light winds with a gradual shift from the west to the south and southeast as the season progresses.

Strong winds commonly occur in November and December when 50 per cent of the afternoon winds occur at speeds greater than 20 km/h. This is due to local atmospheric pressure differences.

Throughout the year, westerlies and northwesterlies attain speeds greater than 40 km/h due to a funnelling effect brought about by the Hunter Valley alignment.

4.7 AMBIENT SOUND LEVELS

Sound level monitoring was conducted by James B. Croft & Associates Pty. Limited at two sites within the proposed mining area in May, 1980. The site locations are shown in Figure 9. Both day and night noise levels were measured.

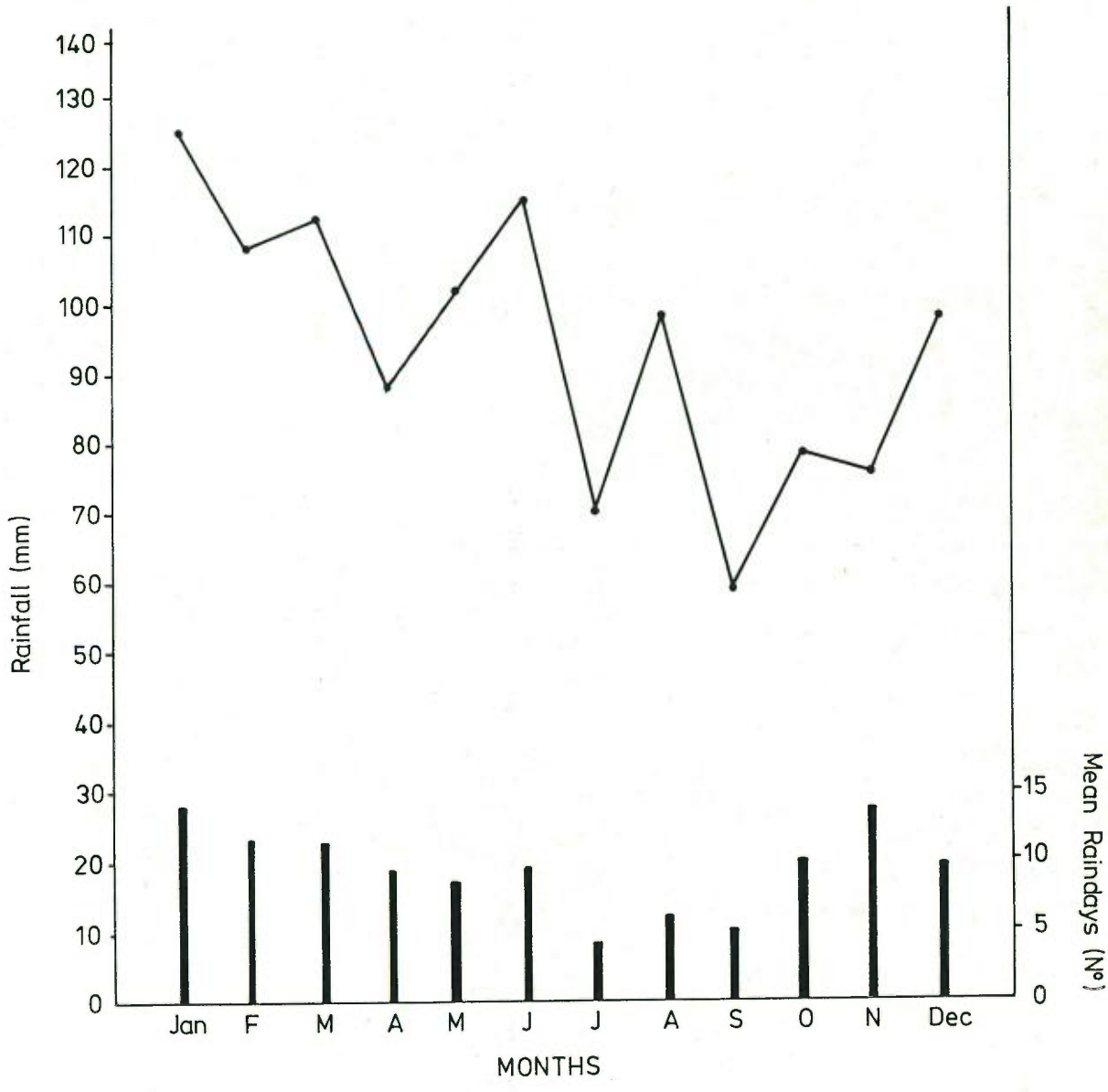
Details of the sound level studies are described in Appendix 13.

Results from the monitoring tests indicate that the mean background (L_{95}) sound level was 43 dB(A) during the day and 30 dB(A) at night. The higher daytime sound level was attributed to traffic movement along Richardson Road.

The results of the octave frequency analyses similarly denote a higher rate of vehicular movement during the daytime. The sound components were predominantly low frequency signals (<2000 Hz).

4.8 FLORA AND FAUNA

A number of field surveys were carried out in the sandbeds area in order to determine the type, structure and distribution of vegetation communities

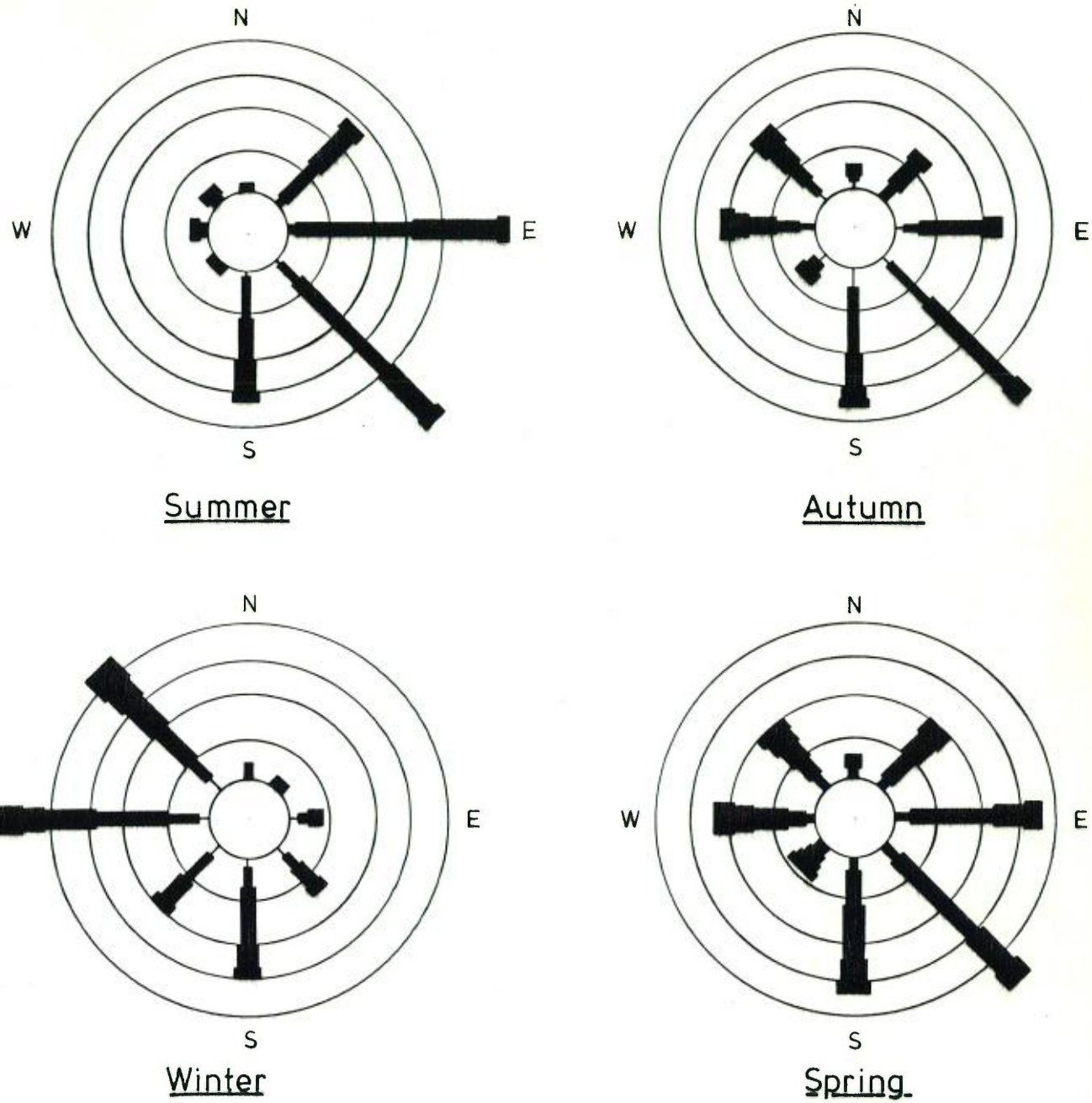


Location : Williamtown

Source : Bureau of Meteorology

MEAN MONTHLY
RAINFALL AND MEAN
NUMBER OF RAINDAYS

FIGURE 7



Location : Williamtown Source: Bureau of Meteorology

WIND, SPEED
AND DIRECTION FIGURE 8

LEGEND

Ore Bodies

■1 Noise Monitoring Sites

Maximum Noise Levels due to Mining Operations

—50— Day

--40-- Night

BIG SWAN BAY

MEDOWIE

Pacific Highway

GRAHAMSTOWN STORAGE RESERVOIR

RAYMOND TERRACE

Campvale Swamp

Moffats Swamp

Richardson Road

CAMPVALE

Moffats Creek

Lemon Tree Passage Road

Tilligerry Creek

Medowie Road

SALT ASH

Masonite Road

Nelson Bay Road

WILLIAMTOWN

Cabbage Tree Road

Tomago Road

FULLERTON COVE

N

Scale

0 500 1 2km

PREDICTED NOISE LEVELS FIGURE 9

and the species of avifauna and non-avian fauna. Full details of the methods employed and the results obtained are given in Appendix 14 together with a discussion of the findings. Investigations of characteristics of areas already mined and revegetated were undertaken in accordance with the scope of this study.

No rare or endangered species have been recorded in the area, although a number of protected plant species do occur and these are listed in tables appearing in Appendix 14.

Wetlands in the area are generally of medium to high value waterfowl habitat *(Goodrick, 1970)*. The most significant wetland is Moffats Swamp which is a nature reserve administered by the State National Parks and Wildlife Service.

Most mammal species are considered adequately conserved within the State park and reserve system. Species such as the Koala *(Phascolarctos cinereus)*, however, have an uncertain status in the long term although they are not considered in any danger at present *(Bell, 1978)*. The New Holland Mouse *(Pseudomys novaehollandiae)* was considered rare or extinct until recently but is now thought to be common in this locality.

The overall value of the site is rated as medium to high. This rating relates to the comparatively undisturbed nature of much of the area, the high diversity of flora species and units and interesting fauna populations.

The assessment of the regeneration process to date suggests successful growth of numerous species and maintenance of a satisfactory species diversity. Some changes in species composition are indicated, however, and would be expected to be of some significance with regard to dominants.

Wetlands, which are dynamic systems, may have a permanent or temporary water cover *(Goodrick, 1970)*. Small changes in the topography of an area may modify the swamp type or even result in a dryland ecosystem.

Wetlands are not presently rehabilitated to similar systems after mining. Despite the significant changes however, which occur as a result of mining, areas which supported Broad-leaved Paperbark *(Melaleuca quinquenervia)*

prior to mining tend to be dominated by this species afterwards irrespective of the final landform.

On the recommendation of the Board's consultant on revegetation, Cypress Wattle *(Acacia cyanophylla)*, a native from Western Australia, has been planted for visual screening purposes along the access roads. The longterm dynamics of this species have yet to be ascertained.

4.9 ECOLOGICAL RELATIONSHIPS

4.9.1 Flora Distribution

Examination of Figures 10 to 13 indicates that the distribution of floral associations in the study area is relatively complex. The distribution of species would appear to be heavily dependent on microclimatic changes associated with variations in microtopography which influence drainage and soil characteristics.

Wetland areas are naturally located in low-lying sectors. An impermeable peat layer is vital to the retention of water in these communities and their longterm survival as wetlands. The type of swamp is dependent on such factors as the depth of standing water and duration of inundation.

Communities such as the Broad-leaved Paperbark Closed-forest association are typically represented as a fringing belt around permanent swampy areas like Moffats Swamp. Wet heath and Christmas Bell communities characterise damp localities.

Dry sclerophyll forest is the most widespread vegetation type with Rusty Gum-Red Bloodwood Open-forest being the most common association.

This association covers approximately 30 to 40 per cent of the area of investigation. It tends to occur on the higher ground in the study area particularly on sandy ridges.

There appears to be a strong correspondence with the occurrence of two

Richardson Road

LEGEND

- Location of Ore Bodies
- Track
- Easement
- Roads
- 7 Pumping Stations
- Duckhole Trig Station
- Tall Sedge Swamp
- Rusty Gum-Red Bloodwood, Open-forest
- Scribbly Gum- Rusty Gum, Open-forest
- Drooping Red Gum, Low Open-Woodland
- Rusty Gum, Open-forest
- Semi-permanent Fresh Swamp
- Drooping Red Gum,- Low Open-forest
- Scribbly Gum Red Bloodwood Open forest
- Scribbly Gum Rusty Gum Red Bloodwood Open forest
- Scribbly Gum Open forest
- Broad leaved Paperbark Swamp Mahogany Open forest
- Broad leaved Paperbark Rusty Gum Open forest
- Pasture Cleared Land
- Disturbed Wetlands
- Heath
- Natural Vegetation

N

Scale

0 100 200 400m

8

10

7

FLORAL ASSOCIATIONS
IN STUDY AREA

FIGURE 10

LEGEND

- Location of Ore Bodies
- Roads
- •10 Water Pumping Stations
- Drooping Red Gum, Low Open-Woodland
- Rusty Gum, Red Bloodwood, Open-forest
- Eleocharis Swamp
- Broad-leaved Paperbark, Rusty Gum, Open-forest
- Rusty Gum Open-forest
- Broad-leaved Paperbark, Swamp Mahogany, Open-forest
- Blackbutt, Open-forest
- Scribbly Gum, Red Bloodwood, Open-forest
- Scribbly Gum, Open forest
- Pasture / Cleared Land
- Scribbly Gum, Rusty Gum, Open-forest
- Drooping Red Gum, Low Open-forest
- Semi permanent Fresh Swamp
- Heath
- Natural Vegetation

N

Scale

0 100 200 400m

Campvale Swamp

Medowie Road

Richardson Road

10

12

FLORAL ASSOCIATIONS IN STUDY AREA

FIGURE 11

Moffats Swamp

Moffats Creek

Medowie Road

12

18

Richardson Road

LEGEND

- Location of Ore Bodies
- Roads
- 12 Water Pumping Stations
- Scribbly Gum-Rusty Gum, Open-forest
- Scribbly Gum-Rusty Gum, Red Bloodwood, Open-forest
- Drooping Red Gum, Low Open-Woodland
- Rusty Gum-Red Bloodwood, Open-forest
- Blackbutt Open-forest
- Broad-leaved Paperbark - Swamp Mahogany
- Rusty Gum - Open-forest
- Sedge Swamp
- Eleocharis Swamp
- Semi-permanent Fresh Swamp
- Cleared Land
- Broad-leaved Paperbark-Rusty Gum - Open-forest
- Heath
- Natural Vegetation

N

Scale

0 100 200 400m

FLORAL ASSOCIATIONS IN STUDY AREA

FIGURE 12

LEGEND

- Location of Ore Bodies
- Easement
- Road
- Eleocharis Swamp
- Broad-leaved Paperbark, Closed-forest
- Stringy Bark Open-forest
- Scribbly Gum - Rusty Gum, Low Woodland
- Scribbly Gum, Low Woodland
- Rusty Gum - Red Bloodwood, Low Woodland
- Rusty Gum - Red Bloodwood, Open-forest
- Scribbly Gum - Rusty Gum Open-forest
- Scribbly Gum - Red Bloodwood, Open-forest
- Dead Trees - Dense Melaleuca Understudy 3·5m Tall
- Disturbed Area - Some Vegetation Re-establishing
- Mangroves
- Saltmarsh
- Cleared Land
- Natural Vegetation

N

Scale

0 100 200 400m

MOFFATS SWAMP

Cleared
Recently Sand Mined

Moffats Creek

FLORAL ASSOCIATIONS
IN STUDY AREA

FIGURE 13

understorey plants *Banksia serratifolia* and *Macrozamia communis* and the Rusty Gum-Red Bloodwood dominated forest. *Styphelia viridus* also seems to occur frequently in this association.

Grass Trees *(Xanthorrhoea)* on the other hand are frequently associated with the Scribbly Gum-Red Bloodwood Open-forest and *Parsonsia straminea* appeared mainly associated with *Melaleuca quinquenervia.*

All plant species occurring in the study area are adapted to, or tolerant of poor soil conditions. Most of the tree species also occur on good quality soils in other locations and may reach their best development on the latter (for example, Red Bloodwood *[Eucalyptus gummifera]).*

Localised occurrences of Blackbutt *(Eucalyptus pilularis)* as shown on Figure 12 are likely to correspond with an increase of loam in the soil, this species typically occurring on loams or sandy loams *(Hall, 1970).*

The preponderance of zeromorphic heath species in the study area is generally indicative of the harsh soil environment over most of the ore bodies. Mangrove and saltmarsh communities shown in Figure 13 are also associated with harsh conditions resulting from high salinity levels and tidal inundations.

Disturbed vegetation communities comprise only those immediately adjacent to tracks and easements through the area and one wetland, described in Section A14.1.2. These areas of disturbance are apparent on examination of Figures 10 to 13.

4.9.2 Distribution of Fauna Species

Fauna species in the study area are dependent on the habitats provided by the existing vegetation communities.

Some species would be expected to utilise most of the available habitats whereas others are more restricted.

Many of the avifauna species are nomadic and frequent the Tomago Sandbeds vegetation only when food sources are abundant. This was illustrated during the study period when drought conditions prevailed. Wetland habitats were generally in poor condition and many swamps were dry.

Consequently, sightings of waterfowl were restricted to one or two individuals of a few species. Although the study area is not a major wetland habitat, waterfowl populations would be much more apparent during wet seasons, particularly when other regions were dry.

The majority of avifauna species frequenting the vegetation communities are insectivorous and/or nectar feeders. They utilise the forest and heathland habitats particularly during profuse flowering periods. Since the study was undertaken during winter, flowering species were at a minimum and bird populations were generally low. However, in the Blackbutt Open-forest, Blackbutt *(Eucalyptus pilularis)*, *Acacia ulicifolia* and *Pimelea linifolia* were all flowering profusely and birds were locally abundant.

Some species are restricted in their usage. The Yellow-faced Honeyeater *(Lichenostomus chrysops)* is generally characteristic of sclerophyll forest whilst the Southern Emu-Wren *(Stipiturus ruficeps)* and Little Wattlebird *(Anthochaera chrysoptera)* seldom occur outside heathland habitats *(Frith, 1974)*.

Avifauna species such as the Kookaburra *(Dacelo novaeguineae)* and Superb Blue Wren *(Malurus cyaneus)* form resident populations and are therefore permanently dependent on the habitats within the study area.

In contrast to any of the avifauna species, most of the mammals occurring in the area remain permanently within the sandbeds locality. The Eastern Grey Kangaroo *(Macropus giganteus)* would range over most of the terrain but would particularly favour the open-forested sectors and roadside verges. The latter provide favourable forage for the species close to the shelter of the forests. Most sightings of kangaroos were just to the northeast of the Williamtown Air Base along a wide strip of cleared grassland.

The Red-necked Wallaby *(Macropus rufogriseus)* has similar habitat requirements to the kangaroo *(Frith, 1974)* and would therefore be expected to

have a similar distribution pattern. Swamp sclerophyll forest often provides favourable habitat for both species, particularly in drier seasons as the herbage remains green and succulent for longer periods.

Distribution of the Swamp Wallaby *(Wallabia bicolor)* in the study area would be predominantly related to the occurrence of dense undergrowth, which is necessary for this animal's survival. This wallaby also tends to browse on shrubs more than other large wallabies and kangaroos *(Frith, 1974 and Ride, 1970)*. Associations likely to support the greatest number of Swamp Wallabies are 6, 7, 9, 11, 13, 15, 16 and 17.

Arboreal species, such as possums and gliders are mainly restricted to the forested or woodland sectors. The Brush-tailed Possum *(Trichosurus vulpecula)* would be expected in most areas supporting tree growth because the species is one of the most widespread and adaptable of the eastern native mammals *(Ride, 1970)*. On the other hand, the Common Ringtail *(Pseudocheirus peregrinus)* is more restricted to relatively dense vegetation which provides shelter for nest sites. It is often favoured by secondary succession after fire or clearing *(Frith, 1974)*. Sightings of this species in the Tomago Sandbeds were in swamp sclerophyll forest dominated by *Melaleuca quinquenervia*.

Studies of the populations of these two species have shown densities of approximately one female per hectare and one male per three hectares for Brush-tailed Possums *(Trichosurus vulpecula)* near Canberra and from less than 0.5 individuals per hectare to 0.2 per hectare for Common Ringtail *(Pseudocheirus peregrinus)* in Victoria *(Frith, 1974 and Ride, 1970)*.

The Koala *(Phascolarctos cinereus)* has been sighted in numerous localities within the sandbeds area. Its distribution is influenced by the occurrence of its favoured food trees which include Forest Red Gum *(Eucalyptus tereticornis)* and Grey Gum *(Eucalyptus punctata)*. The animal can be quite mobile and travel some kilometres to find food sources.

The small ground mammals occurring in the area have various habitat requirements. The Southern Bush Rat *(Rattus fuscipes)* is vegetarian and is found in a number of habitats including sandy heaths *(Serventy and Raymond, 1974)*. Generally, however, it prefers moist situations *(Ride, 1970)*.

Another rat, the Eastern Swamp Rat *(Rattus lutreolus)* also prefers moist conditions and has been found beside swampland in the area. The animal tends to burrow in dense undergrowth and readily tolerates waterlogged ground conditions. It would be expected around most wetlands in the study area.

The Brown Antechinus *(Antechinus stuartii)* generally inhabits schlerophyll forests in New South Wales *(Seymour, 1980)* and appears to tolerate a variety of conditions. It has been trapped in areas with a very dense understorey and with a scattered understorey within the Newcastle Region and in the study area was found in swamp sclerophyll forest. It would also be expected to occur in other habitats, particularly forested sectors, within the area. This animal has a pronounced breeding season with all young weaned in spring when the insect food is optimum. The males all die by the time the young are born *(Seymour, 1980)*.

Population studies of the Bush Rat *(Rattus fuscipes)* and Brown Antechinus *(Antechinus stuartii)* at Nadgee Nature Reserve showed individual densities of eight rats and seven Antechinus per hectare of forest.

Another small mammal which appears abundant in the study area is the New Holland Mouse *(Pseudomys novaehollandiae)*. This species was trapped in a number of habitats including heath, open-forest and a regenerating mined area. It tends to be associated with seral stages after fire; such habitat is prevalent in the study area due to the frequent occurrence of bush fires.

Studies by *Fox and Fox (1978)* on this species in sandmined areas at Hawks Nest, to the north of the proposal, showed an apparent linear relationship between plant species diversity and the biomass of *P. novaehollandiae*. There was a linear increase in both plant species diversity and *P. Novaehollandiae* biomass with regeneration age.

The species was found in mid-seral post-mining areas to be associated with localities having a variety of heath plants, vegetation cover below 50 cm and softer substrates. PM 37 (defined in Section 3.5.8) in which *P. Novaehollandiae* was trapped in the Tomago Sandbeds, appears to have a number of characteristics comparable with the Hawks Nest study site. The general structure and composition of PM 37 is presented in Table 8,

Section 4.9.4.

Little is known of the distribution of amphibians and reptiles in the area. Amphibians are naturally associated with wetland areas as are such reptiles as the Eastern Water Skink *(Sphenomorphus quoyii)*. Species such as the Red-bellied Black Snake *(Pseudechis porphyriacus)* and the Bearded Dragon *(Amphibolorus barbatus)* would be expected in most habitats.

4.9.3 Human Impact

The study area has been subject to a number of human influences in recent years. These influences and their effects are considered to be -

i. Clearing of areas of natural vegetation for roads, transmission line easements, an airport, meteorological station and pumping stations. (See also Section 6.3.2). This has decreased the habitat for a number of fauna species and, at times, favoured other species such as the Eastern Grey Kangaroo *(Macropus giganteus)* and Red-necked Wallaby *(Macropus rufogriseus)*.

ii. Sand mining has resulted in the clearing of natural vegetation and associated removal of resident fauna populations. Regeneration of such areas is in progress but original habitats have been altered.

iii. Increased incidence of fire through frequent deliberate and accidental lightings. This has caused changes in understorey and increased the incidence of such plants as Acacias. Fauna populations may also have been adversely affected by too frequent and too fierce fires.

iv. Introduction of exotic animals into the region. The full effect of such introductions is not known but wildlife populations are generally believed to have suffered. Feral pigs and hares are prevalent in the sandbeds area and are particularly destructive of vegetation.

v. Establishment of exotic plant species which typically colonise public road easements and other disturbed locations such as regenerating sand mined areas. This does not appear to have had a marked effect at present.

vi. Shooting of wildlife. This has been controlled to a large degree by the Board locking access gates in the area and ranger patrols.

vii. Increased noise levels associated with air traffic at Williamtown Air Base. The effect of this is noticeable but probably temporary in relation to wildlife as animals appear to adapt readily to noisy conditions.

