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**PRELIMINARY STUDY INTO
THE MINING OF THE
LYONS RIVER MAGNESITE DEPOSIT
TASMANIA**

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