4.9.4 Revegetation Characteristics of Mineral Sands Mined Areas

Table A14.1 lists plant species recorded in the sand mining path by the Company prior to mining. Most of these species correspond with those listed in Table A14.2, although the latter is a more comprehensive list covering the majority of the ore bodies.

Tables 7 and 8 present lists for two defined areas which represent one months mining advance, namely PM 32 and PM 37, prior to mining and at two stages after mining. The location of the two PMs are shown in Figure 1. The history of treatment of these two areas is presented in Table 9.

Examination of Tables 7 and 8 suggests a number of relationships.

i. Species diversity determined from the Company's 1981 post-mining studies appears to be comparable and in some instances higher than the recorded pre-mining diversity and significantly more numerous than for the 1980 studies. The difference between the 1980 and 1981 surveys may be a function of two factors.

   Firstly, the 1981 studies sampled along a 6 m wide continuous transect through the centre of the mining path whereas the 1980 survey sampled only five random 1 m^2 quadrats along a 100 m transect in the northern half of each PM. Secondly, drought conditions prevailed during 1979 and 1980. It is assumed that good rains prior to the 1981investigations would have encouraged the growth and development of many plant species.

ii. Some species have been consistently recorded at all stages prior to and post-mining. These include *Bossiaea hetrophylla, Acacia ulicifolia* and *Hardenbergia violaceae* in PM 32 and *Acacia botrycephala, A. ulicifolia, Bossiaea heterophylla* and *Dillwynia retorta* in PM 37. The latter area generally showed greater correspondence with the original vegetation and greater species diversity than PM 32.

   Different treatments of the two PMs in terms of fertiliser application and slight variations in the species selected for planting would also be expected to account for some differences.

iii. The regenerating vegetation shows differences in species'

composition from the original flora. Tree species tend to be scarce and there also appears to be a greater preponderance of plants such as wattles after mining. This would be expected at this stage since wattles are typically recolonising plants.

Table 10 indicates the frequency of occurrence of recorded species in 138 PM areas. The species with greatest frequency include wattles, peas, *Persoonias*, *Senecio lautus*, *Lomandra glauca* and *Platysace ericoides*. The latter three species are very common two or more years after mining.

As would be expected, there are changes in species' frequency and occurrence during the different post-mining periods. Wattles, for instance, appear to be best developed two to six years after mining and general diversity is also greatest in this period.

Table 11 compares the characteristics of two mined and two naturally vegetated areas examined systematically in 1980 by *James B. Croft & Associates*. A number of major differences emerge from examination of the table.

Large trees are absent from the mined areas, but this is to be expected because these take longest to develop. Juvenile species of trees were recorded in both PM 32 and PM 37, and were also recorded in the 1981 post-mining survey as shown in Tables 7 and 8. Generally, the species are present but in low concentrations and the species' composition differs from that of the pre-mined community.

Eucalypts appeared more prevalent in PM 32 than in PM 37, although species' diversity appears greater in PM 37.

Another difference between the mined and unmined areas is the abundance of leaf litter in the forested sectors and the almost complete lack of litter in mined areas. This again, can be related to the lack of large trees and overall cover and can only be expected to occur with the development of the vegetation.

Acacia species (which are typical secondary succession plants) are generally the dominant plants in the mined areas investigated by *James B. Croft & Associates*.

TABLE 7

PLANT SPECIES FOUND IN PM 32 PRIOR TO AND AFTER MINING

Company Studies				James B. Croft & Associates Studies 4/6/80
Species observed in random walk on 28/6/75 (Mining commenced 1/12/75)		Post-Mining 30/4/81		
TREES				
Angophora costata		*Eucalyptus eugenioides*		*Eucalyptus spp.*
Eucalyptus gummifera				*E. haemastoma*
E. punctata				
SHRUBS				
Acacia botrycephala	*Isopogon anemonifolius*	*Acacia longifolia*	*Helichrysum diosmifolium*	*Acacia cyanophylla*
A. suaveolens	*Lambertia formosa*	*var. sophorae*	*Leptospermum attenuatum*	*A. elongata*
A. ulicifolia	*Leptospermum attenuatum*	*A. suaveolens*	*Leucopogon ericoides*	*A. longifolia*
Amperea xiphoclada	*L. flavescens*	*A. ulicifolia*	*Lomandra glauca*	*A. ulicifolia*
Aotus ericoides	*Lomandra longifolia*	*Actinotus helianthi*	*Persoonia levis*	*Bossiaea heterophylla*
Baeckea denticulata	*Melaleuca nodosa*	*Amperea xiphoclada*	*P. linearis*	*B. rhombifolia*
B. ramosissima	*M. sieberi*	*Aotus ericoides*	*Phytolacca octandra*	*Dillwynia sp.*
Banksia asplenifolia	*Persoonia laevis*	*Boronia falcifolia*	*Pimelea linifolia*	*Persoonia sp.*
B. serrata	*P. linearis*	*Bossiaea ensata*	*Platysace ericoides*	*Pimelia linifolia*
Bossiaea heterophylla	*Petrophile fucifolia*	*B. heterophylla*	*Ricinocarpus pinifolius*	
Conospermum taxifolium	*Pimelia linifolia*	*B. rhombifolia*	*Trachymene incisa*	
Dianella caerulea	*Pteridium esculentum*	*Conospermum taxifolium*	*Zieria laxiflora*	
Dillwynia glaberrima	*Ricinocarpos pinifolius*	*Conyza bonariensis*	*Banksia serratifolia*	
D. retorta	*Styphelia laeta*	*Dianella revoluta*		
Epacris longiflora	*Xanthorrhoea minor*	*Dillwynia glaberrima*		
Eriostemon australasius		*D. retorta*		
GROUND COVER				
Beackea diosmifolia		*Baeckea denticulata*		*Baeckia ramosissima*
Caustis recurvata		*B. ramosissima*		*Chloris gayana*
Entolasia stricta		*Daviesia acicularis*		*Cynodon dactylon*
Hardenbergia violacea		*Entolasia stricta*		*Hardenbergia violacea*
Lepidosperma longitudinale		*Hardenbergia violacea*		*Taraxacum officinale*
Leptocarpus tenax		*Pomax umbellata*		*Trachymene incisa*
Selaginella uliginosa				
Sowerbaea juncea				
Trachymene incisa				

TABLE 8

PLANT SPECIES FOUND IN PM 37 PRIOR TO AND AFTER MINING

Company Studies			James B. Croft and Associates Studies
Species observed in random walk on 17/5/76 (Mining commenced on 7/6/76)	Post Mining 16/7/81		10/6/80
Trees			
Eucalyptus gummifera	*Eucalyptus botryoides*	*Eucalyptus pilularis*	*Eucalyptus spp.*
E. haemastoma	*E. eugenioides*	*E. tereticornis*	
	E. gummifera	*Melaleuca quinquenervia*	
	E. haemastoma		
Shrubs			
Acacia botrycephala	*Acacia botrycephala*	*Lomandra longifolia*	*Acacia botrycephala*
A. ulicifolia	*A. cyanophylla*	*Melaleuca sieberi*	*A. cyanophylla*
Actinotus helianthi	*A. longifolia*	*M. thymifolia*	*A. elongata*
Aotus ericoides	var. *sophorae*	*Persoonia levis*	*A. ulicifolia*
Banksia aspleniifolia	*Acacia myrtifolia*	*P. linearis*	*Actinotus helianthi*
B. serrata	*A. suaveolens*	*Phytolacca octandra*	*Banksia serrata*
Bossiaea ensata	*A. ulicifolia*	*Pimelea linifolia*	*Boronia pinnata*
B. heterophylla	*Aotus ericoides*	*Pultenaea elliptica*	*Bossiaea heterophylla*
B. rhombifolia	*Bossiaea ensata*	*Trachymene incisa*	*B. rhombifolia*
Dianella caerulea	*Bossiaea heterophylla*		*Dillwynia retorta*
Dillwynia glaberrima	*B. rhombifolia*		*Haemadorum sp.*
D. retorta	*Conospermum taxifolium*		*Melaleuca ericifolia*
Eriostemon australasius	*Conyza bonariensis*		*Persoonia sp.*
Isopogon anemonifolius	*Dillwynia glaberrima*		*Pimelea linifolia*
Lambertia formosa	*Dillwynia retorta*		*Platysace ericoides*
Leptospermum attenuatum	*Gompholobium latifolium*		*Pteridium esculentum*
Melaleuca sieberi	*Haemodorum planifolium*		*Ricinocarpus pinifolius*
Persoonia lanceolata	*Helichrysum diosmifolium*		
P. levis	*Leptospermum attenuatum*		
Pteridium esculentum	*L. flavescens*		
Ricinocarpus pinifolius	*Leucopogon ericoides*		
Xylomelum pyriforme	*Lomandra glauca*		
Ground Cover			
Entolasia stricta	*Astroloma pinifolium*	*Eragrostis brownii*	*Hardenbergia violacea*
Haloragis teucricides	*Baeckea ramosissima*	*Haloragis teucrioides*	*Lomandra glauca*
Xanthorrhoea minor	*Carpobrotus aequilaterus*	*Hardenbergia violacea*	*Paspalum sp.*
	Cassytha pubescens	*Hemarthria uncinata*	
	Caustis recurvata	*Hibbertia scandens*	
	Daviesia acicularis	*Platysace ericoides*	
	Eleusine indica	*Pomax umbellata*	
	Entolasia marginata	*Schoenus ericetorum*	
	E. stricta	*Tephrosia scariosa*	

TABLE 9

HISTORY OF TREATMENT OF PM 32 AND PM 37

Treatment		Date	Amount
PM 32			
Soil Removed		10.11.75	
Soil Replaced		19. 1.76	
Fertiliser (10.88 kg Phosphorus)			
First Application		21. 4.76	1.36 kg
Second Application		26. 5.76	1.36 kg
Third Application		30. 8.76	2.72 kg
Fourth Application		6. 1.77	2.72 kg
Fifth Application		5. 5.77	2.72 kg
Seedlings Planted			
Eucalyptus eugenioides	White Stringybark		255
E. gummifera	Bloodwood		175
E. haemastoma	Scribbly Gum		230
E. maculata	Spotted Gum		10
E. oblonga	Narrow-leaf Stringybark		25
E. parramattensis	Drooping Red Gum		140
E. pilularis	Blackbutt		55
E. piperita	Peppermint		85
E. punctata	Grey Gum		135
E. tereticornis	Forest Red Gum		15
Angophora costata	Smooth barked Apple		405
Banksia serrata	Saw-toothed Banksia		50
Casuarina littoralis	Black She-oak		125
Leptospermum flavescens	Common Tea-tree		10
PM 37			
Soil Removed		17. 5.76	
Soil Replaced		14.10.76	
Fertiliser (10.88 kg Phosphorus)			
First Application		15.10.76	2.72 kg
Second Application		5. 5.77	2.72 kg
Third Application		20. 9.77	2.72 kg
Fourth Application		10. 1.78	2.72 kg
Seedlings Planted			
Eucalyptus botryoides	Bangalay		110
E. eugenioides	White Stringybark		210
E. gummifera	Bloodwood		290*
E. haemastoma	Scribbly Gum		205
E. pilularis	Blackbutt		265
E. piperita	Peppermint		306
E. punctata	Grey Gum		360
Angophora costata	Smooth barked Apple		128
Leptospermum flavescens	Common Tea-tree		10

* This figure includes deaths and replants

TABLE 10

FLORAL SPECIES OCCURRING ON REHABILITATED POST MINING AREAS ON TOMAGO SANDBEDS*

0-2 Years After Mining	2-4 Years After Mining	4-6 Years After Mining	6-8 Years After Mining
Occasional Species			
Acacia cyanophylla x#	*Acacia brownii*	*Acacia cyanophylla* x#	*Acacia botrycephala*
A. elongata	*A. cyanophylla* x#	*A. myrtifolia*	*A. brownii*
A. myrtifolia	*A. elongata*	*Acanthospermum australe*	*A. cyanophylla* x#
Acanthospermum australe	*Acanthospermum australe*	*Acetosella vulgaris*	*A. longifolia*
Actinotus helianthi	*Actinotus helianthi*	*Actinotus helianthi*	var. *sophorae* #
Amperea xiphoclada	*Baeckea denticulata*	*Angophora costata* #	*A. myrtifolia*
Aotus ericoides	*B. diosmifolia*	*Astroloma pinifolium*	*Actinotus helianthi*
Baeckea denticulata	*Banksia serratifolia* #	*Baeckea denticulata*	*Amperea xiphoclada*
B. diosmifolia	*Blandfordia grandiflora*	*B. diosmifolia*	*Angophora costata* #
B. ramosissima	*Boronia falcifolia*	*B. linearis*	*Aotus ericoides*
Banksia serratifolia #	*B. pinnata*	*B. ramosissima*	*Astroloma pinifolium*
Billardiera scandens	*Brachyloma daphnoides*	*Banksia asplenifolia*	*Baeckea denticulata*
Bossiaea ensata	*Callistemom pachyphyllus* #	*B. serratifolia* #	*B. diosmifolia*
B. heterophylla	*C. viminalis* #	*Boronia falcifolia*	*B. linearis*
Callistemon citrinus	*Calytrix tetragona*	*Callistemon viminalis* #	*B. ramosissima*
C. pachyphyllus #	*Carpobrotus aequilaterus* x	*Carpobrotus aequilaterus* x	*B. asplenifolia*
Carpobrotus aequilaterus x	*Cassytha pubescens*	*Cassytha pubescens*	*B. serratifolia* #
Conospermum taxifolium	*Caustis recurvata*	*Casuarina littoralis* #	*Bossiaea ensata*
Conyza albiba	*Chenopodium ambrosioides*	*Cheilanthes tenuifolia*	*B. heterophylla*
C. bonariensis	*Chloris gayana*	*Chenopodium ambrosioides*	*B. rhombifolia*
Cynodon dactylon	*Commelina cyanea*	*Chloris gayana*	*Callistemon viminalis* #
Dampiera stricta	*Cynodon dactylon*	*Conyza albiba*	*Carpobrotus aequilaterus* x
Dillwynia glaberrima	*Dampiera stricta*	*Cynodon dactylon*	*Cassytha pubescens*
Digitaria aequiglumis	*Dianella caerulea*	*Cyperus polystachyos*	*Casuarina littoralis* #
Entolasia marginata	*D. revoluta*	*Daviesia ulicifolia*	*Chloris gayana*
Eucalyptus botryoides #	*Eleusine indica*	*Eleusine indica*	*Commelina cyanea*
E. piperita #	*Entolasia marginata*	*Eragrostis brownii* ssp. *lat*	*Conyza albiba*
E. punctata #	*Epaltes australis*	*Eriostemon australasius*	*Cortaderia sellowiana* x
E. robusta #	*Eucalyptus botryoides* #	*Eucalyptus eugenioides* #	*Daviesia acicularis*
Gompholobium pinnatum	*E. parramattensis* #	*E. gummifera* #	*Daviesia ulicifolia*
Gonocarpus micranthus	*E. punctata* #	*E. haemastoma* #	*Dianella caerulea*
Hibbertia fasciculata	*E. robusta* #	*E. oblonga* #	*Dillwynia glaberrima*
H. scandens	*E. tereticornis* #	*E. parramattensis* #	*Epaltes australis*
Imperata cylindrica	*Gompholobium latifolium*	*E. pilularis* #	*Eriostemon australasius*
Kennedia rubicunda	*G. pinnatum*	*E. punctata* #	*Eucalyptus botryoides* #
Leptocarpus tenax	*Gonocarpus micranthus*	*E. tereticornis* #	*E. gummifera* #
Leptospermum attenuatum #	*Haemodorum planifolium*	*Gampholobium latifolium*	*E. haemastoma* #
L. flavescens #	*Helichrysum diosmifolium*	*Gonocarpus micranthus*	*E. oblonga* #
L. laevigatum	*Hibbertia scandens*	*Haemodorum planifolium*	*E. parramattensis* #
Leucopogon ericoides	*Hovea linearis*	*Helichrysum diosmifolium*	*E. pilularis*
Lomandra glauca	*Hypolaena fastigiata*	*Hemarthria uncinata*	*E. robusta*
Melaleuca armillaris #	*Imperata cylindrica*	*Hibbertia fasciculata*	*E. tereticornis*
M. decora	*Isopogon anemonifolius*	*H. scandens*	*Gompholobium latifolium*

Table 10 (cont'd)

0-2 Years After Mining		2-4 Years After Mining		4-6 Years After Mining		6-8 Years After Mining	
Occasional Species (cont'd)							
Melichrus procumbens		*Kennedia rubicunda*		*Isopogon anemonifolius*		*Haemodorum planifolium*	
Monotoca elliptica		*Lepidosperma longitudinale*		*Juncus planifolius*		*Haloragis teucrioides*	
M. scoparia		*L. laevigatum*	#	*Kunzea capitata*		*Hardenbergia violacea*	
Opercularia varia		*Leucopogon setiger*		*Lambertia formosa*		*Helichrysum apiculatum*	
Persoonia levis		*L. virgatus*		*Leptospermum flavescens*	#	*H. diosmifolium*	
P. linearis		*Macrozamia communis*	#	*Leucopogon setiger*		*Leptocarpus tenax*	
P. linifolia		*Melaleuca armillaris*	#	*Leucopogon virgatus*		*Leptospermum attenuatum*	
Platysace ericoides		*M. decora*		*Macarthuria neo-cambrica*		*L. laevigatum*	#
P. lanceolata		*M. nodosa*		*Melaleuca nodosa*		*Leucopogon ericoides*	
Pomax umbellata		*M. quinquenervia*	#	*Melichrus procumbens*		*Macrozamia communis*	#
Pteridium esculentum		*M. sieberi*		*Opercularia varia*		*Melaleuca nodosa*	
Pultenaea elliptica		*M. thymifolia*		*Patersonia sericea*		*M. sieberi*	
Restio tetraphyllus		*Monotoca scoparia*		*Pseudanthus orientalis*		*Melichrus procumbens*	
Schoenus ericetorum		*Opercularia varia*		*Pteridium esculentum*		*Monotoca scoparia*	
Senecio lautus	x	*Patersonia glabrata*		*Pultenaea blakelyi*		*Patersonia sericea*	
Trachymene incisa		*P. sericea*		*P. elliptica*		*Petrophile fucifolia*	
Xanthorrhoea minor	#	*Pultenaea blakelyi*		*Schoenus brevifolius*		*Pomax umbellata*	
Zieria laxiflora		*P. elliptica*		*Sida rhombifolia*		*Pseudanthus orientalis*	
		P. retusa		*Styphelia laeta*		*Pteridium esculentum*	
Common Species		*Restio tetraphyllus*		*Tephrosia scariosa*		*Restio pallens*	
Acacia longifolia var. *sophorae*	#	*Schoenus ericetorum*		*Woollsia pungens*		*Ricinocarpus pinifolius*	
Angophora costata	#	*Selaginella uliginosa*				*Schoenus ericetorum*	
Bossiaea rhombifolia		*Tephrosia scariosa*		Common Species		*Styphelia laeta*	
Callistemon viminalis	#	*Wahlenbergia gracilis*				*Trachymene incisa*	
Daviesia acicularis		*Xanthorrhoea minor*	#	*Acacia botrycephala*			
Dillwynia retorta		*Zieria laxiflora*		*A. longifolia* var. *sophorae*	#	Common Species	
Entolasia stricta				*A. suaveolens*	#		
Eucalyptus eugenioides	#	Common Species		*Amperea xiphoclada*		*Acacia suaveolens*	#
E. parramattensis	#	*Acacia botrycephala*		*Billardiera scandens*		*Cynodon dactylon*	
Haemodorum planifolium		*A. longifolia* var. *sophorae*	#	*Bossiaea ensata*		*Dampiera stricta*	
Haloragis teucrioides		*A. myrtifolia*		*B. heterophylla*		*Dianella revoluta*	
Melaleuca sieberi		*Amperea xiphoclada*		*B. rhombifolia*		*Dillwynia retorta*	
M. thymifolia		*Angophora costata*	#	*Conospermum taxifolium*		*Eucalyptus punctata*	
Phytolacca octandra	x	*Astroloma pinifolium*		*Dampiera stricta*		*Facelis retusa*	x
Ricinocarpus pinifolius		*Billardiera scandens*		*Daviesia acicularis*		*Hibbertia scandens*	
		Bossiaea ensata		*Dianella caerulea*		*Lomandra longifolia*	
Very Common Species		*B. rhombifolia*		*D. revoluta*		*Melaleuca thymifolia*	
Acacia suaveolens	#	*Daviesia acicularis*		*Dillwynia glaberrima*		*Pimelea linifolia*	
A. ulicifolia		*Entolasia stricta*		*D. retorta*			
Eucalyptus gummifera	#	*Eucalyptus eugenioides*	#	*Entolasia stricta*		Very Common Species	
E. haemastoma	#	*E. gummifera*	#	*Epaltes australis*			
E. oblonga	#	*E. oblonga*	#	*Haloragis teucrioides*	x	*Acacia ulicifolia*	
E. pilularis	#	*E. pilularis*	#	*Leptocarpus tenax*		*Conospermum taxifolium*	
E. tereticornis	#	*Hardenbergia violacea*		*Leptospermum attenuatum*		*Conyza bonariensis*	
				L. flavescens		*Lomandra glauca*	
				Lomandra longifolia		*Persoonia levis*	
						P. linearis	

Table 10 (cont'd)

0-2 Years After Mining	2-4 Years After Mining	4-6 Years After Mining	6-8 Years After Mining
Very Common Species (cont'd)	Common Species (cont'd)	Common Species (cont'd)	Very Common Species (cont'd)
Hardenbergia violacea	*Hibbertia fasciculata*	*Melaleuca sieberi*	*Platysace ericoides*
	Leptocarpus tenax	*M. thymifolia*	*Senecio lautus* x
	Leptospermum attenuatum	*Phytolacca octandra* x	
	L. flavescens	*Pimelea linifolia*	
	Lomandra longifolia	*Pomax umbellata*	
	Melichrus procumbens	*Ricinocarpus pinifolius*	
	Phytolacca octandra x	*Trachymene incisa*	
	Pomax umbellata	*Zieria laxiflora*	
	Pteridium esculentum		
	Ricinocarpus pinifolius	Very Common Species	
	Schoenus brevifolius		
	Styphelia laeta	*Acacia brownii*	
	Trachymene incisa	*A. ulicifolia*	
		Aotus ericoides	
	Very Common Species	*Conyza bonariensis*	
		Hardenbergia violacea	
	Acacia suaveolens #	*Leucopogon ericoides*	
	A. ulicifolia	*Lomandra glauca*	
	Aotus ericoides	*Persoonia levis*	
	Baeckea ramosissima	*P. linearis*	
	Bossiaea heterophylla	*Platysace ericoides*	
	Conospermum taxifolium	*Senecio lautus* x	
	Conyza bonariensis		
	Dillwynia glaberrima		
	D. retorta		
	Eucalyptus haemastoma #		
	Haloragis teucrioides		
	Leucopogon ericoides		
	Lomandra glauca		
	Persoonia levis		
	P. linearis		
	Pimelia linifolia		
	Platysace ericoides		
	Senecio lautus x		

Key: Frequency - Occasional - occurs in less than one-third of the P.M's covered by the transect
Common - occurs in one-third to two-thirds of the P.M's covered by the transect
Very Common- occurs in more than two-thirds of the P.M's covered by the transect.

Note: # Species planted by the Company to supplement natural regrowth.
x Indicates not native to area.
* Studies carried out by the Company.

TABLE 11

COMPARISON OF VEGETATION CHARACTERISTICS OF MINED AND UNDISTURBED AREAS*

ASSOCIATION/ COMUNITY	HABITAT TYPE AND STRUCTURE	TREES Observed Species	TALLER SHRUBS Observed Species	LOW SHRUBS Observed Species	GROUND COVER Observed Species	AVERAGE DISTANCE TO TALLEST STRATUM SPECIES FROM A RANDON POINT	COMMENTS
Regenerating Mined Area P.M. 32			Eucalyptus haemastoma Eucalyptus spp. Acacia elongata A. cyanophylla A. longifolia	Acacia ulicifolia Persoonia lanceolata Bossiaea sp. Pimelea linifolia Pea spp. 2 unidentified spp.	Trachymene incisa Chloris gayana Hardenbergia violacea Cynodon dactylon Baeckia ramosissima Taraxacum officinale 2 unidentified spp.	3.8 m	Lot of patches of bare sand. A number of dead low shrubs and grass tussocks evident. Also some evidence of fire.
HEIGHT % COVER			2-3 m 20	0.5-2 m 20-30	$\bar{x}$ = 0.2 m, r = 0.04-0.7 m $\bar{x}$ = 43 , r = 15-80		
Regenerating Mined Area P.M. 37			Acacia cyanophylla A. elongata	Actinotus helianthi Persoonia lanceolata Acacia botrycephala A. ulicifolia Eucalyptus spp. Ricinocarpus pinifolius Pea spp. Haemadorum corymbosum Pimelea linifolia Banksia serrata Melaleuca ericifolia Bossiaea rhombifolia B. heterophylla 3 unidentified spp.	Hardenbergia violacea Grass spp. Paspalum dilatatum one unidentified sp.	25 m	Low shrub stratum is visually dominant.
HEIGHT % COVER			2 m 1	$\bar{x}$ = 55m, r = 0.3-0.6m	$\bar{x}$ = 34, r = 20-50		
Ecotone between Scribbly Gum Open-forest and Rusty Gum - Red Bloodwood Open-forest	Dry Sclerophyll Forest. Open-forest with dense low understorey and ground cover.	Eucalyptus haemastoma E. gummifera Angophora costata	Angophora costata Banksia serrata Eucalyptus spp. Persoonia levis	Eriostemon australasius Pea spp. Pteridium esculentum Bossiaea heterophylla Aotus ericoides Leptospermum sp. Dillwynia sp. Actinotus helianthi Banksia serrata Beronia pinnata Zieria laxiflora Xanthorrhoeasp. Acacia suaveolens Ricinocarpus pinifolius	Baeckia ramosissima Dampiera australis Grass spp. Selaginella uliginosa Schizaea bifida Epacris sp. Platysace ericoides Goodenia sp. Lomandra glauca Hardenbergia violacea Leaf litter one unidentified sp.	5 m	Leaf litter comprises about 98% of ground cover.
HEIGHT % COVER		16-20 m 40-50	3-5 m 30	$\bar{x}$ = 0.9m, r = 0.25-2m $\bar{x}$ = 60 , r = 10-80			

TABLE 11 (Cont'd)

ASSOCIATION/ COMMUNITY	HABITAT TYPE AND STRUCTURE	TREES Observed Species	TALLER SHRUBS Observed Species	LOW SHRUBS Observed Species	GROUND COVER Observed Species	AVERAGE DISTANCE TO TALLEST STRATUM SPECIES FROM A RANDOM POINT	COMMENTS
Broad-leaved Paperbark - Swamp Mahogany Open-forest	Swamp Sclerophyll Forest. Open-forest with dense clumps of tall understorey.	Eucalyptus robusta E. propinqua Melaleuca quinquenervia	Callistemon sp. Melaleuca nodosa M. sieberi Eucalyptus robusta Acacia longifolia Leptospermum juniperinum Leptospermum sp. Persoonia lanceolata	Sedge sp. Helichrysum diosmifolium	Themeda australis Grass spp. Leaf litter Platysace sp. Hibertia sp.	2.6 m	Leaf litter comprises about 80% of ground cover.
HEIGHT % COVER		16-20 m 40	$\bar{x}$ = 2.4m, r = 2-3m 20-70	$\bar{x}$ = 1.3m, r = 1.0-1.5m $\bar{x}$ = 23 , r = 15-40	$\bar{x}$ = 96, r = 90-100		

* Studies by *James B. Croft & Associates (1980).*

4.9.5 Potential Ecological Constraints in the Tomago Sandbeds

Potential ecological constraints associated with the study area are considered to be:

i. High incidence of fire affecting plant species, growth regeneration and community composition.

ii. Possible water stress on plants owing to the nature of the sandbeds and the moderate annual rainfall.

iii. Possible intrusion of exotic plant species into disturbed areas.

iv. Continued presence of exotic animals, particularly feral pigs and hares.

4.10 LAND USE

4.10.1 Planning

Planning for this area is the responsibility of Port Stephens Shire Council in accordance with Interim Development Order No. 23 (May 1974).

The zoning classifications for the proposed mine site and the surrounding area are shown in Table 12. Mineral sands mining is permissible with consent, in all four zones. Clause 11(2) of IDO 23 includes the provisions requiring DEP concurrence to mineral sands mining.

TABLE 12

PLANNING ZONES

Zone	Use
Special Uses - Zone 5A	Area reserved for Tomago Sandbeds Water Supply Catchment.
Non-Urban - Zone 1A	Restricts land use to agriculture and forestry. A minimum subdivision of 40 ha is permitted.
Non- Urban - Zone 1B	Subdivisions less than 40 ha and having a frontage to the main roads of less than 400 m are restricted. Commercial and industrial land use is also restricted.
Non-Urban - Zone 1C	Flood-prone land restricted to agricultural land use.

4.10.2 Special Uses

Within the study area, the land is used for a number of special purposes as shown in Figure 14.

Tomago Sandbeds Water Supply Catchment Area

This reserve which covers an area of 106 km^2 is the major land use.

Apart from the mining of mineral sands, the area remains relatively undisturbed and is a restricted area for the protection of the groundwater aquifer. Within this proclaimed area any permitted development is subject to strict controls and regulations imposed by the Board.

R.A.A.F. Base

This military establishment at Williamtown is located to the southwest of the proposed mining site and covers an area of 730 ha. The base is one of the largest air force bases in Australia and employs 2000 uniformed and 150 non-uniformed personnel.

Air Weapons Range

Adjacent to the northeast section of the proposed sands mining operation is the Salt Ash Air Weapons Range, which is used by the air force approximately one week in each month.

4.10.3 Agricultural Land Use

The land use pattern of the surrounding area is predominantly rural in character as shown in Figure 14.

Poultry

Four poultry farms operate on Richardson Road, west of the Medowie turnoff. These farms breed chickens for Steggles Pty. Ltd. and the produce is sent to a processing plant at Beresfield. The number of chickens held on each

farm varies from 48 000 to 80 000. Bulk feed supplies are delivered regularly by Steggles Pty. Ltd.

A similar poultry farm is located on the Medowie Road, north of the proposed mining leases.

Horse Breeding - Cattle Grazing

Along Grahamstown Road, northwest of the proposed mining leases, horse breeding and cattle grazing occur, with horse breeding the dominant activity.

The largest farm of this type is the Wayfarers Riding Ranch. Thoroughbred mares and foals are also grazed in the area. One local resident breeds greyhounds while another raises donkeys, sheep and goats.

Horse grazing is a common occurrence on similar farms along Medowie Road, north of the proposed mining area.

Hobby Farming - Rural Residency

Hobby farming is a land use which is becoming more significant in the area. Typically the farm is of variable size, featuring a dwelling and land utilised for the growing of vegetables and the keeping of a number of domestic pets such as goats, dogs and horses. Two residences with roadside stalls are located on Richardson Road.

4.10.4 Urban Land Use

Urban development in the area is typically ribbon development along the main roads.

Ninety families live on the Williamtown R.A.A.F. Base to the south of the proposed mining area. Residential development is also occurring in the Salt Ash and Lemon Tree Passage region to the east of the proposed mining area and at Medowie and Campvale to the north.

Nursery
Grahamstown Road
Grahamstown Storage Reservoir
Campvale Swamp
Dog Pound
Moffats Swamp
Richardson Road
CAMPVALE
Medowie Road
132 kV Transmission Line
Duckhole Trig. Station
8
10
12
13
18
HDWB Main Access Road
7
9
11
Lemon Tree Passage Road
Timber Yard
Nelson Bay Road
Tilligerry Creek
WILLIAMTOWN

LEGEND

- Location of Ore Bodies
- ●7 Water Pumping Stations
- ■ Rural Residence
- Catchment Boundary
- Residential Development
- Forested Areas
- Swamp Land subject to Periodic Inundation
- Military
- Partially Cleared/Horse & Beef Cattle Grazing
- Crop & Pasture Lowlands
- Dairying
- Existing Use - Mining
- Poultry Farming
- Market Gardening
- Heavy Mineral Sand Mining
- Orchard
- Abandoned Quarry - Sand Pit
- Mini-Bike Riding Area

N

Scale
0 250m 500m 1km

LANDUSE

FIGURE 14

4.10.5 Recreational Land Use

Facilities such as a tennis court and a number of recreation halls are located along Nelson Bay Road between Williamtown and Salt Ash. A mini-bike club is being established north of Richardson Road at Campvale.

Recreational use of the Tomago Sandbeds Water Supply Catchment Area is prohibited. Approximately 10 km east of the sandbeds, Newcastle Bight beach provides for buggy and trail bike riding within the dunes as well as fishing and swimming.

4.10.6 Extractive Industries

Rutile & Zircon Mines (Newcastle) Limited conducts the only mining operation within the sandbeds catchment area. Several other companies extract limited amounts of glass sands adjacent to the catchment area near Lemon Tree Passage.

4.11 ARCHAEOLOGICAL ASPECTS

Evidence that the Garuagal aboriginal tribe once inhabited the Tomago Sandbeds is limited primarily to bark incisions for canoes, shields and wooden bowls *(P. Haslam, 1978)*. During the past decade of mining the Company has not found any archaeological evidence.

4.12 VISUAL ASPECTS

The Tomago Sandbeds form part of the coastal lowlands' landscape as defined by *Reynders (1978)*. This coastal strip features a mosiac of open heath, farm swampland and forest.

The proposed mining locations are well-vegetated and therefore, according to a visual preference survey conducted by *Radford & Bartlett (1977)*, would rank as having high visual quality, exceeded only by coastal foreshores,

river in a rural setting and enclosed rural valleys.

Visual preference diminishes with an extension of man-made intrusions and hence the mining operations themselves would be given a low ranking.

The flat topography and dense vegetation surrounding recently mined sites will assist in alleviating the visual impact.

The visual quality of mined areas will be improved after eight to ten years of regeneration when the trees reach 7 to 10 m and the shrub layer becomes well advanced.

4.13 SOCIO-ECONOMIC ASPECTS

Population

Since 1966, Port Stephens Shire has exhibited a population growth rate greater than any other local government area in the Lower Hunter. This regional trend has resulted in part from a decline in the significance of Lake Macquarie as the major centre of suburban expansion.

The growth of population in Port Stephens and the local area is illustrated in Table 13. The significance of the Tomago, Williamtown, Campvale and Medowie districts, as contributors to the Shire's growth, is made apparent by the high (49.96) percentage increase in the population of the local area.

The population of approximately 2000 represents 8.5 per cent of the Shire's total population of 23 450 (1979). The continued growth of such areas as Medowie since 1976 has further increased the significance of the local area as a centre of suburban development in the Lower Hunter.

Industry and Employment

Port Stephens Shire has a well diversified rural base with poultry, dairying, beef cattle, fruit and vegetable farming, the principal activities. The expansion of manufacturing and tertiary industries has broadened the economic base. Continued population growth and the attractiveness of Port Stephens

for tourism and recreation has also significantly influenced this trend in the Shire.

TABLE 13

POPULATION CHANGE IN PORT STEPHENS SHIRE AND THE LOCAL AREA 1971-76

	1971 Number	1976 Number	Change Per Cent
Port Stephens Shire:			
Total	17 734	20 935	18.05
Male	9 431	10 720	13.67
Female	8 303	10 215	23.03
Local Area:			
Total	1 281	1 921	49.96
Male	669	966	44.39
Female	612	955	56.05

Source: *Australian Bureau of Statistics.*

Table 14 shows in detail the various industries in which the workforce is employed for both the Shire and for the district surrounding the mining area.

TABLE 14

INDUSTRY OF THE EMPLOYED WORKFORCE IN PORT STEPHENS SHIRE AND THE TOMAGO SANDBEDS AREA* (1976)

Industry	Port Stephens Shire		Tomago Sandbeds Area	
	Number	Percentage	Number	Percentage
Agriculture	672	8.5	75	9.5
Mining	142	1.8	12	1.5
Manufacturing	1332	16.8	207	26.1
Electricity, Gas and Water	161	2.0	18	2.3
Construction	614	7.7	66	8.3
Wholesale and Retail Trade	1164	14.7	134	16.9
Transport, Storage	255	3.2	40	5.1
Communications	56	0.7	34	4.3
Finance, etc.	370	4.7	34	4.3
Public Administration, Defence	1477	18.6	50	6.3
Health	262	3.3	26	3.3
Education	303	3.8	31	3.9
Entertainment, Recreation etc.	569	7.2	36	4.5
Other	548	7.0	57	7.2
Total	7926	100.0	792	100.0

Source: *Australian Bureau Statistics - Census of Population and Housing 1976.*

* The Tomago Sandbeds area is represented by the Tomago, Williamtown, Campvale and Medowie collector districts.

Manufacturing, wholesale and retail trade, agriculture and defence are the main employment industries.

As at November 1980, there were no skilled mining personnel unemployed in the Newcastle and Maitland Commonwealth Employment Service districts.

Section 5

Details and Effectiveness of Safeguards

SUMMARY

In Section 3, a full description was given of the safeguards and environmental controls that will be incorporated into the proposal. In this section, the efficacy of those controls is discussed with particular reference to their effectiveness over the past years of the Company's similar operations in the sandbeds.

5.1 MINERAL SANDS MINING IN GENERAL

The Company has been dredging the sandbeds since 1972 to the satisfaction of the Department of Mineral Resources and the Board (the authority responsible for the protection and management of this groundwater source). The existing operation has been, and is, subject to rigorous controls with special emphasis on water quality control and site restoration.

Using similar, carefully monitored safeguards and controls, it will be possible for heavy mineral sands mining operations to be undertaken so as to not adversely affect the Board's utilisation of the sandbeds. The effectiveness of these safeguards is discussed in this Section. In addition, the Company will pursue a policy of intensive progressive restoration and rehabilitation procedures subsequent to the heavy mineral extraction.

5.1.1 Site Preparation

Prior to any modification of the environment, the pedologic and hydrologic conditions will be investigated to ensure that no new factor exists which may require particular surveillance, for example local silt formations.

Vegetation removal will be restricted to an absolute minimum as outlined in Section 3.5.2. The mining path will vary in width from 60 m for the land-based concentrator plant to 150 m for the floating plant. Vegetation up to 120 m in advance of the dredge pond will be cleared. The area cleared in front of the dredge pond will vary according to climatic conditions, as

the fallen timber must be burnt (at times other than those proscribed by the Bush Fires Control Act) and raked prior to mining.

Clearing will be undertaken in daylight hours only.

Where no economic mineralisation exists, islands of vegetation will be left between mining runs to assist in the protection of the area and to facilitate revegetation.

No disturbance will occur beyond the width of the mining path, except for the purpose of access. Every attempt will be made to restrict vehicular movement to existing Company and Board roads and to previously mined areas.

5.1.2 Topsoil Preservation

The topsoil and remaining understorey vegetation will be stripped to a depth of 300 mm and stored in windrows on either side of the mining path.

The value of the topsoil as a viable seed source is subject to the duration of storage and it is anticipated that this soil will be respread within three months, based on a mining advance of 100 m per four weekly mining period.

The islands of native vegetation left intact along the mining path will assist in alleviating erosion of the exposed surfaces by wind. Should such measures prove insufficient, screens of vegetation will be planted.

Erosion by water is unlikely as the sand is very porous and all rainfall rapidly infiltrates the soil.

5.1.3 Topography Restoration

The proposed action in the mined-over area is to contour the tailings to a profile similar to that which existed prior to mining. Pre-mining contour surveys will assist in restoring the surface features.

The topsoil will then be replaced in topographic conditions similar to those which existed before mining. For example, every attempt will be

made to ensure that topsoil from low-lying swampy areas is replaced in similarly restored areas.

The conditions under which earthmoving equipment will operate are the same as those pertaining to vegetation and topsoil removal.

5.1.4 Rehabilitation

A management programme designed to control soil erosion and to ensure progressive rehabilitation to a stable vegetation cover will be pursued by the Company. To facilitate successful revegetation, a detailed botanic survey will be undertaken prior to mining to ascertain the existing flora regime. Seed will be collected from indigenous species to be germinated in the Company's nursery.

Immediately after the topsoil has been replaced on a mined area, a cereal cover crop may be sown in instances where the soil requires prompt stabilisation.

In locations where cover cropping has failed to prevent soil erosion, brush matting will be employed to provide protection.

Indigenous seedlings raised in the nursery will be planted out as soon as practicable after the cover crop is able to afford reasonable protection.

Normally no cover crop will be used, hence the seedlings will be planted out immediately after site restoration.

The Company will use sprinkler irrigation to supplement rainfall as required, especially during dry periods. Irrigation will not exceed the equivalent of the amount approved by the Board.

Numerous trial plots already in existence are being monitored by the Company and the Board to ascertain the relative performance of selected species under varying topographical and fertility conditions.

Vegetation and animals which are considered to have a detrimental influence on the progress of rehabilitated areas will be controlled.

Specific reviews of the progress of the revegetation programme will be held by the relevant parties every six months.

As has been stated elsewhere in this document, the Company conducts its mining operations under strict conditions imposed by the Department of Mineral Resources and the Board. The Company proposes that any future mining operations conducted within the subject areas will be in accordance with the Conditions of Authority negotiated with the Board and approved by the Minister for Mineral Resources.

5.2 WATER QUALITY CONTROL

Four aspects are of importance:

i. The effect that the physical disturbance (cutter-suction dredging) has on the groundwater in the immediate vicinity of the mining operation.

ii. The quality of clarifier overflow returned to the dredge pond.

iii. The quantity of settled slime to be disposed of in the settlement ponds and the life of those ponds.

iv. The volume and quality of any water overflowing those ponds and discharging to Dawsons Drain and thence to Fullerton Cove.

5.2.1 Effect of Mining on Adjacent Groundwater

During the initial trial programme of heavy mineral extraction undertaken outside the catchment area, it was found that a layer of slime, containing a relatively high concentration of organic detritus, tended to settle to the bottom of the dredge pond. The subsequent return of cleaned sand (tailings) from the floating or land-based concentrator resulted in the compaction and compression of this unconsolidated slime. Reports from the Board's consultants at the time showed that lower permeability and water quality changes were associated with a thin layer of slime and low permeability between the overlying sand and the undisturbed aquifer below.

The possible consequences of this were twofold:

i. Rates of infiltration of rainwater could have decreased in the areas affected.

ii. Bacteriological and chemical reactions on the settled slime layer could have produced ferrous iron. An increase in the concentrations of iron in this unoxidised form could cause periodic difficulties in the processing of the natural water at the Board's water treatment facility at Tomago.

After discussions between the Company and the Board, a programme of regular inspections by scuba-divers employed by the Company was instituted. This procedure has been adopted as an integral part of the mining operations since that time. If, during these inspections a slimes layer is found at the toe of the recycled tailings, it is removed using a suction pump. The slimy residues are then pumped to the clarifier/thickener for removal with the clarified water being recycled to the dredge pond. An independent assessment of the conditions of the bottom of the pond is made twice daily and a report given to the mine supervisor.

After the deposition of at least two weeks of tailings, 10 boreholes are drilled on a variable grid to ensure that any residual process slimes on the former pond bottom total no more than 50 mm in thickness. Similarly no more than 30 mm of slime is permitted in any one borehole.

It is intended that these water quality safeguards will be continued as required during the life of the extended operations described in this Statement. Should the specification concerning the thickness of settled slime be exceeded at any time, the Company, if required, will re-mine the area concerned.

The monitoring of controls and safeguards relating to the mining operations will be undertaken by consultants engaged by the Board and the quality of the groundwater will be monitored regularly to verify, on a continuous basis, the efficacy of the control measures adopted.

5.2.2 Clarifier Overflow

Over past years, the concentration of suspended matter in the overflow

has averaged around 100 mg/L. The range has been between almost zero (crystal clear water) to a few hundred mg/L. The use of polyelectrolytes and the low overflow rate (20 kL/m^2.d) has ensured that slime removal is sufficient to meet the requirements of the Board in accordance with the Conditions of Authority.

The quantity of suspended solids in the clarifier overflow represents a 3 per cent recirculating load as part of the water clarification process.

This overflow has been satisfactorily monitored for a number of years as described previously in Section 5.2.1 and these procedures are subject to constant review by the Board.

5.2.3 Slime Ponds and their Life Expectancy

The location of the existing slime ponds is shown in Figure 3. They occupy an area of 30 ha and when full will contain dried slime to a depth of 2 to 25 m.

There are four ponds and filling commenced in December 1972. Number 4 pond is full and the dry fertile solids are to be grassed in the near future. Number 1 pond is nearly full and the remaining two have a combined capacity adequate to handle another five years of supply from the slime thickener.

On 16th October 1980, the Company received consent from the Port Stephens Shire Council to develop a further area shown in Figure 3 for the construction of approximately 12 additional ponds, each 3.3 m deep and covering an area of 50 ha. On the basis of the experience to date, these ponds will provide a capacity for slime settling, compaction and storage for the life of the extended mining operations. This is more than sufficient to cope with the quantity of solids that will result from the extension of operations for which approval is being sought.

The construction of these ponds has been approved by the State Pollution Control Commission (under Section 19 of the Clean Waters Act) and by the Department of Public Works as the area is a gazetted floodplain.

The Company has supplied the Commission will full engineering details and has been granted a licence to discharge clear overflow from these ponds.

5.2.4 Overflow from Slime Ponds

The Company holds a licence under the Clean Waters Act to discharge supernatant from the slime settling ponds into Dawsons Drain. (A copy of this licence, renewed annually, is shown in Appendix 8).

The licence permits the overflow of clear water, containing less than 30 mg/L of suspended solids, at a maximum rate equal to the peak rate at which slime is pumped to the ponds from the clarifier/thickener.

As a condition of the licence the Company monitors the quality of the effluent weekly and submits an annual report to the State Pollution Control Commission with its annual application for renewal. A typical set of results (for the year ending July 1977 to the end of July 1978) is reproduced in Appendix 9.

These results show that the pH of the effluent ranged from 4.1 to 6.6 with a geometric mean of 4.55. The concentration of suspended matter ranged from 2 mg/L to 990 mg/L with a geometric mean of 20.2 mg/L.

(The abnormally high value of 990 mg/L occurred on 27th July 1977, when very strong westerly winds caused high turbidity levels.)

A similar analysis of all data obtained between July 1977 and July 1979 (107 results) showed that the geometric mean of the suspended solids concentrations was 16.7 mg/L. The calculation of this mean took into account inexplicably high values on three occasions of 4400 mg/L, 990 mg/L, and 345 mg/L.

The operation of the ponds, in terms of their effectiveness in producing effluent of the high quality required by the State Pollution Control Commission has been good. Water containing between 15 and 30 mg/L of suspended matter is reasonably clear, exhibiting only a slight cloudiness, and would have a negligible effect on waters normally flowing in Dawsons

Drain to Fullerton Cove.

If one allows for the delivery of 670 kL/d of slime containing 6.8 per cent solids, assumes that the dried slime still retains 15 per cent moisture and allows for the annual evaporation in the area (which exceeds annual precipitation by 59 mm), it is estimated that a total volume of about 120 ML/y would be discharged as clear overflow to Dawsons Drain. Under average weather conditions, this overflow would occur at a rate of between about 600 kL/d and 300 kL/d, the latter figure estimated by allowing for attenuation by the large pondage.

In actual fact, there have been few instances during the past 24 months when any discharges have occurred. This has been the result of the prevailing drought conditions in 1980 and successful attempts by the Company to reduce water consumption.

5.3 AIR QUALITY CONTROLS

The mining operations involve wet processing at all stages and generation of any dust around the mining areas themselves will not occur. There is a possibility that dust may be generated by haul-trucks using unsealed roads during very dry weather. The Company will employ water carts for dust suppression purposes as required.

Reference was made in Section 3.5 to the Company's intention of burning piles of timber removed during the stripping of the mining path. The Company recognises that, under Section 24 of the Clean Air Act, open burning is prohibited in Port Stephens Shire, except where it is carried out for the purpose of preventing and controlling bush fires as authorised under the Bush Fires Act, 1949. No open burning will be undertaken without appropriate approval under that Act.

The introduction of spark arrestors on heavy earthmoving equipment used in the mining operation will eliminate the fire hazard associated with the use of such equipment.

5.4 NOISE CONTROLS

As discussed later in Section 6.5, there will be some occasions when the mining operations will approach the residences at Campvale as shown in Figure 9.

The safeguards to be employed are as follows:

i. Mining will not be carried out within 200 m of any principal residence without the owner's or occupier's written permission as specified in the Mining Act (1973).

ii. In these locations, the bulldozers and front-end loaders will be modified to achieve an overall reduction in exhaust and engine noise of 15 dB(A). This will be accomplished by the fitting of high performance mufflers, placing acoustic panels around the engines and temporarily fitting cooling fans having specially shaped blades. (All of these actions severely reduce the performance of mobile equipment and increase running costs. It is for this reason that these modifications will be carried out only when operating within approximately 1 km of residences.)

iii. Bulldozers and loaders will operate only during the hours of 7 a.m. to 3 p.m. except in emergencies.

iv. All equipment will be carefully and regularly maintained to ensure that noise levels are kept at practicable minima.

The Company recognises the need to obtain approval from the State Pollution Control Commission under Section 27 of the Noise Control Act. The operation would be deemed to be carried out on Scheduled Premises (as specified by Clause 4 of the Schedule).

The Company will, at that time, supply full engineering details of the equipment to be used and the noise abatement plant and procedures to be incorporated into the operation.

5.5 VISUAL ASPECTS

To minimise the period of ground disturbance and to reduce visual impact the area to be cleared in advance of the dredge pond will be restricted to

120 m. Similarly preparation of the tailings for revegetation will commence promptly after the mining plant has passed through.

The principal objective of the rehabilitation programme is to return the area to a viable ecosystem compatible with the surrounding unmined areas.

Because the terrain is basically flat, the visual consequences will only be significant in those areas where mining is planned adjacent to roads and residences, for example along Richardson Road. In this and other instances, sections of the natural vegetation will be retained where practicable to screen the development. Where there is little or no natural vegetation to act as a cover, special plantings of acacia species will be undertaken to encourage screening from main roads.

5.6 PROTECTION OF MOFFATS SWAMP

During the mining of heavy minerals from the orebody in M.L.A.'s 256 and 1171, it is proposed that all phases of the mining operation will be restricted to an area outside the physical boundary of Moffats Swamp. Topographic and vegetative criteria will be used to determine the extent of the wetland to ensure that drainage of the swamp remains unaffected.

Water quality controls as outlined in Section 5.2 will prevent effluent from the development entering the wetland. Similarly water from Moffats Swamp will not be used in connection with the mining operations.

5.7 EFFECTIVENESS OF SAFEGUARDS

Current mining operations being conducted by Rutile & Zircon Mines (Newcastle) Limited in the gazetted catchment area of the Tomago Sandbeds are proceeding to the satisfaction of the Board.

With the exception of additional noise controls near residential areas, all the safeguards outlined in this section have already been adopted by

the Company in their existing operations. A detailed control and monitoring system has been in existence for a number of years to ensure compliance with, and the adequacy of, these controls.

The evidence from the studies undertaken to date indicates that dredging of the Tomago Sandbeds has caused minimal effect to groundwater quality and yield. The impact of this in relation to the total area to be mined is considered to be negligible.

Section 6

Analysis of the Impact of the Proposal

SUMMARY

This section of the Statement aims to describe the impacts expected to occur as a result of the mining operations. Account is taken of the design and operational safeguards proposed by the Company in assessing the potential interaction of the project on the site and its surrounding environs.

6.1 TOPOGRAPHY

Whilst mining is in progress, the terrain along the mining path will be significantly disturbed but topography restoration safeguards proposed for the project and outlined in Section 5.1 will ensure satisfactory replacement of the surface features within three to four months after mining.

6.2 SOILS

The Company proposes to strip and replace the topsoil as outlined in Section 5.1.2.

Topsoil removal is to be restricted to an absolute minimum ahead of the advancing mining plant to reduce the erosion potential of the disturbed surface and to minimise visual impact.

The retention of islands of native vegetation, cover cropping and brush matting will ensure that a high standard of erosion protection is maintained. The impact of any resultant soil erosion will be minimal.

6.3 HYDROLOGY

6.3.1 Drainage

This coastal sandbed is susceptible to sources of surface pollution due to the high infiltration rates of such a deposit. Stringent operational procedures adopted by the Company will ensure that no lubricants or effluents are permitted to come in contact with the highly porous soil. With such controls, the impact should be negligible.

By implementing the Board's requirements with respect to the control of the deposition of slime, the possible adverse effect of impermeable layers on the former pond bottom will be minimised.

Large-scale water pumping tests have indicated that the permeability of the mine tailings is significantly greater than that of the undisturbed ground. *(Herzog and Gerard 1973, and Hindley et al 1974.)* This impact is considered likely to improve groundwater recharge due to the greater permeability of the sands in the mined areas.

Mineral sands mining does however disturb the consolidated nature of the sandbeds and has a tendency to destroy stratification in underlying indurated sands which are advantageous in providing perched or elevated water tables. Thus, if the proposed sands mining operations were to extend over the whole of the sandbeds, the disturbance and reduced consolidation of the sands may lead to a flattening of the water table throughout and a resultant decrease in the storage capacity.

Whilst the zone of operations is small relative to the total area of the sandbeds and is located centrally within the catchment area, evidence to date indicates that mineral sands mining will have negligible detrimental effect on the water retaining characteristics of the sandbeds.

6.3.2 Ground and Surface Waters

The safeguards to be employed (as described in Sections 3 and 5) will ensure that the impacts on groundwater quantity and quality and on surface waters will be negligible. Experiences over the past nine years vindicate

this confidence.

Whilst there are areas subject to occasional inundation which support swamp vegetation (even with a permeable base) existing in the proposed mining area, few of these wetlands are considered true swamps. This consideration, together with the continued development of the sandbeds by the Board as a domestic water source may modify the hydrologic conditions such that true swamps become less common in the proposed mining area.

6.4 AIR QUALITY

Dust deposition rates resulting from mining operations are considered unlikely to cause any significant impact on the sandbeds or surrounding environs. Dust emissions generated by vehicular movement on unsealed Board and Company roads will be minimal and will be controlled if and when necessary.

6.5 NOISE LEVELS

The results of studies carried out in order to assist in the prediction of impacts from noise are detailed in Appendix 13 and are shown schematically in Figure 9.

Predicted noise levels due to the mining operations shown in Table 15 will exceed existing daytime ambient levels at Campvale for almost two years. Night time noise levels will exceed background levels for approximately eight months and will be more than 5 dB(A) in excess of ambient levels for a period of two months.

The introduction of the special noise control safeguards as outlined in Section 5.4 will significantly reduce the potential impact on the 17 residences (housing approximately 70 people) likely to be affected in the Campvale area.

TABLE 15

PREDICTED NOISE LEVELS AT CAMPVALE
DUE TO MINING OPERATIONS

Noise Level dB(a)	Duration in Months	
	Daytime	Night Time
45 - 50	6	-
40 - 45	15	-
35 - 40	36	2
30 - 35	60	6
<30	Remainder of time	Remainder of time

6.6 FLORA

6.6.1 Tomago Sandbeds Environment

The proposal will involve the clearing of approximately 500 to 600 ha of natural vegetation including sclerophyll forest, heath and heathland and wetlands. This clearing will not be concurrent but will be carried out continuously over a period of 15 to 20 years at a maximum rate of 30 ha/y for two plants operating within the main orebody.

Regeneration practices will mitigate the longterm effects of clearing although the return of vegetation to a climax community may not directly correspond to the original community. This is particularly true in the Tomago Sandbeds where the complex array and distribution of species appears dependent on minor changes in microtopography, soils and drainage characteristics.

Wetland and heath areas will be the most affected; present procedures dictate that such habitats be restored to potential sclerophyll forest.

Whilst areas close to Moffats Swamp will be mined, the safeguard of restricting disturbance to areas outside the physical boundary of the swamp as outlined in Section 5.6 should ensure that the wetland itself remains unaffected.

By placing more emphasis on ascertaining the structure and content of the original communities prior to mining a more diverse number of species may be planted out during the rehabilitation stage.

Consideration of the characteristics of the original communities may also be valuable in determining the size of remnant vegetation islands to be retained in the mining path as seed sources. This option will only be feasible, however, when the grades of mineralisation allow some flexibility in the sizing of the vegetation remnants.

6.6.2 Possible Effect of Fluorides on Revegetation

The Company's revegetation programme is unlikely to be affected by atmospheric fluorides that may be present as a result of existing emissions in the industrial areas of Newcastle and the proposed construction of an aluminium smelter at Tomago. There are two main reasons for this judgement.

Firstly, the areas relevant to this proposal are at least 10 km away from the smelter site (and even further from existing fluoride emissions) and hence will be exposed to little if any fluoride fallout.

Secondly, the species proposed to be used in the revegetation programme are not considered to be unduly sensitive to fluoride.

Further information pertaining to the aluminium smelter proposal and its impact on surrounding flora is documented in the Tomago Aluminium Company Pty. Limited's Environmental Impact Statement *(James B. Croft & Associates, 1980)*.

6.7 FAUNA

The removal of the existing habitats will result in a loss in existing fauna populations for a considerable period of time. Sedentary birds and small non-avian fauna will be most affected.

Arboreal species such as possums and gliders will be affected for a long period as such species require mature trees for nesting and shelter sites. Studies carried out in Buccleuch State Forest on Greater Gliders *(Recher, 1979)*, indicate that no individuals from the mined areas can be expected to survive by moving into adjacent habitat.

Some small ground species may be able to utilise regenerating areas relatively quickly as indicated by the capture of a New Holland Mouse *(Pseudomys novaehollandiae)* in PM 37. This species favours seral communities after fire and it is likely that such regenerating areas simulate the required habitat sufficiently for the animal to colonise. *Fox and Fox (1978)* considered that a minimum period of 20 years was necessary for the vegetation and *Pseudomys novaehollandiae* biomass to correspond with values for undisturbed areas of heath.

The overall impact is anticipated to be a 6 per cent decrease in the forest and wetland habitats within the Tomago Sandbeds ecosystem as areas are mined progressively over a 15 to 20 year period. There will be a corresponding decrease in the populations of some fauna species in the affected areas for a period of up to 40 years as a consequence of the loss of shelter and nesting sites.

6.8 LAND USE ON THE SITE

The Tomago Sandbeds Water Supply Catchment Area is designated for the purposes of groundwater extraction and has been zoned "Special Use".

Water quality control, restoration and rehabilitation safeguards to be implemented by the Company will ensure that there is no conflict of

interests in the dual utilisation of this resource for both heavy minerals and water for domestic consumption.

6.9 LAND USE IN ADJOINING AREAS

Proposed mining operations in the Campvale area will be undertaken in accordance with the provisions of the Mining Act (1973) and as agreed upon following consultations with landholders affected in terms of the Act.

No existing land use is expected to be adversely affected by the mining operations.

6.10 IMPACT ON LOCAL RESIDENTS

Residents who live along Richardson Road, near the intersection with Medowie Road may experience some visual impact. This impact will be minimised by providing screen plantings of vegetation adjacent to the roadways.

The possible haulage of mined materials along Richardson Road will have a minimal impact on residents. It is anticipated that on average, one truck will leave the mine site every 20 to 40 minutes, one to two days per week, assuming a weekly production of 500 t of heavy mineral. The balance of raw product will be transported via Board and mine access roads as outlined in Section 3.6.

Local residents are likely to experience low levels of noise from bull-dozers working in conjunction with the mining plant when the operation is nearby.

The dredge itself will pose no noise problems as it is electrically operated.

6.11 VISUAL ASPECTS

An analysis of the existing environment indicates that the proposed mining site is of significant visual quality. The landscape is characterised by flat to undulating terrain and dense vegetation. These features will, in essence, assist in alleviating the visual impact of mining by providing an effective screen when viewed from main roads in the district. Screen planting will be provided where mining is to be undertaken adjacent to public roadways.

The rehabilitation safeguards outlined in Section 5.1.4 will facilitate revegetation of the disturbed areas as soon as possible, thus lessening the visual impact of human intrusion.

6.12 SOCIO-ECONOMIC ASPECTS

This proposal relates to the progression of the Company's existing operations within the Tomago Sandbeds. As such, the proposal represents in socio-economic terms, a continuation of the existing relationship between the Company's operations and the regional economic and social structure.

Socio-economic impacts may arise from two possible sources as a consequence of the proposal. Firstly, impacts will occur from the introduction of a third mining plant. This aspect of the proposal will result in an additional 23 employment positions and other associated contributions to the regional economy.

Secondly, significant impacts will also arise should the proposal be refused. As the existing socio-economic structure of the region reflects in part the contribution by the Company's current operations, a refusal is likely to result in a withdrawal of these contributions causing adverse flow-on effects.

The assessment of socio-economic impacts arising from the proposal is addressed in terms of these two factors.

6.12.1 Impacts Resulting From the Introduction of a Third Mining Plant

Employment

Given approval by the Board and suitable market conditions, the introduction of a third mining plant will provide employment for an additional 23 persons.

By the application of employment multipliers of 1.3176 (Type I) and 1.9811 (Type II) for the mining industry in the region (other than coal mining), the proposal may create a further 59 indirect and 126 induced employment positions. Due to the location of the proposal and the manner in which operations expenditure and employee's incomes are spent, the majority of these additional positions are estimated to be located in the Lower Hunter.

Based upon existing employment characteristics, it is estimated that the 23 positions will comprise 12 skilled, 6 semi-skilled and 5 unskilled employees. Although there currently exists a shortage of skilled and semi-skilled personnel in the Hunter Valley, it is expected that due to the relatively small number involved, together with the Company's policy of hiring and training unskilled personnel, the need for inmigration of labour will be minimal.

Economic Growth

The operation of a third mining unit will result in additional expenditure and income contributions to the regional economy. Wages and salaries paid to the 23 employees are estimated to total $0.42 million.

The growth in operating expenditure is likely to result in an increase in the value of regional production output due to indirect and induced multiplier effects. Similarly the additional income paid to direct employees is predicted to create a further $0.34 million in income throughout the region due to multiplier effects.

Population Growth

Based upon the Company's existing labour supply patterns, it is estimated

that inmigration of labour and hence, increased population, will be negligible.

6.12.2 Consequences of Not Implementing the Proposal

Direct and indirect socio-economic impacts will be felt if the Company is not permitted to maintain operations in those areas of the Tomago Sandbeds contained in this proposal. A refusal is likely to result in the cessation of the Company's local operations causing adverse flow-on effects.

In addition, as the Company's entire operations are dependent upon the continuation of the Tomago mining plants, a refusal is likely to result in a closure of all the Company's regional operations. Socio-economic implications of a refusal are thereby considered in terms of a cessation of all operations.

Employment Impacts

Should the proposal be refused the closure will involve the loss of 188 existing employment positions. This figure includes the 79 positions at Tomago and an additional 109 elsewhere in the region. These latter positions are largely associated with the Company's Tomago processing plant.

Table 16 shows the direct, indirect and induced employment should the Company's operations be closed. (The calculations are based on employment multipliers discussed in Appendix 15.)

TABLE 16

IMPACT ON EMPLOYMENT (HUNTER REGION)

Employment Effect	Employment Number
Direct	188
Indirect	60
Induced	126
Total 1 and 2	248
Total 1, 2 and 3	374

The Type II employment multiplier of 1.9811 calculates that up to 374 jobs could be lost in the Hunter area should the proposal be refused. The 188 jobs directly related to the operation would be lost in addition to 60 jobs indirectly created. A further 126 jobs induced by the development would also disappear.

The regional industries that would be most affected by a displacement of employees embrace mining, wholesale and retail trade, transport, building and construction.

In terms of the occupations of those who could be rendered unemployed (based on the multiplier calculations and including direct, indirect and induced effects) up to 98 mining jobs would be lost together with 68 jobs for skilled tradesmen. In addition, 43 clerical workers and 48 unskilled and semi-skilled production workers would also become redundant. These latter positions involve those occupations which comprise a large proportion of the existing pool of unemployed.

Economic Impact

Effect on Income in the Local and Regional Economies: Table 17 lists the various income effects of the Company's operations. Direct income payments that would be lost if the development did not proceed total $3.37 million per year (1981 prices).

TABLE 17

INCOME PAYMENTS LOST BY CESSATION OF PROJECT (HUNTER REGION)

Income Effect	$ Million
Direct	3.37
Indirect	1.05
Induced	1.91
Total 1 and 2	4.42
Total 1, 2 and 3	9.33

Based on the Type I income multiplier of 1.3112, (discussed in Appendix 15), the indirect income loss would represent an additional $1.05 million. The induced income associated with the project has been estimated to total $1.90 million.

The proposal has the potential to generate income worth between $94.8 million and $126 million in the region over 15 to 20 years. Denial of this proposal would mean the loss of a valuable contribution to economic growth and continued productivity in the Hunter Region.

Effects on the Value of Industry Output:
Table 18 shows the value to industry of operational expenditure by the Company. These figures have been calculated using the Simple Output and Total Output multipliers for the Hunter Region.

TABLE 18

INDUSTRIAL OUTPUT LOST BY CESSATION OF PROJECT (HUNTER REGION)

Output Value Effect	$ Million
Direct	10.00
Indirect	3.03
Induced	8.58
Total 1 and 2	13.03
Total 1, 2 and 3	21.61

The Simple Output multiplier of 1.3033 estimates that 13.03 million of industrial output would be lost each year should the project not go ahead. Similarly, the Total Output multiplier of 2.1601 predicts that lost industrial output would total $21.61 million.

The proposed development has the potential to increase industrial output in the region over 15 to 20 years by between $260.6 million and $423.2 million (1981 prices).

Effect on Export Earnings:

The Company presently exports $10 million of heavy minerals per year through the Port of Newcastle. If approval is not given to continue mining in the Tomago Sandbeds these export earnings will1 be lost.

Appendices

APPENDIX 1

USE OF HEAVY MINERALS

Rutile and zircon, ilmenite and monazite are the most commercially useful heavy minerals. Other significant heavy minerals extracted include leucoxene, tourmaline, cassiterite and garnet. All have a specific gravity well above the 2.67 value for sand.

Details of the four main minerals and their uses are outlined in Table A1.

TABLE A1

COMMERCIAL USES OF HEAVY MINERALS

Mineral	Chemical Composition	Specific Gravity	Uses
Rutile	Oxide of Titanium	4.2	Space travel vehicles, welding rods (flux), desalination plants. Pigments for paints, rubber, plastics and high quality papers. In particular Superior grade pigment from rutile used for 'one-coat' paints.
Ilmenite	Oxide of Titanium and Iron	4.4 - 5.0	Refractory kiln linings Silicosis free sandblasting grit
Zircon	Zirconium Silicate	4.7	Refractories, ceramics, precision castings for chemicals used in cosmetics, glass, specialised cements, food preservatives, tanning, flame retardants, atomic reactor components, Acid plants, fertiliser production.
Monazite	Phosphate of the rare earths, e.g. cerium, thorium, yttrium, europium, terbium, ytterbium.	4.9 - 5.2	Polishing powder in optical industry and flints. Nuclear fuel. Colour television

APPENDIX 2

LAND TENURE

The subject area is comprised of:

(a) Crown Land in the Parishes of Stockton, Eldon and Stowell contained within Water Reserves Nos. 51277 and 57573 which are comprised within the gazetted Tomago Sandbeds Water Supply Catchment Area under the control of the Board.

(b) Part Crown Lands in the Parish of Eldon adjacent to the RAAF Base at Williamtown leased to the Commonwealth of Australia and comprised within an easement proclaimed in Government Gazette G23 of 17th June, 1975, for establishment of approach lighting system to the runway of the RAAF Base.

(c) Part Crown Lands and private lands leased to the Commonwealth of Australia for an air gunnery range at Salt Ash containing an area of about 87 ha in the Parish of Stowell.

(d) Freehold lands owned by the Board.

(e) Privately owned freehold lands, being part of Portions 55 and 57 in the Parish of Sutton.

APPENDIX 3

THE ROLE OF STATE, LOCAL GOVERNMENT AND STATUTORY AUTHORITIES

A3.1 DEPARTMENT OF MINERAL RESOURCES

The Department of Mineral Resources processes all applications for mining leases with respect to the Mining Act, 1973. The Act stipulates that a mining lease applicant must obtain development consent if prescribed by the relevant Planning Scheme or Interim Development Order.

The Department permits mining operations in those areas covered by the proposed mining leases only after careful evaluation of the Company's proposals and after having specified the conditions under which mining may commence. Should development consent be given, a mining lease is granted for a period of up to 21 years.

Appendix 4 lists the Schedule of Authorities under the Mining Act, 1973, as amended, held by the Company in respect to areas within the Tomago Sandbeds Water Supply Catchment Area as at July, 1981.

A3.2 DEPARTMENT OF ENVIRONMENT AND PLANNING (DEP)

This Statement has been prepared following consultations with the DEP and is submitted for assessment and approval under Section 77 (3) of the Environmental Planning and Assessment Act, 1979. The concurrence of the Department is required pursuant to the conditions of the Interim Development Order.

A3.3 HUNTER DISTRICT WATER BOARD

Control of the water supply in the Hunter Region is vested in the Board by virtue of The Hunter District Water Sewerage & Drainage Act, 1938-1956, and part of the Board's responsibility is to control the Tomago Sandbeds Water Supply Catchment Area proclaimed on 11th July, 1941, together with subsequent extensions and amendments

to that area.

Any mining operations proposed to be conducted within the Tomago Sandbeds Water Supply Catchment Area are only permitted in accordance with the safeguards and controls laid down by the Board.

Special safeguards which may be stipulated by the Board are incorporated in the conditions approved by the Department of Mineral Resources and are binding on the registered holder of the mining lease. In general, these conditions relate to the protection of the subterranean waters of the Tomago Sandbeds and to the post-mining revegetation programme to ensure that the longterm effect of mining has minimal impact on the environment.

A3.4 PORT STEPHENS SHIRE COUNCIL

In accordance with Sections 90 and 112 of the Environmental Planning and Assessment Act 1979, Port Stephens Shire Council as the consent authority is required to consider the environmental, social and economic impact of the development proposal.

A3.5 STATE POLLUTION CONTROL COMMISSION

The proposal is deemed to be 'scheduled premises' as defined by the Noise Control Act and following the granting of development consent an approval will be sought from the State Pollution Control Commission under Section 27 of the Noise Control Act.

Approval has been granted under Section 19 of the Clean Waters Act for the construction and use of new slime ponds at Williamtown. Similarly, approval has been granted under the Clean Waters Act to discharge clean overflow from the ponds into the 14 foot drain.

A3.6 MINERAL SANDS MINING COMMITTEE

This Committee was established by the New South Wales Government in 1977 pursuant to a new policy being determined on coastal mineral sands mining. The Committee is comprised of six members representing the following bodies:

* Department of Mineral Resources
* Department of Environment and Planning
* Nationals Parks and Wildlife Service
* Mineral Sands Producers' Association
* Nature Conservation Groups
* Australian Workers Union.

The role of this Committee includes the consideration of all new mining applications, the monitoring of existing operations, and the monitoring of the progress of rehabilitation in areas previously mined.

The Committee meets on a regular basis and conducts frequent field inspections for the purpose of reporting and making recommendations to the Minister for Mineral Resources and the Minister for Environment and Planning.

A3.7 OTHER DEPARTMENTS

The Department of Lands, as owner of the Crown Lands in the Water Reserves, and the Department of Public Works as the constructing authority in respect of settlement ponds on the Hunter River Floodplain, are also involved in the proposal.

APPENDIX 4

MINING LEASES HELD BY RUTILE & ZIRCON MINES (NEWCASTLE) LIMITED IN THE TOMAGO SANDBEDS WATER SUPPLY CATCHMENT AREA

Lease Number	Date of Grant	Term	Parish	Area in Hectares
594	3. 5.'78	15 years	Eldon	731.35
744	6. 6.'79	21 years	Stockton	14.29
785	17.10.'79	21 years	Eldon	245.32

APPENDIX 5

SCHEDULE OF SPECIAL CONDITIONS OF AUTHORITY PERTAINING TO MINING LEASE 594 (1973 ACT) [NUMBERS 135 TO 188 ONLY]

DEFINITIONS: In these Conditions (as hereinafter defined) the following words shall have the meanings hereby assigned to them except where the context otherwise requires.

(a) The Board shall mean the Hunter District Water Board.

(b) The Registered Holder shall mean the Mining Company granted this authority within the Board's gazetted Catchment Area, and "subject area" has a corresponding meaning.

(c) Conditions means the Conditions of Authority to be applied in Protection of the Board's interests regarding mineral extraction from the Tomago Sandbeds.

(d) A dredging plant shall consist of one (1) cutter suction dredge with associated concentrating units.

135. The registered holder shall abide by the provisions of the Catchment Area By-Laws applying to the Catchment Area of the Tomago Sandbeds Water supply works and shall conduct operations in such a manner as not to cause any detrimental effect to the aquifer or the Board's assets. As there may be a time interval before some of these effects are recognised and assessed, the mining of the subject area shall be considered as a trial and for this reason the rate of mining shall be limited to the maximum rate of progress hereinafter stipulated.

136. The registered holder shall give one month's notice in writing to the Board of its intention to enter upon the Board's gazetted Tomago Sandbeds Catchment area for mining operations to permit supervision by the Board's officers to be arranged.

137. The registered holder shall formally notify the Board of its exit from the subject area upon the completion of mining operations in the subject area.

138. All the registered holder's operations within the Tomago Sandbeds area shall be subject to approval of the Board and will be carried out under the supervision of the Minister and of officers of the Board.

139. Compliance with the terms of these conditions shall be entirely at the expense of the registered holder.

140. The registered holder shall comply expeditiously with instructions issued by the Board within the terms of these Conditions and in the event of failure so to comply, the registered holder shall cease all mining operations in the Catchment Area within twenty-four hours of receipt of written instructions to that effect from the Board and mining shall not recommence until these instructions are rescinded by the Board.

141. The registered holder shall comply with any instructions which may be given by the Board for the purposes of preventing the pollution of the Tomago Sandbeds and/or the water supply derived therefrom, and, failing such compliance the Board may order the additional measures to be carried out by others at the expense of the registered holder and may order suspension of all mining operations until such work is completed.

142. The Board reserves the right to withdraw approval to mine in areas for which this authority has been granted should the Board consider it necessary in order to safeguard its interests.

143. (a) Operations on the subject area shall be conducted in such a manner as not to cause any damage to or interference with the Board's installations and/or operations.

(b) During the course of mining operations the registered holder may apply to the Board for permission to re-site any road, powerline, pipeline or other asset of the Board located on the subject area and shall comply with such Conditions as may be imposed by the Board if any such permission is granted.

144. The registered holder shall compensate the Board for any damage which may be caused to the installations or property of the Board.

145. Whenever possible the registered holder shall restrict his access through the Board's land to formed roads. Alternative or additional access by the registered holder shall be subject to the prior approval of the Board.

146. The registered holder shall indemnify the Board against any claims whatsoever arising out of mining operations on the Board's land.

147. (a) The registered holder shall lodge with the Board security in a form acceptable to the Board in the sum of twenty-five thousand dollars ($25,000) per mining plant conditioned upon compliance by the Registered Holder with the terms and conditions of this Authority generally and in particular with the requirements of all those conditions thereof

which may in the opinion of the Board require for the evaluation of their satisfactory performance the lapse of a period of time extending beyond the time for which this Authority may remain in force. In the event of such terms and conditions not being fulfilled in their entirety or if upon cancellation or other determination of this Authority the Board is of the opinion that the requirements of any of the conditions requiring the lapse of time as aforesaid have not been fully complied with then notwithstanding any release or acquittance given by the Minister in respect of any of the terms and conditions aforesaid the Board may demand and receive payment of the sum secured by the security.

(b) i. Subject to subparagraph (ii) of this paragraph the Board may at any time or times after the expiration of two years from the commencement of this Authority review the amount of security required in accordance with paragraph (a) of this condition and increase or decrease the amount to be secured.

ii. Not more than one variation in the amount of security required shall be made under sub-paragraph (i) of this paragraph during any period of two years.

148. Unless otherwise approved by the Minister and the Board, mining operations on the subject area shall be confined to dredging and associated processes.

149. Unless otherwise approved in writing by the Minister and the Board, not more than two dredging plants shall be used within the subject area. No dredging plant or major part thereof shall be brought on to the subject area without the approval of the Minister and the Board first had and obtained.

150. Stockpiles of mine concentrate shall be sited at localities previously agreed to by the Board.

151. (a) Mining shall be restricted in depth from the surface down to such depth below the surface as may be approved from time to time by the Minister and the Board.

(b) The registered holder shall submit to the Minister and the Board at yearly intervals proposals defining the extent of mining desired both in respect to area and to depth during the following year. The proposals shall include plans and sections showing surface levels and depths of mining; depths of mining should be related to the datum nominated by the Minister and the Board.

(c) Furthermore the above proposals shall include plans of the proposed future mining advances within the subject area, with the anticipated mining advance locations shown at 12 monthly intervals.

The advances should be such that mining of the subject area

will be undertaken at a maximum rate of 30 hectares per annum.

152. (a) The registered holder shall ensure that any water added or returned to the pond with the exception of any suspended solids shall be of no lesser quality than that of the local ground water as determined to the satisfaction of the Minister and the Board. Suspended solids in any water added or returned to the pond shall not exceed the limit to be set from time to time by the Minister and the Board.

(b) The Minister and the Board may direct that the dredging operations shall be so conducted as to maintain such a positive hydrostatic head of the additional water above mean sea level as is from time to time required to prevent pollution of the water supply.

153. Mining operations shall be carried out in such a manner that no soil fines (defined as material passing B.S. No. 100 Sieve) and no potential pollutant solids, including iron and organic matter, hereafter denoted together as process slime or slime, are permitted to accumulate in the bottom of the dredge pond. This requirement will be considered to have been complied with:

(a) If not more than 50 mm total in situ thickness of process slimes is encountered in 10 investigation boreholes and not more than 30 mm in any one of the 10 boreholes through the former pond bottom within one month of the deposition of tailings; the 10 boreholes are to be put down on a defined pattern subject to the position of two of the boreholes being movable to other defined positions when instructed by the Minister and the Board. The areas investigated are to be contiguous and will represent, on average, two weeks deposition of tailings or such longer period as may be determined by the Minister and the Board. In the event of this requirement not being complied with the Board will require initially further investigation holes to be put down to delineate the slime area.

(b) While mining is proceeding, as a guide to the effectiveness of the measures taken, samples of the pond bottom shall be taken with samplers, approved by the Minister and the Board, prior to backfilling with tailings and the Minister and the Board shall have the right to suspend mining operations if the results, in the opinion of the Minister and the Board, indicate that 19 (a) above will not be complied with.

154. The registered holder shall conduct tests of the dredge pond water as required by the Minister and the Board shall so conduct operations that there is no increase above that existing naturally in the local ground water prior to mining operations in the saline, iron or other deleterious content of the water caused by the mining

process or by the addition of any oils or greases or other substances which may be used either directly or indirectly in the mining process. Suspended solids in the pond water shall not exceed the limit set from time to time by the Minister and the Board. Furthermore no deleterious material including organic matter will be permitted to float on the surface of the pond.

155. All sanitary arrangements for the persons employed in mining operations on the subject area (demised) shall be such as may be approved and directed by the Board. At no time shall the mining pond be used for disposal of sewerage wastes.

156. All solid or liquid discharge onto open ground within the Tomago Catchment Area or any area which may effect the Board's existing or potential water supply and any discharge back into the pond from any water treatment plant forming a part of the mining process shall conform to the standards of Clauses 152, 153 and 154 of these Conditions.

157. The supply of water for the mining operations shall be by arrangement with and to the approval of the Board.

158. The dredge pond shall not be connected to the sea or to the areas of highly saline groundwater. Special measures may be required by the Minister and the Board should the dredge be located at any stage near the sea or a highly saline area. The registered holder shall comply with all measures deemed necessary by the Minister and the Board to prevent the intrusion of salt water into the Tomago aquifer.

159. The process slime removed in the mining processes shall be disposed of outside the Tomago Catchment Area in a location which will not affect the Board's existing or potential water supply. If such material is temporarily stored within the Catchment Area after extraction, then the storage area shall be completely isolated from the aquifer and regularly cleared to the satisfaction of the Minister and the Board.

160. (a) Unless required otherwise for such purposes as roads, pipelines, firebreaks, the registered holder shall ensure that the area affected by the mining operations shall be revegetated with the flora indigenous to the area, or such other types as may be decided by the Minister and the Board.

The overall revegetation programme including the types and density of flora selected for revegetation and the procedures to be adopted for revegetation will be determined periodically at reviews of progress, having regard to the trial and routine planting undertaken. The overall programme and any changes thereto shall be approved by the Minister and the Board.

(b) The registered holder shall be responsible for introducing and implementing in the mined and other affected areas a management programme approved by the Minister and the Board designed to control soil erosion and to ensure progressive rehabilitation to a stable vegetation cover. The registered holder's responsibility shall remain until such time as the Minister and the Board are satisfied that the revegetation is adequately and fully established.

(c) Mining paths shall be planned by the registered holder to preserve the existing vegetation wherever economically feasible, especially in areas where the existing vegetation includes trees and shrubs over 4 metres high. Preservation areas of undisturbed vegetation known as "islands of vegetation" shall be left such that no mined area is greater than 150 metres from islands of vegetation which are not less than 0.15 hectares in area and not less than 15 metres in average width: the dimensions noted may be varied from time to time by the Minister and the Board. Alternatively, islands of vegetation may be obtained artificially by planting advanced seedlings of trees and shrubs and obtaining accelerated growth of all species in the multilayered forest system in protected and, where necessary, irrigated areas, all subject to the agreement of the Minister and the Board first had and obtained. All the above applies particularly to non swamp areas.

161. Any fertilisers to be used in assisting regrowth of pasture or vegetation on the area demised shall be of a kind approved by the Minister and the Board and shall not contain any substance in quantity likely to be deleterious to the water supply.

162. (a) Unless otherwise directed by the Minister and the Board the registered holder shall remove the surface material to a depth of 300 millimetres on such part of the subject area as may be disturbed by mining operations and shall stack such surface material separately on the subject area.

(b) After extraction of mineral sands by the dredge mining process, the dredge pond shall be backfilled with the sand previously excavated from the pond, any surface material previously removed shall be replaced and the ground surface levelled to a form similar to that existing before mining or to such other form as may be decided by the Board.

(c) The registered holder shall restore all worked areas concurrently with mining operations and shall observe any instructions which may be given by the Minister and the Board in connection with the restoration of the subject area.

(d) The registered holder shall as far as may be practicable so conduct operations as not to cause any damage to shrubs and trees or other native flora growing upon the subject area and shall stack and burn all shrubs and trees or other native

flora which may be disturbed or destroyed as a result of the operations hereby consented to provided that before doing so the registered holder shall obtain from the responsible authority permission to light fires. The registered holder shall take all precautions necessary to prevent the spread of fire from such burning operation. In the event of a fire occurring other than from such burning operations within the areas designated for burning in the cleared areas in advance of the mining path, the registered holder shall take the measures necessary to control the fire and shall keep the Minister and the Board informed of the situation and shall be subject to the instructions of the Minister and the Board. The registered holder shall co-operate with the Minister and the Board both in preventing, and where fires occur, controlling the fires.

163. (a) Before mining is commenced in any part of the subject area the registered holder shall, if required by the Minister and the Board, provide for the carrying out of an initial site investigation to the satisfaction of the Minister and the Board and obtain clearance in writing from the Minister and the Board for mining all land selected to be mined. Such investigation may include the putting down of boreholes and the taking of samples to provide soil and water data for the Minister and Board as further described under subclause (b) below.

(b) Within the overall site investigation programme, either before, during or after mining, the Board may require boreholes to be put down within and outside the subject area to provide soil and water data for the control and assessment of the effects of the mining operation. The boreholes are to be put down in such positions and at such times as the Minister and the Board may determine. The boreholes may be used, inter alia, for in-situ testing such as for permeability tests, for taking soil samples and for the installation of water sampling points. Physical and/or chemical testing of soil samples will be required. Chemical testing of water samples will be required. Periodic accurate readings of groundwater levels will be required. The investigation programme will not necessarily be limited to the sampling of boreholes and associated work and testing but may include such investigatory work as undertaking continuous soundings of the soil profile.

(c) The registered holder shall make provision for the taking and testing of samples as instructed by the Minister and the Board for a period starting at the date of this authority and continuing up to three years after completion of mining operations or such further period as may be determined by the Minister and the Board should the results indicate a situation of concern to the Minister and the Board.

(d) All the above investigation, sampling and testing work shall be at the expense of the registered holder.

(e) The Board shall be entitled to arrange for independent monitoring checks to be undertaken, either by the Board or others, as and when it considers fit and the registered holder shall co-operate to the extent required by the Board in such checks. The registered holder shall not necessarily be liable for the costs incurred for the work undertaken under this subclause.

164. The registered holder shall conduct tests of the groundwater existing after mining, in such positions as may be determined by the Board, and will so conduct operations that the groundwater in and around the ground mined is not caused to become of a lesser quality after mining than the groundwater in the area before mining.

165. Notwithstanding the above the registered holder shall be responsible for any deterioration in the quality of water drawn by the Board caused by any effect of the mining operations, irrespective of whether such effect is recognised or unrecognised at present.

166. At any time in the event that the Minister or the Board decides that as a result of the mining there is a deterioration in the quality of water drawn from the aquifer, or there is a danger that this will occur, the registered holder shall cease all mining operations within twentyfour hours in the Catchment Area upon receipt of a written instruction to this effect from the Minister and the Board. The instruction to cease operations shall be followed as soon as possible by a statement of the problem from the Minister and the Board in order that the registered holder may take such steps as are necessary to investigate the problem and to determine means acceptable to the Minister and the Board to counteract it before mining shall be allowed to continue.

167. The registered holder shall send to the Minister and the Board regularly and promptly written records and reports regarding all matters affecting the aquifer and the Board's assets, including in particular:

(a) Results of all routine tests and investigations called for by the Conditions. The requirements contained in the conditions may be varied or amended by the Board during the currency of the term of this authority if deemed necessary by the Board.

(b) Any event that represents a detrimental effect.

(c) Any information of which the registered holder becomes aware that suggests there may be a possible detrimental effect.

Furthermore, the registered holder shall keep the Minister and the Board fully informed of all investigations and research work undertaken under the direction of the registered holder with regard to all matters affecting the aquifer and shall supply the Minister and the Board with results and reports, as applicable, on

completion of the various stages of the work. To avoid duplication of work the Board intends to inform the registered holder of work being undertaken or planned to be undertaken by the Board of a similar nature relevant to the mining operations.

168. If, in the opinion of the Minister and the Board, the quantity of silica being removed from the subject area as a consequence of mining operations is likely to impair the restoration of the subject area or cause damage to or interference with adjoining mining leases or other lands the Minister and the Board may direct by writing under his or its hand from time to time as the circumstances so require the registered holder to reduce the quantity of silica being so removed. The registered holder shall comply forthwith with any direction so given and in the event of non-compliance this authority may be cancelled.

169. The registered holder shall treat by means of spiral concentrators or other approved method of concentration on or adjacent to the subject area all material mined so as to produce a concentrate containing not less than sixty-five per centum of heavy minerals and all tailings from such operations shall be returned continuously as far as may be practicable to the excavations made on the subject area.

170. In the event of operations by the registered holder on the subject area causing damage to any lands which have been rehabilitated after the mining the registered holder shall repair such damage at the registered holder's own expense to the satisfaction of the Minister and the Board.

171. The registered holder shall confine the deposition of overburden removed during dredging and/or other mining operations within the boundaries of the subject area.

172. Upon the expiry or sooner determination of this authority or any renewal thereof, the registered holder shall remove all machinery and buildings and the subject area shall be left in a clean and tidy condition to the satisfaction of the Minister and the Board.

173. If so directed by the Minister and the Board, the registered holder shall fill in any dredge pond or other excavation on the subject area and shall observe any instruction which may be given from time to time in this regard by the Minister and the Board.

174. If so directed by the Minister and the Board, the registered holder shall provide and maintain a secure fence to the satisfaction of the Minister and the Board around each dredge pond or other excavation opened up or used by the registered holder and shall observe any instructions which may be given from time to time in this regard by the Minister and the Board.

175. If so directed by the Minister and the Board, the registered holder shall spread fertiliser of such type and in such quantity as may be directed over the restored area to assist the growth of such grasses, plants, shrubs and/or trees as may have been planted in accordance with any of the foregoing special conditions.

176. If so directed by the Minister and the Board, the registered holder shall enclose the subject area with a secure stock-proof fence and such fencing shall be erected and maintained in a manner satisfactory to the Minister and the Board.

177. The registered holder shall observe any instructions which may be given by the Minister and the Board with a view to minimising or preventing public inconvenience or damage to public or private property.

178. In the event of any improvements on the subject area being damaged or disturbed by dredging and/or other mining operations by the registered holder such improvements shall be restored to the satisfaction of the owner of such improvements or the Minister and the Board.

179. (a) The registered holder shall conduct operations in such a manner as not to cause any danger to fauna or stock on the subject area, except where measures are required to control fauna deemed to be objectionable by law or by the Minister or the Board (e.g. Feral pigs and hares), where control measures are required they shall be to the approval of the Minister and the Board and the registered holder shall observe and perform any instructions given or which may be given by the Minister and the Board with a view to minimising or preventing damage to such area or the restoration thereof by the said objectionable fauna.

(b) Unless with the approval of the Minister and the Board, the registered holder shall not keep nor permit to be kept any dog on the subject area.

180. The registered holder shall not cut, destroy, ringbark or remove any timber or other vegetative cover on the said land except such as directly obstructs or prevents the carrying on of the operations hereby authorised.

181. The registered holder shall not interfere in any way with any fences on or adjacent to the subject area unless with the consent of the owner or the Minister and the Board first had and obtained.

182. The registered holder shall conduct operations in such a manner as not to create any danger from floods or storms and shall observe and perform any instructions given or which may be given by the Minister and the Board with a view to minimising or preventing any flood or storm damage.

183. If it is found that the operations hereby authorised are causing any undue damage to or erosion of the subject land or other land in the vicinity thereof the Governor with the advice of the Executive Council may cancel this authority or any renewal thereof without compensation to the registered holder upon giving one month's notice of his intention so to do.

184. (a) The registered holder shall within twelve months of the date of this authority or any renewal thereof, erect a separation plant upon the subject land or other land to the satisfaction of the Minister and the Board or furnish to the Minister and the Board satisfactory evidence that the registered holder has made suitable arrangements for the treatment of concentrates.

(b) The registered holder shall not permit excessive quantities of silica sand tailings to accumulate around or adjacent to a separation plant and all such tailings shall be returned continuously as far as may be practicable to the excavations made on the subject area or on such other land as may be directed by the Minister and the Board.

185. (a) In the event of operations being conducted other than by means of dredging the registered holder shall mine the area in sections of such dimensions as the Minister and the Board may stipulate from time to time.

(b) Upon completion of mining operations in each section all residues and tailings shall be returned to the excavation made and all worked ground shall be levelled off and any surface material previously removed shall be replaced and planted with such grasses, plants, shrubs and/or trees as may be required by the Minister and the Board provided that the mining of the next section may be carried out conjointly with the restoration of the last worked section but no further section shall be mined until such restoration is completed.

186. The registered holder shall during restoration of the subject area or any part thereof, remove all domestic animals from such area as may trespass thereon and shall take all such action as is necessary to prevent them from depasturing thereon and shall observe and perform any instructions given or which may be given by the Minister and the Board with a view to minimising or preventing damage to such area or the restoration thereof by the depasturing of any animal thereon.

187. (a) Within a period of three months of the commencement of dredging and/or other mining operations on the subject area the registered holder shall establish a nursery for the propagation of a sufficient number and variety of plants, shrubs and trees which in the opinion of the Minister and the Board is adequate for the purpose of satisfactorily rehabilitating the subject area in the secondary and tertiary stages.

(b) Provided that in the event of -

(i) an adequate nursery having been established by the registered holder in the vicinity of the subject area; or

(ii) satisfactory evidence being furnished that the registered holder has made suitable arrangements for adequate quantities of plants, shrubs and trees to be provided and maintained, the Minister and the Board may dispense with the requirements of the foregoing clause (a).

188. The registered holder shall as far as may be practicable so conduct operations as not to interfere in any way with the public use and enjoyment of Water Reserve 51277 for water supply.

APPENDIX 6

REPORTS ON MINERAL SAND MINING IN THE TOMAGO SANDBEDS

Carmichael, A.J. and Inkson, M.D. "The Environmental Protection of the Tomago Sandbeds." Hunter District Water Board Journal, Vol. 1, No. 6, 1979.

Hindley, M.A. and Inkson, M.D. "A Study into the Effects (Including Environmental) of Mineral Sand Mining on the Tomago Sandbeds Aquifer at Newcastle, N.S.W." Conference of the Institution of Engineers, Australia, 1973.

Hunter District Water Board. "Water Supplied from Underground Sources." Conference of Professional Officers Representing the Authorities Controlling Water Supply and Sewerage Undertakings Serving the Cities and Towns of Australia. Newcastle, 1957.

APPENDIX 7

CONCENTRATING EQUIPMENT USED IN THE MINING OPERATION

The primary concentrating equipment used in the wet gravity separation process consists of multi-sluice cone and spiral concentrators designed by Rutile & Zircon Mines (Newcastle) Limited.

The multi-sluice cone concentrators have distribution cones which feed three banks in series each with 20 pinched sluices. Arranged radially under the cuts of the primary trays are three banks of four pinched sluices flaring outwards. These retreat trays produce the concentrates and middlings fractions of the concentrators.

A fourth bank of four retreat trays sorts remixed high grade tailings and the low grade third retreat concentrate to further upgrade the concentrate fraction.

Pulp density control is essential for proper stratification to occur down the trays and this is automatically controlled by sensing the differential pressure in a rising column of the feed pipe.

A motorised parobolic plug valve controls the amount of water bled into the suction side of the feed pump.

Once cuts are taken from the pinched sluices, the tailings density falls while the concentrate densities rise. As control of densities down the primary concentrator is not practicable, tray slopes are varied to compensate for higher and lower fluid densities but recoveries decline as less than ideal conditions are encountered.

The cleaner concentrators may be of a modified cone-multisluice design as described above, or modularised stacks of pinched sluice trays.

A third type of cleaner concentrator is the spiral type which is utilised on the plants handling reasonably rich, and often variable ore-bodies. Spirals can accept a wider range of densities and feed quantity than can the pinched sluices. Rutile & Zircon Mines (Newcastle) Limited uses a number of different spirals, varying in profile, diameter steepness and number of turns.

Spiral concentrators are used on all plants for the recleaner stage. They are physically identical to the cleaner spirals mentioned above.

The setting of the spiral cutters is based on a visual assessment of the slurry flow. As a result of this methodology the 'lighter' fraction of the heavy minerals may be missed, but the principal minerals of rutile, zircon, ilmenite and monazite are separated out.

The upgrading ratio of heavy mineral to sand decreases on each stage of the separation process. The performances aimed for are outlined below:

Sluice Concentrator	10:1
Cleaner Spirals	5:1
Recleaner Spirals	2:1.

APPENDIX 8

MEO

Form 6

STATE POLLUTION CONTROL COMMISSION
NEW SOUTH WALES
CLEAN WATERS ACT, 1970

LICENCE

D 485

Number: W8-485

Date of issue: 1 August 1981

Name of licensee: R Z MINES (NEWCASTLE) PTY LTD

Address of premises concerned: FULLERTON COVE

Location of authorized point of discharge: 225 mm diameter fibre pipe to the Drainage Union Drain as shown in R.Z. M. Plan No. D6.83 submitted with the application for renewal of licence.

The licensee is licensed for a period of one year from the date of issue of this licence under the provisions of the Clean Waters Act, 1970, on the basis of the information supplied by him in his application of 14 July 1981

and subject to the following conditions:

1. The volume of wastes discharged shall not exceed 2,460 kilolitres per day nor 92 kilolitres per hour (under dry weather conditions).

2. The following matter may be discharged:
   (a) wastes containing not more than 30 milligrams per litre of non-filtrable residues
   (b) wastes having a pH value of not less than 4.0 and not more than 8.5
   (c) wastes having a temperature not greater than 33°C.

3. The following monitoring shall be carried out:
   (a) volume of wastes (kilolitres) discharged daily
   (b) pH measured weekly
   (c) non-filtrable residues (milligrams per litre) determined weekly on samples composited hourly over 4 hours.

   The tests shall be carried out in accordance with the methods in the Clean Waters Regulations 1972.

   The results shall be retained by the licensee for not less than 2 years following measurement. The results shall be kept in a legible form and shall be made available to any authorised officer of the Commission on demand.
   (NOTE: A copy of the results of the monitoring is to be submitted to the Commission by the licensee with the application for renewal of the licence).

4. The licensee shall be responsible for the operation and maintenance of the works and shall ensure that the works are operated by a competent operator in accordance with the conditions of the licence.

5. No alterations or modifications to the works, the outfall or method of disposal shall be made without the approval in writing of the Commission.

Except as hereinbefore provided the pollution of any waters by means of a discharge from the premises concerned is prohibited.

E J Cobby

NOTE: The abovementioned conditions apply only to the period of tenure of this licence, which is one year. The licence will require to be renewed at the end of this period unless revoked or suspended or the licence conditions are changed. On renewal of the licence the Commission may change the conditions or attach additional conditions. Such alteration of conditions or attaching of additional conditions or revocation or suspension of the licence may be carried out by the Commission at any time during the currency of the licence if the circumstances warrant it.

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Executive Director

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APPENDIX 9

QUALITY OF EFFLUENT DISCHARGED FROM WILLIAMTOWN SETTLING PONDS INTO DAWSONS DRAIN

Date	pH	Suspended Solids (mg/L)	Temperature(°C)
27. 7.77	4.5	990	5
4. 8.77	4.5	-	-
11. 8.77	4.7	-	12
26. 8.77	4.4	8	20
5. 9.77	4.6	-	17
16. 9.77	4.6	31	-
22. 9.77	4.4	109	-
30. 9.77	4.6	22	18
7.10.77	4.4	71	22
14.10.77	4.5	54	30
20.10.77	4.4	30	18
24.10.77	4.4	15	-
1.11.77	4.5	10	18
14.11.77	4.4	20	25
24.11.77	4.5	18	22
2.12.77	4.5	10	22
5.12.77	4.4	56	26
12.12.77	4.5	10	22
19.12.77	4.3	22	22
5. 1.78	4.4	19	20
16. 1.78	4.2	9	25
23. 1.78	4.1	9	32
2. 2.78	4.2	24	-
7. 2.78	4.3	20	23
13. 2.78	7.6	9	27
20. 2.78	3.9	68	32
3. 3.78	4.8	4	22
9. 3.78	5.4	10	23
17. 3.78	4.7	14	23
28. 3.78	4.7	21	-
6. 4.78	4.3	2	-
14. 4.78	4.2	54	-
21. 4.78	4.3	3	-
28. 4.78	4.5	3	-
5. 5.78	4.4	8	-
12. 5.78	4.4	29	-
17. 5.78	4.3	4	14
26. 5.78	4.3	2	16
2. 6.78	4.3	46	14
9. 6.78	4.3	7	-
16. 6.78	4.3	148	13
23. 6.78	4.3	73	12
30. 6.78	4.3	5	-
7. 7.78	4.6	106	8
14. 7.78	4.6	-	-
21. 7.78	4.6	79	12
28. 7.78	6.6	198	-
Geometric Mean	4.55 units	20.2 mg/L	

APPENDIX 10
DESCRIPTION OF THE HEAVY MINERAL SEPARATION PROCESS

The Tomago separation plant, which operates a wet concentration circuit, receives mine concentrates containing approximately 85 per cent heavy mineral. Wet screening at 1.4 mm removes trash. Non-magnetics are abraded at high pulp density in a two cell Wemco attritioner with a 47 per cent caustic soda solution added automatically so that the pH of the discharge is constant. This allows for fluctuations in the volume of caustic soda to cope with variations in amount of organic coating.

Attritioner discharge is cycloned before spiralling to remove as much brackish water, slime and excess caustic soda as possible. This water is treated to lower its suspended solids content and to adjust its pH level to comply with set water quality levels before being discharged. Spirals reduce the quartz and light-heavy mineral content. Spiral concentrates are dewatered with cyclones and stockpiled under cover to allow for drainage and air drying to approximately four per cent moisture to provide feed for the dry separation circuit.

Counter current drying is done at 14 t/h, using a stainless steel rotary drier heated by hot gases from a coal fired oven fitted with an under fed stoker. Drier gasses are cycloned before discharge to the atmosphere.

Coarse mineral is removed from the drier discharge by Rotex screening at 0.32 mm and stockpiled. Screen undersize is electrostatic circuit feed.

The conductor fraction from six high tension rougher rolls in parallel is cleaned three times using high tension rolls. The non-conductors from the second and third conductor cleaner rolls return to rougher feed.

The non-conductors from the rougher rolls and the first conductor cleaner rolls constitute the feed to the non-conductor cleaning

circuit which contains eleven stages - three stages of H.T. plates, 2 x 3 stages of H.T. rolls and two stages of H.T. screen plates. The conductors from the first nine stages recirculate while the screen plate conductors are wet tabled together with air table tailings. The wet table concentrate after filtering and drying is introduced into the non-conducting cleaner circuit along with the feed to the first stage of rolls.

Conductors and non-conductors are magnetically separated each using two 2 x 3 roll induced roll magnets. The conductor magnetics - ilmenite - is sold as sand blasting material. The non-conductor magnetics - monazite and garnet, together with some zircon - are double screened. The + 0.25 mm is sold as sand blasting material, the - 0.25 mm + 0.18 mm is stockpiled for zircon recovery and the - 0.18 mm is stockpiled for zircon and monazite recovery.

The conductor non-magnetic - rutile - is bagged or bulk stored. The non-conductor non-magnetics - zircon with quartz - are air tabled to yield a coarse grained top cut of premium zircon, a medium grained centre cut of standard zircon and a bottom cut of fine zircon with quartz which is wet tabled as described above. The premium zircon is magnetically separated to yield a non-magnetic low phosphorus premium grade zircon while the magnetic fraction which amounts to some 20 per cent of the magnet feed is combined with the standard zircon. Zircon is bagged,bulk stored or ground.

A dry grinding circuit consisting of three Humboldt Palla 50U vibrating ball mills each with a Sturtevant air classifier in closed circuit grinds zircon sand to zircon flour of three grades - 95 per cent passing either 0.075 mm or 0.053 mm or 0.045 mm. Although mild steel balls and liners are used a low iron pick up results.

All mill products are automatically sampled using air operated samplers. Quality control is based on physical examination using sink-floating with tetrabromoethane and grain counting. All chemical analyses are performed by a public analyst.

APPENDIX 11

RUTILE & ZIRCON MINES (NEWCASTLE) LIMITED
NURSERY PROCEDURE

A11.1 SEED COLLECTING

Wherever practical, seed is gathered from the mining lease before mining operations commence. If seed is unavailable it is then purchased from the New South Wales Forestry Commission.

The majority of seed can be collected before completely ripe and placed under heating lamps to open (with the exception of *Eucalyptus gummifera).*

All seed is then placed in containers and labelled as to its identification and source area.

A11.2 SEED GERMINATION

Wooden seed boxes are used for seed planting. Box dimensions are 38cm x 38cm x 10cm. A layer of drainage material in the form of ashes or pine needles is placed on the bottom before adding a very loose sandy soil mix, generally 50 per cent sandy loam and 50 per cent river sand. This mix can be varied according to species requirements. Fertilisers are not used in seed boxes.

Under humid conditions 'Damping Off' disease may occur. This mainly affects eucalypts but can readily be controlled by use of Dry Bordox Fungicide.

Seedlings are transferred to tubes four to five weeks after germination, depending on weather conditions.

A11.3 TUBING OF SEEDLINGS

Seedlings are transferred to clip-on type tubes containing soil obtained

from an area stripped for mining. The soil is then fertilised with 1 per cent blood-and-bone mixture to allow establishment of seedlings to a height of 15 cm. These seedlings can then be transferred to advanced seedling containers or can be held in a dormant stage for upward of 12 months.

A11.4 ADVANCED SEEDLINGS

Seedlings are transferred to large plastic bags as required.

Topsoil and the soil mixture is varied according to the area requirements.

Topsoil and coarse river sand are mixed and placed in the bags which are then laid out on a pad of river sand for drainage. Blood-and-bone fertiliser is added to the soil in accordance with the required growth rate.

A11.5 PLANTING METHOD

After the seedling is well established and has grown to a height of approximately 30 cm (usually 10-12 weeks after germination), it is ready for planting.

Seedlings are then transported to the required area and a hole dug according to the container size. With the bottom of the plastic bag completely cut around, the seedling is placed in the hole and the bag pulled up over the top of the seedling. This method eliminates any disturbance to the plant roots and under normal conditions a recovery rate of better than 90 per cent is obtained.

A11.6 WEED PREVENTION

Potted plants are kept free of perennial grasses and other weed species, since these may become troublesome in revegetated areas.

A11.7 REQUIRED CONDITION OF SEEDLINGS PLANTED OUT

Only healthy weed-free seedlings are planted out. Root bound seedlings are discarded as these plants may be weak and subject to wind throw.

APPENDIX 12

UPPER STOREY SPECIES SUITABLE FOR SEEDLING PROPAGATION UNDER VARIOUS CONDITIONS

A12.1 SWAMP AREAS

Areas with free standing water for most of the year tend to be dominated by Melaleuca and Callistemon species, herbaceous plants and the occasional eucalypt.

Species suitable to be planted include *Melaleuca leucadendron*, *Callistemon macrophyllus*, *Eucalyptus parramattensis* and *Banksia serrata*.

A12.2 HIGH WATER TABLE AREAS

These areas are normally free of flooding with the water table less than 0.75 m below the ground surface. In such areas the following species may be planted -

Eucalyptus robusta
E. parramattensis
E. tereticornis
E. punctata
E. maculata
E. haemastoma
Leptospermum laevigatum.

A12.3 LOW WATER TABLE AREAS

In locations where the water table is lower than 0.75 m below the ground surface, this list of species is considered appropriate for planting

Angophora costata
Eucalyptus gummifera
E. haemastoma
E. piperita
E. pilularis.

In intermediate water table areas, species from both the relevant groupings may be used.

APPENDIX 13

NOISE STUDIES

A13.1 BACKGROUND NOISE LEVELS

General

Noise levels were measured in accordance with Australian Standard AS1055-1978.

Night-time and daytime noise levels were monitored at two locations shown in Figure 9 on the 28th May 1980.

Procedure

A Bruel & Kjaer Precision Impulse Sound Level Meter Type 2209 and an Octave Frequency Analyser Type 1613 were used to measure noise levels as well as major frequency components. Calibration was checked regularly using a Bruel & Kjaer Sound Level Calibrator Type 4230.

Sixty recordings were taken at two second intervals at each monitoring station with the sound level meter set on fast response and using the 'A' weighted scale which approximates the loudness level sensitivity of the human ear. This data formed the basis for the statistical analysis of the noise climate over the measurement periods.

Frequency components were measured at Site 1 for the day and night-time periods.

Noise Levels

Table A13.1 details the exact time of measurement as well as meteorological information.

Table A13.2 provides in summary form, the results obtained.

The dominant noise of boths sites (1 and 2) was vehicular and the main background noise levels (L_{95}) for the daytime and night-time periods were 43 and 30 dB(A) respectively.

TABLE A13.1

FIELD MEASUREMENT CONDITIONS

Conditions	Time of Measurement	
	10.50 pm to 11.05 pm on 28/5/1980	12 noon to 12.10 pm on 28/5/1980
Cloud Cover (%)	50	100
Temperature (°C)	13	20
Wind Intensity (Km/h)	-	-
Wind Direction	-	-

TABLE A13.2

NOISE LEVEL (in dB[A])

Location	Night			Day		
	Leq	L_{10}	L_{95}	Leq	L_{10}	L_{95}
1	31	33	29	53	58	44
2	33	35	31	50	55	42
Mean			30			43

Note: *Leq* = *Equivalent continuous noise level*
L10 = *Noise level exceeded 10 per cent of the time*
L_{95} = *Noise level exceeded 95 per cent of the time.*

The higher daytime noise level reflects vehicular movement along Richardson Road.

Frequency Analysis

Table A13.3 presents a frequency analysis of the noise levels monitored at Site 1.

TABLE A13.3

OCTAVE FREQUENCY ANALYSIS

Filter Setting (Hz)	Noise Level (dB[A])	
	Site 1 Night-time	Site 1 Daytime
31.5	42	72
63	41	61
125	40	62
250	32	54
500	29	40
1000	30	36
2000	24	34
4000	19	31
8000	15	27
16000	10	24
31500	10	23
Lin. (measured)	55	69
Lin. (calculated)	46	73

The results in Table A13.3 reflect the increased vehicular movement during the daytime rather than night-time periods, however, the noise is predominantly low frequency (<2000 Hz).

A13.2 PREDICTED NOISE LEVELS

Noise Source Levels

The noise levels of the machinery used in the mining operations are shown in Table A13.4. These levels take into account the special noise reduction measures discussed in Section 5.4.

During the daytime, the Hough front-end loader will produce the maximum source noise level of 94 dB(A) at 1 m.

A consistent source noise level of about 83 dB(A) at 1 m will be produced at night-time. This value was obtained by monitoring an existing floating dredge and associated concentrator plant in operation.

TABLE A13.4

EQUIPMENT NOISE LEVELS WITH ACOUSTICAL TREATMENT

Equipment	Noise Level (dB[A] at 1m)
D5 Bulldozer	90
D7 Bulldozer	91
Caterpillar 930 Front-end Loader	90
Hough Front-end Loader	94

Noise Attenuation

The attenuation of noise generated by the mining operation has been calculated using the expression 20 log (r). The term 'r' is the distance in metres from the noise source to the receptor.

Prediction of Noise Climate

The maximum noise levels due to the mining operations are shown in Figure 9. An analysis of this figure indicates that the mining operations will have the greatest impact at Campvale.

The predicted noise levels at Campvale due to the mining operations and the duration of these noise levels, are shown in Table A13.5. The maximum noise level experienced during the daytime will be 48 dB(A), while 37 dB(A) will be the maximum night-time noise level.

Based on these calculations, daytime noise levels will exceed the current ambient levels for almost two years. Night-time noise levels will be in excess of ambient levels for a period of eight months and will be more than 5 dB(A) in excess of ambient levels for a period of two months.

For almost two years noise levels at Campvale will be greater than the current daytime ambient levels. Night-time noise levels will exceed

ambient levels for a period of eight months and will be more than 5 dB(A) in excess of ambient levels for a period of two months.

TABLE A13.5

PREDICTED NOISE LEVELS AT CAMPVALE
DUE TO MINING OPERATIONS

Noise Level (dB[A])	Duration in Months	
	Daytime	Night-time
45 - 50	6	-
40 - 45	15	-
35 - 40	36	2
30 - 35	60	6
<30	Remainder of time	Remainder of time

APPENDIX 14

FLORA AND FAUNA STUDIES

A14.1 FLORA

A14.1.1 Methods

Field Procedures

Field surveys were carried out in the study area (the orebodies mapped in Figure 1) to investigate the type, structure and distribution of vegetation communities.

Wherever possible communities were distinguished in terms of associations according to *Specht (1974)* and named on the basis of visually dominant species. Wetland classification was based on *Goodrick (1970)*.

Descriptions of communities generally were derived from ground surveys within each vegetation type. All species identified during such surveys were recorded. (There had been severe fires in the area prior to the study period.)

Mapping of the communities was carried out during the field surveys and use was also made of colour and black and white aerial photographs.

Transect Studies

The general areas for the preliminary transect studies were chosen in part subjectively with regard to ease of access and proximity to one another. Two localities with distinctly different habitat types, both of which are common in the study area were selected for the naturally vegetated transects.

The general area containing PM 37 and PM 32 was chosen for the two regenerating mined area transects. (PM's are defined in Section 3.5.8.) From this point on, selection of the transect site (and hence the PM number) and the actual quadrats was based on a table of random numbers. One

transect, 100 m long, was made in each selected area with five 1 m^2 quadrats sampled at random points along the transect.

All transects were adjacent to an access road or track.

Lists of all species observed within the vicinity of each transect were also compiled.

Information obtained included:

* Species identification.
* Height of shrubs and ground cover.
* Percentage cover of shrubs and ground cover.
* Distance to nearest three individuals of the dominant stratum of the community, measured from the centre of the random quadrats. Numerical information was averaged for each transect.

A general description of the area was also made and all species observed were recorded.

Revegetation Studies

Together with the Company's information on areas prior to and after mining, the information from the transect studies was used to examine the status of revegetation on two mined areas (PM 32 and PM 37). Discussion of this work is presented in Section 4.9.

A14.1.2 Floristics and Community Types

The study area consists of a complex array of vegetation types typically dominated by members of the *Eucalyptus* genus with numerous subordinate heath species. Heath plants are completely dominant in some small sectors, common species including *Banksia serrata, Banksia serratifolia, Banksia collina, Banksia aspleniifolia, Macrozamia communis, Xanthorrhoea sp., Melaleuca thymifolia, Dillwynia spp.* and other peas, *Boronia spp., Acacia spp., Lambertia formosa, Petrophile sessilis* and *Isopogon anemifolius.*

Wetlands are interspersed with the drier communities and are generally dominated by various sedge species. The largest swamp in the study area is Moffats Swamp.

Table A14.1 presents species recorded by the Company in the sand mining path.

A total of 273 plant species has been recorded for the sandbeds' area from a number of sources. These species are listed in Table A14.2. Plant families exhibiting the most species diversity are *CYPERACEAE, EPACRIDACEAE, MIMOSACEAE, FABACEAE, PROTEACEAE* and *MYRTACEAE.*

A14.1.3 Vegetation Associations

Twenty-four vegetation associations have been distinguished within the areas over and around the ore bodies proposed to be mined. Figures 10 to 13 show the extent and distribution of these associations.

Characteristics of each vegetation type are detailed in Table A14.3 and variations of some of these communities are described in the following text.

Drooping Red Gum Low Open-forest

It appears that in the absence of fire, there may develop a dense understorey of *Melaleuca nodosa* to 5 m. Low understorey species include *Exocarpus cupressiformis, Isopogon anemonifolius, Acacia ulicifolia, Lambertia formosa, Pimelea linifolia, Ampera xiphoclada, Trachymene incisa* and *Bossiaea spp.*

Scribbly Gum Open-forest

This association typically has a heath shrub understorey although in one lower-lying sector, the ground cover is dominated by *Melaleuca thymifolia, Selaginella uliginosa* and *Blandfordia grandiflora.* This area is fringed by *Callistemon citrinus.* In another locality, *Imperata cylindrica* dominates the ground cover and *Melaleuca quinquenervia* forms a mid-understorey to 10 m. These areas were not considered large enough to classify as separate associations.

Rusty Gum - Red Bloodwood Open-forest

The typical understorey species of this association listed in Table A14.3 were joined by numerous *Banksia collina* plants in some areas.

Disturbed Wetlands

At the time of the study, one area of wetland, shown in Figure 10, was dry with large areas of black mud exposed. Clumps of *Eleocharis acuta*, *Gahnia sp.* and *Sedge sp.* were scattered over this expanse of mud and *Melaleuca quinquenervia* was also present.

The latter species was generally in poor condition and exhibited two distinct layers of root growth, one at ground level and one up to a metre above this.

Another disturbed wetland area is shown in Figure 13. This comprised black mud with scattered *Gahnia spp.* clumps, juvenile *Eucalyptus robusta* plants and dense clumps of *Phragmites australis*. The margins of this wetland were characterised by some *Scirpus sp.* and the introduced grass *Andropogon virginicus*. Overall cover on the mud was very sparse.

Adjacent to this disturbance was an expanse of dead trees along a line of a drainage course. There was a dense living under-storey of *Melaleuca sp.* reaching 3 to 5 m in height.

Heath

Heath areas generally exhibit a high species diversity in the low shrub layer with a high propensity to some species including *Melaleuca thymifolia*. This latter species, however, was particularly prevalent in one small area of heath observed and general species diversity was much lower than in other localities.

TABLE A14-1

PLANT SPECIES FOUND IN PAST MINERAL SANDS MINING PATHS IN TOMAGO SANDBEDS*

Scientific Name	Common Name
PTERIDOPHYTA	
DENNSTAEDTIACEAE	
Pteridium esculentum	Bracken
SCHIZAEACEAE	
Schizaea bifida	
ASTERACEAE	
Helichrysum diosmifolium	Ball Everlasting Daisy
CASSYTHACEAE	
Cassytha sp.	Devil's Twine
CUNONIACEAE	
Cerapetalum gummiferum	Christmas Bush
CYPERACEAE	
Baumea juncea	
Caustis recurvata	
Lepidosperma longitudinals	
Schoenus brevifolius	
S. ericetorum	
DILLENIACEAE	
Hibbertia australis	Rough Guinea Flower
EPACRIDACEAE	
Epacris longiflora	Coral Heath
E. pulchella	Teatree Beard-heath
Leucopogon leptospermoides	
L. setiger	
L. virgatus	Common Beard-heath
Melichrus procumbens	
Monotoca scoparia	
Styphelia laeta	
Woollsia pungens	Woollsia
EUPHORBIACEAE	
Amperea xiphoclada	Broom Spurge
Ricinocarpus pinifolius	Wedding Bush
FABACEAE	
Aotus ericoides	Common Aotus
Bossiaea ensata	Small Leafless Bossiaea
B. heterophylla	Variable Bossiaea
B. rhombifolia	Appressed Bossiaea

TABLE A14-1 (cont'd)

Scientific Name	Commom Name
Dillwynia glaberrima	Heath Parrot-pea
D. retorta	Twisted Parrot-pea
Gompholobium latifolium	Broad Wedge-pea
G. pinnatum	Pinnate Wedge-pea
Hardenbergia violacea	False Sarsparilla
Pultenaea elliptica	
GOODENIACERE	
Dampiera stricta	Blue Dampiera
Scaevola ramosissima	Hairy Fan-flower
HAEMODORACEAE	
Haemodorum planifolium	Bloodroot
HALORAGACEAE	
Haloragis teucroides	Germander Raspwort
JUNCACEAE	
Juncus planifolius	
LILIACEAE	
Astraloma pinifolium	
Blandfordia nobilis	Christmas Bells
Dianella caerulea	Paroo Lily
D. revoluta	Black-anther Flax Lily
Sowerbaea juncea	Vanilla Plant
MENYANTHACEAE	
Villarsia exaltata	
MIMOSACEAE	
Acacia botrycephala	Sunshine Wattle
A. elongata	Slender Wattle
A. myrtifolia	Myrtle Wattle
A. sophorae	Coast Wattle
A. sauveolens	Sweet Scented Wattle
MYRTACEAE	
Angophora costata	Smooth-barked Apple
Eucalyptus gummifera	Red Bloodwood
E. haemastoma	Scribbly Gum
E. pilularis	Blackbutt
E. piperita	Sydney Peppermint
E. propinqua	Grey Gum
E. signata	Scribbly Gum

TABLE A14-1(cont'd)

Scientific Name	Common Name
Baeckia denticulata	
B. diosmifolia	Diosma Heath-myrtle
B. ramosissima	Rosy Heath-myrtle
Callistemon citrinus	Lemon Bottlebrush
C. pachyphyllus	Smooth Bottlebrush
Leptospermum arachnoides	Stiff Tea-tree
L. attenuatum	Slender Tea-tree
L. flavescens	Common Tea-tree
L. laevigatum	Coast Tea-tree
Melaleuca decora	
M. nodosa	Ball Honey-myrtle
M. quinquenervia	Paperbark Tea-tree
M. sieberi	Sieber's Paperbark
M. thymifolia	Feather Honey-myrtle
POACEAE	
Imperata cylindrica	Blady Grass
Paspalum compressium	Paspalum
POLYGALACEAE	
Comesperma ericinum	Pyramid Flower
PROTEACEAE	
Banksia aspleniifolia	Rock Banksia
B. robur	Swamp Banksia (or Broad-leaved Banksia)
B. serrata	Saw Banksia
Conospermum taxifolium	
Grevillea sericea	Pink Spider-flower
Hakea dactyloides	
H. teretifolia	Dagger Hakea
Isopogon anemonifolius	Drumsticks
Lambertia formosa	Mountain Devil
Petrophile fucifolia	Conesticks
Persoonia levis	Broad-leaved Geebung
P. linearis	
Xylomelum pyriforme	Woody Pear
RESTIONACEAE	
Leptocarpus tenax	
Lepyrodia interrupta	
Restio pallens	
R. tetraphyllus	
RUTACEAE	
Boronia pinnata	Pinnate Boronia
Eriostemon australasius	Pink Waxflower
Ziera laxiflora	

TABLE A14-1 (cont'd)

Scientific Name	Common Name
SAPINDACEAE	
Dodonaea triquetra	Hop Bush
THYMELACEAE	
Pimelia linifolia	Slender Rice-flower
TREMANDRACEAE	
Tetratheca thymifolia	Thyme Pink-bell
UMBELLIFERAE	
Actinotus helianthi	Flannel Flower
Platysace ericoides	Heath Platysace
Trachymene incisa	
XANTHORRHOEACEAE	
Lomandra glauca	Pale Mat-rush
L. longifolia	Spiky Mat-rush
Xanthorrhoea minor	Small Grass-tree
ZAMIACEAE	
Macrozamia communis	

* *List compiled by Keith Hanson and John Gilbey [Rutile & Zircon Mines (Newcastle) Limited.]*

TABLE A14-2

FLORA SPECIES LIST

PLANTS OCCURRING NATURALLY ON AND IN THE VICINITY OF THE ORE BODIES PROPOSED TO BE MINED

FAMILY/Scientific Name		Common Name
PTERIDOPHYTA		
ADIANTACEAE		
Adiantum aethiopicum #	L.	
BLECHNACEAE		
Blechnum indicum	Burm. f.	
DENNSTAEDTIACEAE		
Pteridium esculentum	(Forst.f) Cockayne	Bracken
GLEICHENIACEAE		
Gleichenia microphylla	R. Br	Scrambling Coral Fern
SCHIZAECEAE		
Schizaea bifida	Willd.	
ANGIOSPERMAE		
AMARYLLIDACEAE		
Crinum pedunculatum	R.Br	Swamp Lily
APOCYNACEAE		
Parsonsia straminea	(R. Br) F. Muell	
BAUERACEAE		
Bauera capitata	Ser. ex DC	
BIGNONIACEAE		
Pandorea pandorana	(Andr.) Steen	Wonga Wonga Vine
CAMPANULACEAE		
Wahlenbergia gracilis	(Forst. et F) Shrad	
CASSYTHACEAE		
Cassytha glabella	R. Br.	
C. pubescens	R. Br.	

TABLE A14-2(cont'd)

FAMILY/Scientific Name		Common Name
CASUARINACEAE		
C. littoralis	Salisb.	Black She-oak
C. torulosa	Ait	Forest Oak
CELASTRACEAE		
Maytenus silvestris		
COMMELINACEAE		
Commelina cyanea	R. Br.	Wandering Sailor
COMPOSITAE (ASTERACEAE)		
Facelis retusa	(Lam) Sch. Bip.	
Helichrysum apiculatum	(labill.) D.C.	
Helichrysum diosmifolium	(Vent.)	Tick Bush
Senecio lautus	Forst. ex Willd	Variable Groundsel
Cotula reptans	Benth	Creeping Cotula
CONVOLVULACEAE		
Cuscuta australis	R. Br.	Dodder
CUNONIACEAE		
Callicoma serratifolia	Andr	Callicoma
Ceratopetalum gummiferum #	Sm	Christmas Bush
CYPERACEAE		
Baumea articulata	(R.Br.) S.T. Blake	
B. juncea **	(R.Br.) Palla	
Carex appressa	R.Br.	
Caustis recurvata #	Spreng	
C. flexuosa	R.Br.	
Eleocharis acuta		
Gahnia aspera	R.Br. Spreng	
G. clarkei		
Lepidosperma flexuosum	Labill	
Lepironia articulata	(Retz) Domin	
Schoenus ericetorum	R.Br.	
Scirpus caldwellii		
S. inundatus	Spreng	
S. nodosus	Rottb	
DILLENIACEAE		
Hibbertia aspera	DC.	Rough Guinea Flower
H. dentata	R.Br. ex DC.	Twining Guinea Flower
H. fasciculata	R.Br. ex DC.	Bundled Guinea Flower
H. linearis	R.Br. ex DC.	Showy Guinea Flower
H. scandens	(Willd.) Gilg.	Climbing Guinea Flower
H. sericea	(R.Br ex DC) Benth	Blue Mountain Guinea Flower

TABLE A14-2 (cont'd)

FAMILY/Scientific Name		Common Name
DROSERACEAE		
Drosera binata	Labill	Forked Sundew
D. peltata	Sm. ex Willd	Pale Sundew
D. pygmaea	DC.	Tiny Sundew
D. spathulata	Labill	Rosy Sundew
EPACRIDACEAE		
Astroloma humifosum	(Cav.) R. Br.	Cranberry Heath
A. pinifolium	(R.Br) Benth	Pine Heath
Brachyloma daphnoides	(Sm.) Kunth	Daphne Heath
Epacris paludosa	R.Br.	Swamp Heath
E. pulchella	Cav.	N.S.W. Coral Heath
E. microphylla	R. Br.	Coral Heath
E. obtusifolia	Sm.	Blunt-leaf Heath
Leucopogon ericoides	(Sm.) R. Br.	
L. lanceolatus	(Sm.) R. Br.	Lance Beard-heath
L. leptospermoides	R. Br.	Teatree Beard-heath
L. microphyllus	R. Br.	Straggling Beard-heath
L. parviflorus	(Andr.) Lindl.	Coast Beard-heath
L. virgatus	R. Br.	Common Beard-heath
Melichrus urceolatus	R. Br.	Urn Heath
Monotoca elliptica	(Sm.) R. Br.	Tree Broom Heath
Sprengelia sprengelioides	(R. Br.) Druce	White Swamp-heath
Styphelia viridis	Andr.	Green Five Corners
Woollsia pungens	(Cav.) F. Muell	Woollsia
EUPHORBIACEAE		
Amperea xiphoclada	(Sieb. ex Spreng) Druce	Broom Spurge
Breynia oblongifolia	J. Muell	Coffee Bush
Glochidion ferdinandi	(J.Muell) F.M.Bailey	Cheese Tree
Poranthera corymbosa	Brogn	Clustered Poranthera
P. microphylla	Brogn	Small Poranthera
Ricinocarpus pinifolius	Desf.	Wedding Bush
FABACEAE		
Aotus ericordes	(Vent.) G. Don	Common Aotus
Bossiaea ensata	Sieb. ex Dc.	Small Leafless Bossias
B. heterophylla	Vent.	Variable Bossiaea
B. rhombifolia	Sieb. ex DC.	Appressed Bossiaea
Daviesia corymbosa	Sm.	Clustered Bitter-pea
Dillwynia floribunda	Sm.	Flowery Parrot-pea
D. glaberrima	Sm.	Heath Parrot-pea
D. ramosissima	Benth.	Bushy Parrot-pea
D. retorta	(Wendl.) Druce	Twisted Parrot-pea
Glycine clandestina	(Wendl.)	Twining Glycine
Gompholobium grandiflorum	Sm.	Handsome Wedge-pea
G. latifolium	Sm.	Broad Wedge-pea
G. pinnatum	Sm.	Pinnate Wedge-pea
Hardenbergia violacea	(Schneev.) Stearn	False Sarsparilla

TABLE A14-2 (cont'd)

FAMILY/Scientific Name		Common Name
FABACEAE (Continued)		
Hovea linearis	R.Br.	Erect Hovea
Indigofera australis	Willd.	Austral Indigo
Jacksonia scoparia	R. Br.	Winged Broom-pea
Kennedia prostrata	R. Br.	Running Postman
K. rubicunda	Vent.	Dusky Coral-pea
Mirbelia rubiifolia	(Andr.) G. Don	Heathland Mirbelia
Oxylobium ilicifolium	(Andr.) Domin	Prickly Shaggy-pea
O. robustum	J. Thompson	Tree Shaggy-pea
Pultenaea euchila	D.C.	
Phyllota phylicoides	(Sieb.ex DC.) Benth	Heath Phyllota
Sphaerolobium viminium	Sm.	Leafless Globe-pea
Viminaria juncea	(Schrad.) Hoffmgg	
GOODENIACEAE		
Dampiera stricta	(Sm.) R. Br.	Blue Dampiera
Goodenia hederacea	(Sm.)	Ivy Goodenia
G. ovata	(Sm.)	Hop Goodenia
G. stelligera	R. Br.	Spike Goodenia
Scaevola ramosissima	(Sm.) Krause	Hairy Fan-flower
GRAMINEAE (POACEAE)		
Andropogon virginicus *	L.	Whisky Grass
Axonopus affinis	A. Chase	Narrow-leaved Carpet Grass
Briza maxima *	L.	Quaking Grass
Dichelachne crinita	(L.) Hook. f.	Long-hair Plume Grass
Entolasia marginata	(R. Br.) Hughes	
Eragrostis sp.		A Love Grass
Imperata cylindrica	(L.) Beauv. var major (Nees) C.E. Hubbard	Blady Grass
Phragmites australis	(Cav.) Trin	
Rhyncelytrum repens	Willd.	Natal Grass
Themeda australis	(R.Sm.) Stapf	Kangaroo Grass
HAEMODORACEAE		
Haemodorum corymbosum	Vahl.	
HALORAGACEAE		
Haloragis micrantha	(Thunb) R. Br. ex Sieb. et Zucc	Creeping Raspwort
H. teucroides	(DC.) Schlecht	Germander Raspwort
IRIDACEAE		
Patersonia glabrata	R. Br.	Leafy Purple-flag

TABLE A14-2 (cont'd)

FAMILY/Scientific Name		Common Name
JUNCACEAE		
Juncus continuus		
J. polyanthemus	Buchen	
J. planifolius	R. Br.	
JUNCAGINACEAE		
Triglochin procera	R. Br.	Water Ribbons
LENTIBULARIACEAE		
Utricularia cyanea	R. Br.	
U. dichotoma	Labill	Fairies' Aprons
LILIACEAE		
Blandfordia grandiflora #	R. Br.	Christmas Bell
Dianella caerulea	Sims	Paroo Lily
D. revoluta	R. Br.	Black-anther Flax-lily
Sowerbaea juncea	Sm.	Vanilla Plant
Thysanotus sp.		Fringe Lily
Tricoryne elatior	R. Br.	Yellow Rush Lily
LOBELIACEAE		
Lobelia alata	Labill.	Angled Lobelia
L. dentata	Cav.	Wavy Lobelia
Pratia purpurascens	(R.Br.) Benth.	White Root
LORANTHACEAE		
Amyema pendula	(Sieb. ex Spreng.) Tiegh	Drooping Mistletoe
A. quandong	(Lindl.) Tiegh.	Grey Mistletoe
Dendropthoe vitellina	(F. Muell) Tiegh.	Long-flower Mistletoe
MENYANTHACEAE		
Villarsia exaltata	(Simd.) Don	
MIMOSACEAE		
Acacia botrycephala	(Vent.) Desf.	Sunshine Wattle
A. decurrens	(Wendl.) Willd.	Sydney Green Wattle
A. elongata	Sieb. ex DC.	Slender Wattle
A. falcata	Willd.	Sickle Wattle
A. longifolia	(Andrews) Willd.	Coast Wattle
A. myrtifolia	(Sm.) Willd	Myrtle Wattle
A. suaveolens	(Sm.) Willd.	
A. terminalis	Macbride	New Year Wattle
A. ulicifolia	(Salisb.) Court	Prickly Moses

TABLE A14-2 (cont'd)

FAMILY/Scientific Name		Common Name
MYRTACEAE		
Angophora costata	(Gaertn.) Druce	Rusty Gum
Baeckia diosmifolia	Rudge	Diosma Heath-myrtle
B. imbricata	(Gaertn.) Druce	Ridged Heath-myrtle
B. ramosissima	A. Cunn. in Field	Rosy Heath-myrtle
Callistemon citrinus	(Curtis) Skeels	Lemon Bottlebrush
C. linearifolius	D.C.	Netted Bottlebrush
C. linearis	D.C.	Narrow-leaved Bottlebrush
C. pachyphyllus	Cheel	Smooth Bottlebrush
C. salignus	(SM.) D.C.	Willow Bottlebrush
Calytrix tetragona	Labill.	Common Fringe-myrtle
Darwinia leptantha	Briggs	Narrow Scent-myrtle
Eucalyptus botryoides	Sm.	Bangalay
E. globoidea	Blakely	White Stringbark
E. gummifera	(Gaertn) Hochr	Red Bloodwood
E. haemastoma	Sm.	Scribbly Gum
E. longifolia	Link	Woollybutt
E. parramattensis	C. Hall	Drooping Red Gum
E. pilularis	Sm.	Blackbutt
E. propinqua	Deane et Maiden	Grey Gum
E. resinifera	Sm.	Red Mahogany
E. robusta	Sm.	Swamp Mahogany
E. tereticornis	Sm.	Forest Red Gum
E. umbra subsp. *umbra*	R. T. Baker	Bastard Mahogany
Leptospermum arachnoides	Gaertn.	Stiff Teatree
L. attenuatum	Sm.	
L. flavescens	Sm.	
L. juniperinum	Sm.	Prickly Teatree
L. liversidgei	Baker	Lemon-scented Teatree
L. parvifolium	Sm.	Small-leaf Teatree
Melaleuca ericifolia	Sm.	Swamp Paperbark
M. nodosa	Sm.	Ball Honey-myrtle
M. quinquenervia	(Cav.) S.T.	Broad-leaved Paperbark
M. sieberi	Schau in Walp.	Sieber's Paperbark
M. stypheloides	Sm.	Prickly-leaved Paperbark
M. thymifolia	Sm.	Feather Honey-myrtle
OLACACEAE		
Olax stricta	R.Br.	Eastern Olax
ORCHIDACEAE		
Acianthus fornicatus	R.Br.	Pixie Caps
Caladenia alba	R.Br.	White Caladenia
C. carnea	R.Br.	Pink Fingers
Calochilus sp.		
Chiloglottis reflexa	(Labill) Druce	Autumn Bird Orchid
Dipodium punctatum #	(Sm.) R. Br.	Hyacinth Orchid
Diurus punctata	Sm.	Purple Diurus

TABLE A14-2 (cont'd)

FAMILY/Scientific Name		Common Name
ORCHIDACEAE (Continued)		
Diurus sulphurea	R.Br.	Tiger Orchid
Glossodia minor	R.Br.	Small Wax-lip Orchid
G. major	R.Br.	Wax-lip Orchid
Microtis parviflora	R.Br.	Slender Onion-orchid
Pterostylis nutans	R.Br.	Nodding Greenhood
Thelmitra ixioides	Swartz	Dotted Sun-orchid
OXALIDACEAE		
Oxalis corniculata	L.	Yellow Wood Sorrel
PHILESIACEAE		
Geitonoplesium cymosum	(R.Br.) A. Cunn. ex Hook	Scrambling Lily
PHILYDRACEAE		
Philydrum lanuginosum	Gaertn	Frogmouth
PHYTOLACCACEAE		
Phytolacca octandra *	L.	Inkweed
PITTOSPORACEAE		
Billardiera scandens	Sm.	Dumplings
Bursaria spinnosa	Cav.	
PLANTAGINACEAE		
Plantago sp *		
POLYGALACEAE		
Comesperma ericinum	DC.	Pyramid Flower
C. volubile	Labill	Love Creeper
PRIMULACEAE		
Samolus repens	(Forst. et f.) Pers.	Creeping Brookweed
PROTEACEAE		
Banksia aspleniifolia	Salisb.	Rock Banksia
B. collina	R.Br.	Hill Banksia
B. integrifolia	L.f.	Coast Banksia
B. robur	Cav.	Large-leaved Banksia
B. serrata	L.f.	Saw Banksia
B. serratifolia	Salisb.	Swamp Banksia
B. spinulosa	Sm.	Hill Banksia
Conospermum ericifolium	Sm.	Heath Conospermum
Grevillea sericea	(Sm.) R.Br.	Pink Spider-flower
Hakea gibbosa	Cav.	Peeling Hakea
H. sericea	Schrad	Silky Hakea

TABLE A14-2 (cont'd)

FAMILY/Scientific Name		Common Name
PROTEACEA (Continued)		
Hakea teretifolia	(Salisb.) J. Britten	Dagger Hakea
Isopogon anemonifolius	(Salisb.) Knight	Drumsticks
Lambertia formosa	Sm.	Mountain Devil
Lomatia silaifolia #	(Sm.) R. Br.	Crinkle Bush
Petrophile sessilis	Sieb. ex Schult et f.	Prickly Conesticks
Persoonia lanceolata	Andr.	Lance-leaf Geebung
P. levis	(Cav.) Domin	Broad-leaved Geebung
P. pinifolia	R. Br.	Pine-leaf Geebung
Symphionema paludosum	R. Br.	Swamp Symphionema
Xylomelum pyriforme #	(Gaertn.) Knight	Woody Pear
RESTIONACEAE		
Hypolaena fastigata	R. Br.	
Leptocarpus tenax	(Labill.) R. Br.	
Lepyrodia gracilis	Benth	
Restio complanatus	R. Br.	
R. tetraphyllus	Labill	
spp.meiostachyus	Johnson et Evans	
RUBIACEAE		
Pomax umbellata	(Gaertn.) Soland ex A	
RUTACEAE		
Boronia falcifolia #	A. Cunn.	Sickle Boronia
B. parviflora #	Sm.	Swamp Boronia
B. pinnata #	Sm.	Pinnate Boronia
Correa reflexa	Labill.	Correa
C. alba	Andr.	White Correa
Eriostemon australasius #	Pers.	Pink Waxflower
Phebalium squaemeum	(Labill) Engl.	Satinwood
P. squamulosum	Vent.	Scaly Phelabium
Philotheca salsolifolia	Benth	
Zieria laxiflora	Andr.	
SANTALACEAE		
Choretrum candollei	F. Muell ex Benth	White Sour-bush
Exocarpus cupressiformis	Labill	Native Cherry
E. strictus	R. Br.	Pale-fruit Ballart
SAPINDACEAE		
Dodonaea triquetra	Wendl.	Large-leaf Hop-bush
SCROPHULARIACEAE		
Euphrasia speciosa	R. Br.	Large Eyebright
SOLANACEAE		
Solanum stelligerum	Sm.	Star Nightshade

TABLE A14-2 (cont'd)

FAMILY/Scientific Name		Common Name
STERCULIACEAE		
Rulingia pannosa	R.Br	Kerrawang
THYMELACEAE		
Pimelea linifolia	Sm	Rice Flower
TREMANDRACEAE		
Tetratheca ericifolia	Sm.	Heath Pink-bell
T. thymifolia	Sm.	Thyme Pink-Bell
TYPHACEAE		
Typha latifolia *	L.	Great Reedmace
T. orientalis	Pers.	
UMBELLIFERAE		
Actinotus helianthi #	D.C.	Flannel Flower
Hydrocotyle bonariensis *	Lan.	
Platysace ericoides	(Sieb. ex Spreng) C. Norman	Heath Platysace
P. lanceolata	(Labill.) Druce	Shrubby Platysace
P. linearifolia	(Cav.) C. Norman	Narrow-leaved Platysace
Trachymene incisa	Rudge	
Xanthosia pilosa	Rudge	
VERBENACEAE		
Chloanthes stoechadis	R.Br.	
VIOLACEAE		
Viola betonicifolia	Sm.	Purple Violet
V. hederacea	Labill.	Ivy-leaf Violet
Hybanthus filiformis	(DC.) F. Muell.	
XANTHORROEACEAE		
Lomandra glauca	(R.Br.) Ewart	Pale Mat-rush
L. longifolia	Labill.	Spiny-headed Mat-rush
L. micranthra	(Endl.) Ewart	Small-flower Mat-rush
L. multiflora	(R.Br.) J. Britt.	Many-flowered Mat-rush
Xanthorrhoea minor	R. Br.	Small Grass-tree
X. resinosa ssp. fulva	Lee	Spear Grass-tree
XYRIDACEAE		
Xyris operculata	Labill	Tall Yellow-eye

TABLE A14-2 (cont'd)

FAMILY/Scientific Name	Common Name
ZAMIACEAE	
Macrozamia communis	L.A.S. Johnson

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* Exotic plants
\# Protected plants
** Population of adequate size but needs constant monitoring (Specht et al, 1974).

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TABLE A14.3

CHARACTERISTICS OF VEGETATION COMMUNITIES
OCCURRING OVER ORE BODIES

ASSOCIATION/ COMMUNITY	HABITAT TYPE	TREES Common Species	TALL SHRUBS (3-10m) Common Species	LOW SHRUBS Common Species	GROUND COVER Common Species	OVERALL STRUCTURE	COMMENTS
1. Drooping Red Gum, Low Open-forest HEIGHT % COVER	Heathland	Eucalyptus parramattensis occasional Angophora costata 7-10 m 70	Persoonia levis Banksia serratifolia Hakea teretifolia <4 m 10-20	Eucalyptus parramattensis Acacia sp. 1 m	Sedge spp. Lomandra longifolia Stylidium graminifolium <1 m 80	Low Open-forest	
2. Drooping Red Gum, Low Open-woodland HEIGHT % COVER	Heathland	Eucalyptus parramattensis 7-10 m 10	-	Banksia serratifolia Hakea teretifolia Petrophile sessilis Melaleuca sieberi Callistemon sp. 1.5 m 0-70	Grass spp. Sedge spp. Bossiaea sp. Selaginella uliginosa Melaleuca thymifolia <1 m 90	Low Open-woodland	Low shrub layer in clumps - appeared dead from effects of fire. Clumps are typically monospecific
3. Rusty Gum Open-forest HEIGHT % COVER	Dry Sclerophyll Forest with heathland elements.	Angophora costata 17 m <70	Melaleuca nodosa Persoonia levis Banksia serratifolia 5 m 10-20	Acacia suaveolens Leptospermum spp. Petrophile sessilis Gahnia sp. 1-2 m <50	Dianella caerulea Pteridium esculentum Caladenia alba Leaf litter 1 m <50	Open-forest	Lot of leaf litter. Recent fire through area.
4. Scribbly Gum-Red Bloodwood Open-forest HEIGHT % COVER	Dry Sclerophyll Forest	Eucalyptus haemastoma, E. gummifera a few Angophora costata 15 m 70-80	-	-	Lomandra glauca Xanthorrhoea sp. Trachymene incisa <1 m 50	Open-forest with patches of closed forest.	Area of investigation burnt and understorey species difficult to identify.

TABLE A14.3 (cont'd)

ASSOCIATION/ COMMUNITY	HABITAT TYPE	TREES Common Species	TALL SHRUBS (3-10m) Common Species	LOW SHRUBS Common Species	GROUND COVER Common Species	OVERALL STRUCTURE	COMMENTS
5. Scribbly Gum - Rusty Gum Open-forest	Dry Sclerophyll Forest	Eucalyptus haemastoma Angophora costata occasional E. gummifera			Grass spp. Lomandra glauca	Open-forest	Area of investigation burnt so understorey cover expected to be underestimated.
HEIGHT % COVER		10-15 m 60-70			<1 m 20-30		
6. Scribbly Gum - Open-forest		Eucalyptus haemastoma occasional E. gummifera E. parramattensis Angophora costata	Banksia serratifolia B. aspleniifolia	Acacia sauveolens A. longifolia Melaleuca thymifolia Persoonia levis Isopogon anemonifolius Eucalyptus haemastoma Blandfordia grandiflora	Baeckia ramosissima Xanthorrhoea sp. Hardenbergia violacea Lindsaea sp. Bossiaea sp. Leaf litter	Open-forest	Tall shrubs typically clumped.
HEIGHT % COVER		15 m 60-70	⩽5 m 0-70	1-2 m 30-50	1-1.5 m 70		
7. Rusty Gum - Red Bloodwood Open-forest		Angophora costata, Eucalyptus gummifera occasional E. haemastoma	Banksia serratifolia	Banksia aspleniifolia Pimelia linifolia Leptospermum spp. Acacia ulicifolia Persoonia levis Actinotus helianthi	Grass spp. Pteridium esculentum Macrozamia sp. communis		
HEIGHT % COVER		15 m 40-50	⩽5 m 20	1-2 m 50	⩽1 m		
8. Broad-leaved Paperbark - Swamp Mahogany Open-forest	Swamp Sclerophyll Forest	Melaleuca quinquenervia Eucalyptus robusta		Banksia aspleni Melaleuca thymifolia	Themeda australis Sedge spp. Dampiera australis	Open-forest	One patch of Eucalyptus amplifolia (Cabbage Gum) observed.
HEIGHT % COVER		15-17 m 40-60		1-2 m 50	1 m 80		

TABLE A14.3 (Cont'd)

ASSOCIATION/ COMMUNITY	HABITAT TYPE	TREES	TALL SHRUBS (3-10m) Common Species	LOW SHRUBS Common Species	GROUND COVER Common Species	OVERALL STRUCTURE	COMMENTS
9. Broad-leaved Paperbark - Rusty Gum Open-forest HEIGHT % COVER		Melaleuca quinquenervia Angophora costata some Banksia serratifolia ⩽20 m 50-70	Banksia serratifolia Angophora costata Persoonia levis 3 m 20-60	Pimelea linifolia Acacia ulicifolia Leptospermum sp. Banksia collina 1-2 m 10-20	Imperata cylindrica Pteridium esculentum 1 m 80	Open-forest	
10. Heath HEIGHT % COVER	Dry-wet Heath	Eucalyptus parramattensis Melaleuca quinquenervia E. robusta <10 m 2	-	Melaleuca thymifolia Banksia aspleniifolia Isopogon anemonifolius Ricinocarpus pinifolius Leptospermum sp. 0.5-1 m 100		Closed-heath	High species diversity.
11. Blackbutt Open-forest HEIGHT % COVER	Dry Sclerophyll Forest	Eucalyptus pilularis Angophora costata Eucalyptus gummifera 20-23 m 50	Banksia serratifolia Monotoca elliptica Persoonia levis ⩽5 m 10	Acacia ulicifolia Pimelea linifolia A. longifolia A. botrycephala 1.5 m 80	Imperata cylindrica Pteridium esculentum Macrozamia communis Lomandra longifolia 1 m 50	Open-forest	
12. Eleocharis Swamp HEIGHT % COVER	Semi-permanent Fresh Swamp	-	-	-	Eleocharis acuta Polygonum sp. Villarsia exaltata Philydrum lanuginosum 1-2 m 80	Closed-sedgeland	Very dry at time of study. No standing water.

TABLE A14.3 (Cont'd)

ASSOCIATION/ COMMUNITY	HABITAT TYPE	TREES	TALL SHRUBS (3-10m) Common Species	LOW SHRUBS Common Species	GROUND COVER Common Species	OVERALL STRUCTURE	COMMENTS
13. Scribbly Gum - Rusty Gum - Red Bloodwood Open-forest HEIGHT % COVER	Dry Sclerophyll Forest - heathland understorey	Eucalyptus haemostoma E. gummifera Angophora costata 14-16 m 60	Banksia serratifolia Eucalyptus spp. ≤7 m 20-30	Acacia suaveolens Banksia serratifolia Eucalyptus spp. 2 m 70-80	Xanthorrhoea sp. Pteridium esculentum 1 m 50	Open-forest	
14. Sedge Swamp HEIGHT % COVER	Seasonal Fresh Swamp		Melaleuca quinquenervia Melaleuca spp. Eucalyptus robusta 3-5 m 10		Selaginella uliginosa Restio tetraphyllus Sedge spp. ≤1 m 70-80	Closed-sedgeland	
15. Scribbly Gum - Rusty Gum Low Woodland HEIGHT % COVER	Heathland	Eucalyptus haemastoma Angophora costata 5-10 m 10-30	Banksia serrata 3-4 m 20-40	Eriostemon australasius Acacia ulicifolia Actinotus helianthi 1-2 m 50	Pteridium esculentum Xanthorrhoea sp. Restio tetraphyllus 1-2 m 80	Low Woodland	
16. Scribbly Gum Low Woodland HEIGHT % COVER	Heathland	Eucalyptus haemastoma occasional E. gummifera 5-10 m 10	Banksia serrata 3-4 m 20-40	Acacia ulicifolia Actinotus helianthi Eriostemon australasius 1-2 m 50	Pteridium esculentum Xanthorrhoea sp. Restio tetraphyllus 1-2 m 80	Low Woodland	Very similar to Association 15 in structure and understorey spp.

TABLE A14.3 (Cont'd)

ASSOCIATION/ COMUNITY	HABITAT TYPE	TREES	TALL SHRUBS (3-10m) Common Species	LOW SHRUBS Common Species	GROUND COVER Common Species	OVERALL STRUCTURE	COMMENTS
17. Rusty Gum - Red Bloodwood Low Woodland HEIGHT % COVER	Heathland	Angophora costata Eucalyptus gummifera 5-10 m 10-30	Banksia serrata 3-4 m 20-40			Low Woodland	Similar in structure and understorey species to Associations 15 and 16.
18. Blackbutt - Rusty Gum - Red Bloodwood Open-forest HEIGHT % COVER	Dry Sclerophyll Forest - heath elements	Eucalyptus pilularis E. gummifera Angophora costata 20-25 m <70	Banksia serratifolia 13 m 30-50	Acacia spp. Pea spp. ≤2 m	Pteridium esculentum Imperata cylindrica 1 m Dense in patches	Open-forest	Imperata cylindrica and Pteridium esculentum are generally in regenerating burnt areas/
19. Stringybark Open-forest HEIGHT % COVER	Dry Sclerophyll Forest	Eucalyptus spp. (unidentified) occasional E. tereticornis 20 m 40	-	-	Imperata cylindrica some clumps of Gahnia sp. <1 m 30-50		
20. Tall Sedge Swamp HEIGHT % COVER	Seasonal Fresh Swamp	Melaleuca quinquenervia 10 m 2	-	-	Tall Sedge species (unidentified) ≤2 m 90-100	Closed-sedgeland	Very dry at time of study.

TABLE A14.3 (Cont'd)

ASSOCIATION/ COMUNITY	HABITAT TYPE	TREES	TALL SHRUBS (3-10m) Common Species	LOW SHRUBS Common Species	GROUND COVER Common Species	OVERALL STRUCTURE	COMMENTS
21. Swamp HEIGHT % COVER	Semi-permanent or Seasonal Fresh Swamp	-	-	-	Unidentifiable		Swamp area had been badly burnt at time of study and swamp type, structure and species composition was indeterminable.
22. Broad-leaved Paperbark Closed-forest HEIGHT % COVER	Swamp Sclerophyll Forest	Melaleuca quinquenervia >10 m > 70			Not investigated	Closed-forest	This is a fringing belt around wetlands.

A14.2 FAUNA

A14.2.1 Methods

Fauna occurring in the study area were investigated using the following procedures:

i. *General Observations*

All sightings of animals during general field work were recorded. Most avifauna species were identified in this manner.

ii. *Small Mammal Trapping*

Live trapping was conducted in four habitats over a period of four days in June 1980. A total of 60 Elliott traps (50 sized 33cm x 9cm x 10cm and 10 sized 46cm x 15.5cm x 15 cm) was used, generally divided between two habitats.

The area was sampled for a total of 240 trap nights. Fresh bait of peanut butter, rolled oats, honey and vanilla mixture was used each night and traps were checked each morning.

Location of traps was roughly linear or rectangular except in habitat 4 where only a few traps were placed near burrows observed in the sand. Traps were placed wherever possible in locations showing signs of animal habitation or providing suitable microhabitat for small fauna species.

Habitats sampled were:

* Mined area - PM 37
* Ecotone between Associations 4 and 6
* Association 8
* Association 10.

iii. *Mistnetting*

Two mistnets were used to sample bat species. The nets were erected before dusk and watched continuously for approximately

two hours on one occasion.

iv. *Spotlighting*

General night spotlighting along roads and tracks was conducted for approximately four hours to investigate, on a preliminary basis, the occurrence of larger nocturnal species.

v. *Local Knowledge*

Information on fauna species occurring in the study area was gained from the Company and the Board together with R.A.A.F. personnel in the locality. Local residents also supplied information.

A14.2.2 Avifauna Species Occurrence

Table A14.4 lists all species of avifauna known to occur or expected to occur within the Tomago Sandbeds area. Sixty species have been recorded for the area and a further forty species would definitely be expected to occur.

Most of the avifauna are insectivorous and/or nectar eaters. A number of wetland species also occur, although the prevailing drought conditions during the study period would have discouraged a number of waterbird species from frequenting the area. The distribution of avifauna is discussed in Section 4.9.

The most commonly observed birds during the study were honeyeater species such as the Yellow-faced Honeyeater *(Lichenostomus chrysops)*, the Kookaburra *(Dacelo novaeguineae)* and the Australian Raven *(Corvus coronoides)*. Numbers and proportions of species, however, would tend to change seasonally. The greatest diversity of populations of birds would be expected during spring when most of the heath plants flower.

TABLE A14-4

AVIFAUNA SPECIES OCCURRING OR EXPECTED TO OCCUR IN THE TOMAGO SANDBEDS

Scientific Name	Common Name	Habitat	Occurrence* Mined	Occurrence* Unmined
Pelecanus conspicillatus	Australian Pelican	E		E
Morus serrator	Australian Gannet			
Phalacrocorax carbo	Black Cormorant	W, E		E
P. varius	Pied Cormorant	W, E		E
P. sulcirostris	Little Black Cormorant	W, E		E
P. melanoleucos	Little Pied Cormorant	W, E		E
Tachybaptus novaehollandiae	Little Grebe	W		E
Podiceps cristatus	Great-crested Grebe	W		E
Ardea pacifica	White-necked Heron	P, W		E
Ardea novaehollandiae	White-faced Heron	W		✓
Butorides striatus	Mangrove Heron			
Ardeola ibisi	Cattle Egret	P, W		E
Egretta alba	Large Egret	W		✓
E. garzetta	Little Egret	P, W		E
Nycticorax caledonicus	Nankeen Night Heron	W		E
Botaurus poiciloptilus	Brown Bittern	W		E
Xenorhynchus asiaticus	Jabiru	W		E
Threskiornis molucca	White Ibis	P, W		E
T. spinicollis	Straw-necked Ibis	P, W		E
Plegadis falcinellus	Glossy Ibis	P, W		E
Platelea regia	Royal Spoonbill	W		E
P. flavipes	Yellow-billed Spoonbill	W		E
Cygnus atratus	Black Swan	W		E
Anas superciliosa	Black Duck	W		✓
A. aibberifrons	Grey Teal	W		E
A. castanea	Chestnut Teal	W		✓
Chenonetta jubata	Wood Duck	W		E
Elanus notatus	Black-shouldered Kite	P, H		✓
Haliastur indus	Brahminy Kite	W, E		E
H. sphenurus	Whistling Kite	E		✓
Accipiter fasciatus	Australian Brown Goshawk			
A. cirrhocephalus	Collared Sparrow-hawk			
Hieraertus morphnoides	Little Eagle			
Aquila audax	Wedge-tailed Eagle	F, P	✓	✓
Haliaeetus leucogaster	White-breasted Sea-Eagle	E, F		✓
Circus aeruginosus	Swamp Harrier	W, E, H		E
Falco cenchroides	Nankeen Kestrel	P	E	E
F. berigora	Brown Falcon	P, F		E
Coturnix pectoralis	Stubble Quail	F, H		E
C. australis	Brown Quail	F, H		E
Gallinula tenebrosa	Dusky Moorhen	W		E
Porphyrio porphyrio	Swamphen	W		✓
Fulica atra	Coot	W		E

TABLE A14-4 (cont'd)

Scientific Name	Common Name	Habitat	Occurrence Mined	Occurrence Unmined
Cuculus pyrrhophanus	Fan-tailed Cuckoo	F		✓
Chrysococcyx plagosus	Golden-bronze Cuckoo	F		E
Eudynamys scolopacea	Indian Koel	F		✓
Centropus phasianinus	Pheasant Coucal	F, H, W		✓
Ninox novaeseelandiae	Boobook Owl	F		E
Tyto alba	Barn Owl	F		E
Podargus strigoides	Tawny Frogmouth	F		E
Hirundapus caudacutus	Spine-tailed Swift	P, H, F	E	✓
Apus pacificus	Fork-tailed Swift	F, H, P	E	
Ceyx azureus	Azure Kingfisher	E, W		E
Dacelo novaeguineae	Kookaburra	P, F	✓	✓
Halcyon sancta	Sacred Kingfisher	F		✓
Eurystomus orientalis	Dollarbird	F		✓
Hirundo neoxena	Welcome Swallow	PM32	✓	E
Cecropis nigricans	Tree Martin	F		E
C. ariel	Fairy Martin	P, H	E	E
Anthus novaeseelandiae	Australian/Richard's Pipit	PM32	✓	E
Coracina novaehollandiae	Black-faced Cuckoo-shrike	F		✓
C. robusta	Little Cuckoo-shrike	F		E
C. tenuirostris	Cicadabird	F		E
Pomatostomus temporalis	Grey-crowned Babbler	F		E
Cisticola exilis	Golden-headed Cisticola	W		✓
Acrocephalus stentoreus	Clamorous Reed-warbler	W		✓
Malurus cyaneous	Superb Blue Wren	F, H		✓
M. lamberti	Variegated Wren	F, H		✓
Stipiturus malachurus	Southern Emu-Wren	F, H		✓
Gerygone olivacea	White-throated Warbler	F		E
G. levigaster	Mangrove Warbler	E		E
Acanthiza lineata	Striated Thornbill	F		E
A. nana	Yellow Thornbill	F, H		✓
A. pusilla	Brown Thornbill	F		✓
A. reguloides	Buff-rumped Thornbill	F		E
A. chrysorrhoa	Yellow-rumped Thornbill	F		✓
Sericornis frontalis	White-browed Scrub-wren	F		✓
S. pyrrhopygius	Heath Wren/Chestnut-rumped Hylacola	H		E
Epthianura albifrons	White-fronted Chat	PM37	✓	
Microeca leucophaea	Jacky Winter	F		E
Eopsaltria australis	Eastern Yellow Robin	F		✓
Rhipidura fuliginosa	Grey Fantail	F, H		✓
R. rufifrons	Rufous Fantail	F, H		E
R. leucophrys	Willie Wagtail	P	✓	
Myiagra rubecula	Leaden Flycatcher	F		✓

TABLE A14-4 (cont'd)

Scientific Name	Common Name	Habitat	Occurrence Mined	Occurrence Unmined
Myiagra inquieta	Restless Flycatcher	F		E
Monarcha melanopsis	Black-faced Monarch	F		E
Pachycephala pectoralis	Golden Whistler	F		E
P. rufiventris	Rufous Whistler	F		✓
Colluricincla harmonica	Grey Shrike-thrush	F		✓
Psophodes olivaceus	Eastern Whipbird	H, W		✓
Daphoenositta chrysoptera	Varied Sittella	F		E
Climacteris picumnus	Brown Tree-creeper	F		E
C. leucophaea	White-throated Tree-creeper	F		✓
Dicaeum hirundinaceum	Mistletoe Bird	F		✓
Pardalotus punctatus	Spotted Pardolote	F, H		E
Zosterops lateralis	Silvereye	F, H		✓
Myzomela sanguinolenta	Scarlet Honeyeater	F, H		✓
Meliphaga lewinii	Lewin Honeyeater	F		E
Lichenostomus chrysops	Yellow-faced Honeyeater	F		✓
Melithreptus lunatus	White-naped Honeyeater	F		E
Philemon citreogularis	Little Friarbird	F, H		E
P. corniculatus	Noisy Friarbird	F, H		E
Phylidonyris novaehollandiae	New Holland Honeyeater	F, H		E
P. nigra	White-cheeked Honeyeater	F, H		✓
P. melanops	Tawny-crowned Honeyeater	F, H		E
Acanthorhynchus tenuirostris	Eastern Spinebill	F		✓
Manorina melanocephala	Noisy Miner	F, H		✓
Anthochaera chrysoptera	Little Wattle-bird	F, H		✓
A. carunculata	Red-Wattle bird	F, H		E
Emblema temporalis	Red-browed Firetail	P	E	✓
Poephila bichenovii	Double-barred Finch	P, H	E	E
Passer domesticus	House Sparrow	P		✓
Sturnis vulgaris	Common Starling	P		✓
Acridotheres tristis	Common Myna	P		✓
Oriolus sagittatus	Olive-backed Oriole	F		✓
Dicrurus hottentottus	Spangled Drongo	F		✓
Grallina cyanoleuca	Australian Magpie Lark	P		✓
Corcorax melanorhamphos	White-winged Chough	P, F	✓	E
Artamus leucorhynchus	White-breasted Wood-swallow	F, H, P	E	E
A. cyanopterus	Dusky Woodswallow	F, P, H		✓
Strepera graculina	Pied Currawong	F		E
Cracticus nigrogularis	Pied Butcherbird	P	✓	E

TABLE A14-4 (cont'd)

Scientific Name	Common Name	Habitat	Occurrence Mined	Occurrence Unmined
Venellus miles	Masked Plover	P		E
Charadrius ruficapillus	Red-capped Dotterel	W, E		E
C. bicinctus	Double-banded Dotterel	W, E		E
C. mongolus	Mongolian Dotterel	W, E		E
Pluvialis dominica	Eastern Golden Plover	W, E		E
Arenaria interpres	Turnstone	W, E		E
Gallinago hardwickii	Japanese Snipe	W		E
Numenius minutus	Little Whimbrel	E		E
N. madagascariensis	Eastern Curlew	E		E
Tringa brevipes	Grey-tailed Tattler	W, E		
Calidris acuminata	Sharp-tailed Sandpiper	W, E		E
C. ruficollis	Red-necked Stint	W, E		E
C. ferruginea	Curlew Sandpiper	W, E		
Limosa lapponica	Bar-tailed Godwit	E		E
Philomachus pugnax	Ruff			
Himantopus himantopus	Pied Stilt	W		E
Larus novaehollandiae	Silver Gull	E		E
Hydroprogne caspia	Caspian Tern	E		E
Sterna bergii	Crested Tern	E		E
Ptilinopus regina	Red-crowned Pigeon			
P. magnificus	Wompoo Pigeon			
Lopholaimus antarcticus	Top-knot Pigeon			
Columba leucomela	White-headed Pigeon			
C. livia	Domestic Pigeon			
Macropygia amboinensis	Brown Pigeon			
Streptopelia chinensis	Spotted Turtledove	F, H, P	E	E
Geopelia humeralis	Bar-shouldered Dove	F, H		E
G. striata	Peaceful Dove	F, H, P	E	E
Phaps chalcoptera	Common Bronzewing	F		✓
P. elegans	Brush Bronzewing	F		E
Ocyphaps lophotes	Crested Pigeon	P	E	✓
Trichoglossus chlorolepidotus	Scaly-breasted Lorikeet	F		E
Glossopsitta pusilla	Little Lorikeet	F		E
Calyptorhynchus funereus	Yellow-tailed Black Cockatoo	F		✓
C. lathami	Glossy Black Cockatoo	F		✓
Cacatua galerita	Sulphur-crested Cockatoo			
C. roseicapilla	Galah	P	E	✓
Nymphicus hollandicus	Cockatiel			
Platycercus eximius	Eastern Rosella	F		✓
Cuculus pallidus	Pallid Cuckoo	F		E
C. variolosus	Brush Cuckoo	F		E

TABLE A14-4 (cont'd)

Scientific Name	Common Name	Habitat	Occurrence Mined	Occurrence Unmined
Cracticus torquatus	Grey Butcherbird			✓
Gymnorhina tibicen	Australian Magpie	P, F		✓
Corvus coronoides	Australian Raven	P, F	✓	✓

KEY: Habitat - P = Pastureland/cleared land
F = Forest
H = Heath
W = Wetlands
E = Estuarine

Occurrence- ✓ = Recorded in Area
E = Expected to occur (based on observations in the Myall Lakes National Park and the County of Northumberland species list (*Morris, 1975*) and local observations. Many of these would only be casual or occasional visitors.

NOTE: * The occurrence and expected occurrence of avian species is based on observations during the 1980 field study period. The survey included the naturally vegetated (unmined) areas and the restored mined areas. The vegetation in the regenerating areas was eight years old or younger.

As the vegetation cover in mined areas becomes progressively more compatible with the surrounding undisturbed flora, avian species diversity in such areas will increase accordingly.

A14.2.3 Non-Avian Fauna Species Occurrence

Mammals

Mammals occurring, or expected to occur in the sandbeds area are listed in Table A14.5. This list totals 21 species of which 12 have been definitely recorded.

The macropods comprising the Eastern Grey Kangaroo *(Macropus giganteus)*, Red-necked Wallaby *(Macropus rufogriseus)* and the Swamp Wallaby *(Wallabia bicolor)* are the most obvious form of wildlife and generally most frequently observed. The preference for fresh green herbage alongside tracks, particularly with regard to the two *Macropus spp.*, also increases the potential for sightings.

The Brush-tailed Possum *(Trichosurus vulpecula)* is common in the area. This species is very adaptable in its diet and habitat preferences and is one of the most widely occurring mammals in Australia *(Ride, 1970)*. Other possum and glider species would be expected to occur being native to the habitat present in the study area. The fact that they have not yet been recorded in the area may be related to their more secretive habits and possibly lower population than the Brush-tailed Possum *(Trichosurus vulpecula)*.

A group of Koalas *(Phascolarctos cinereus)* is resident in the southwest section of the Tomago Sandbeds. Only one or two individuals are typically seen at a time.

Knowledge of the small mammal species has resulted from brief trapping programmes in the locality. The trapping results for June 1980 are presented in Table A14.6.

Two species were trapped with the majority of animals being New Holland Mice *(Pseudomys novaehollandiae)*. This species was also captured a number of times in a previous trapping programme to the south *(James B. Croft & Associates)*. Other species recorded were trapped in this previous study.

Spotlighting and mistnetting were unsuccessful in verifying the presence

TABLE A14-5

NON-AVIAN FAUNA SPECIES LIST

SPECIES KNOWN OR EXPECTED TO OCCUR IN THE STUDY AREA

Mammals

Scientific Name	Common Name	Habitat	Occurrence
Macropus giganteus	Eastern Grey Kangaroo	F/P	(C)
M. rufogriseus	Red-necked Wallaby	F/P	(MC)
Wallabia bicolor	Swamp Wallaby	F/H/W	(C)
Trichosurus vulpecula	Brush-tailed Possum	F	(C)
T. caninus	Mountain Possum	F	E
Pseudocheirus peregrinus	Common Ringtail	F/W	E
Schoinobates volans	Greater Glider	F	E
Petaurus breviceps	Sugar Glider	F	E
Phascolarctos cinereus	Koala	F	(MC)
Perameles nasuta	Long-nosed Bandicoot	F/H/W	E
Isoodon macrourus	Short-nosed Bandicoot	F/H/W	E
Dasyurus maculatus	Tiger Cat	F/H	E
Antechinus stuartii	Broad-footed Marsupial Mouse	F/H	(0 - probably MC)
Sminthopsis murina	Common Dunnart	F	(0 - probably MC)
Rattus fuscipes	Southern Bush Rat	F/H	E
R. lutreolus	Eastern Swamp Rat	W	(0)
Pseudomys novaehollandiae	New Holland Mouse	H/M	(MC)
Tachyglossus aculeatus	Echidna	F/H/P	E
Canis familiaris	Dingo	F/H/W	(0)
Pteropus poliocephalus	Grey-headed Fruit Bat	F/H	(C)
	Unidentified Bat sp.		

Exotic Species

Oryctolagus cuniculus	Rabbit
Lepus europaens	Hare
Rattus rattus	Black Rat
Mus musculus	House Mouse
Canis familiaris	Dog
Vulpes vulpes	Red Fox
Felix catus	Cat
Sus scrofa	Pig

Key:

F - Forest/Woodland
P - Pastureland
H - Heath
W - Wetlands (margins)
M - Mined areas
C - Common
MC- Moderately Common
O - Occasional Sightings/Captures
E - Expected to occur (Based on animals recorded in the Myall Lakes National Park by N.P.W.S.)

TABLE A14-5 (CONT'D)

Reptiles

Scientific Name	Common Name	Occurrence
Chelodina longicollis	Long-necked Tortoise	E
Diplodactylus vittatus	Wood Gecko	E
Underwoodisaurus milii	Thick-tailed Gecko	E
Lialis burtonis	Burton's Legless Lizard	E
Pygopus lepidopodus	Common Scaly-foot	E
Amphibolurus barbatus	Bearded Dragon	(MC)
Amphibolurus muricatus	Jacky Lizard	E
Varanus varius	Lace Monitor	(MC)
Carlia vivax		E
Cryptoblepharus boutonii	Fence Skink	E
Ctenotus robustus		E
Ctenotus taeniolatus	Copper-tailed Skink	(MC)
Egernia whitii	White's Skink	E
Lamphropholis guichenoti	Garden Skink	(MC)
Leilopisma delicata		E
L. platynota	Red-throated Skink	E
Sphenomorphus tenuis		E
S. quoyii	Eastern Water Skink	(MC)
Tiliqua scincoides	Eastern Blue-tongued Lizard	E
Morelia spilotes	Carpet Python	E
Boiga irregularis	Brown Tree Snake	E
Dendrelaphis punctulatus	Common Tree Snake	E
Acanthophis antarcticus	Common Death Adder	E
Cryptophis nigrescens	Eastern Small-eyed Snake	E
Demansia psammophis	Yellow-faced Whip Snake	E
Furina diadema	Red-naped Snake	E
Hemiaspic signata	Black-bellied Swamp Snake	E
Pseudechis porphyriacus	Red-bellied Black Snake	(C)
Pseudonaja textilis	Eastern Brown Snake	(MC)
Vermicella annulara	Bandy Bandy	E

Note: Expected species derived from *Cogger (1975)*

Amphibians

Crinia signifera	Common Eastern Froglet	E
Lymnodynastes peronii	Brown-striped Frog	E
L. tasmaniensis	Spotted Grass Frog	E
Pseudophryne bibronii	Brown Toadlet	E
Litorea aurea	Green and Gold Bell Frog	E
L. caerulea	Green Tree Frog	E
L. citropa	Blue Mountains Tree Frog	E
L. dentata	Bleating Tree Frog	E
L. fallax	Dwarf Tree Frog	(C)
L. freycineti	Freycinet's Frog	E
L. latopalmata		E
L. lesueurii	Lesueur's Frog	E
L. nasuta	Rocket Frog	E
L. peronii	Peron's Tree Frog	E
L. verreauxii		E

Note: Expected species derived from *Cogger (1975)*

of any species.

Further details on mammal species' distribution and habitat preferences are presented in Section 4.9.2.

Reptiles and Amphibians

Little is known of the reptilian and amphibian populations in the area, although numerous species would be expected as indicated by Table A14.5. Species which were recorded would seem to be moderately common. The Red-bellied Black Snake *(Pseudechis porphryriacus)* is the most frequently observed reptile and is generally a common species.

Factors affecting the presence of reptiles and amphibians are discussed in Section 4.9.2.

TABLE A14.6

TRAPPING RESULTS

Habitat	Species	Number	Trap Nights
1	*Pseudomyn novaehollandiae*	2	60
2	*Pseudomys novaehollandiae*	2 (Male)	60
3	*Antechinus stuartii*	1 (Female)	108
	Pseudomys novaehollandiae	1 (Male)	
4	*Pseudomys novaehollandiae*	1	12

APPENDIX 15

DERIVATION OF ECONOMIC MULTIPLIERS

A15.1 INTRODUCTION

To assist in assessing the economic significance of the Company's operations on the regional economy mineral sands mining multipliers have been calculated.

Input-Output analyses have been used to derive the employment, income and output multipliers during the operation phase of the project.

A 25 x 26 sector survey based set of Input-Output tables has been constructed for the Hunter Region by *Garlick (1979)*, for the year 1976-77. In these tables the operation of mineral sands mining was included in the mining sector which consisted predominantly of coal mining together with mineral sands mining, construction stone, other non-metallic mineral mining and quarrying.

With recourse to the original survey data, together with published statistics, the author of the tables has divided the mining sector into 'coal mining' and 'other mining' activities. The 'other mining' sector is particularly relevant to mineral sands mining and has been used in this study.

The output, income and employment multipliers calculated for the operation phase of the Company's mining operation as represented by the 'other mining' sector are shown in Table A15.1.

A15.2 OUTPUT EFFECTS

For every one dollar spent during a typical year of operation the direct or immediate effect on the output value in the Hunter Region is a 22 cent increase. The indirect effect on output value of every one dollar spent is an increase of 8 cents. The induced impact on output value is 86 cents. The total effect (direct, indirect and induced) of each dollar spent in

a typical year of operation is worth $1.16 in increased industrial output.

TABLE A15.1

OPERATION PHASE: OUTPUT, INCOME AND EMPLOYMENT MULTIPLIERS, RUTILE & ZIRCON MINES (NEWCASTLE) LIMITED (HUNTER REGION)

	Output	Income	Employment*
Direct	.2248	.1952	17
Indirect	.0785	.0608	6
Induced	.8568	.1108	11
Total (1+2+3)	1.1601	.3668	34
Total (1+2)	.3033	.2560	23
Total (2+3)	.9353	.1715	17
Type I (and Simple Output Multiplier)	1.3033	1.3112	1.3176
Type II (and Total Output Multiplier)	2.1601	1.8787	1.9811

* Number of persons employed per million dollars of output.

A15.3 INCOME EFFECTS

The income multipliers in Table A15.1 show the effect on household income of each dollar spent during a typical operating year. The figures show that of each dollar spent 20 cents are spent on labour in the region. The existing mining operations also increase the household income outlays to supporting industries by 6 cents. The induced income effect is 11 cents.

The total increase in household income of each operation phase dollar is 37 cents. The Type I and Type II multipliers indicate that an increase in household income of one dollar during a typical year of operation increases total regional household income by $1.33 and $1.88 respectively.

A15.4 EMPLOYMENT EFFECTS

The multipliers show that for every million dollars spent on the mining operation during any one year, 17 direct jobs are created in the Hunter region. A further 6 jobs result indirectly from the development. Increases in consumer spending as a consequence of the mining operation result in a further 11 jobs.

The Type I and Type II multipliers indicate that for each person employed in the mining operation an additional 1.3 and 2.0 jobs respectively are created in the region.

A15.5 INTREPRETATION OF THE MULTIPLIERS

* In this analysis Type II multipliers should be considered to be the absolute maximum effects while the most likely effects are reflected in the Type I multipliers *(Mandeville et al, 1979)*
* The normal reservations concerning the restrictive assumptions of Input-Output models, particularly in relation to rigidity of production functions and propensities to consume, should be borne in mind *(Mandeville et al, 1979)*.

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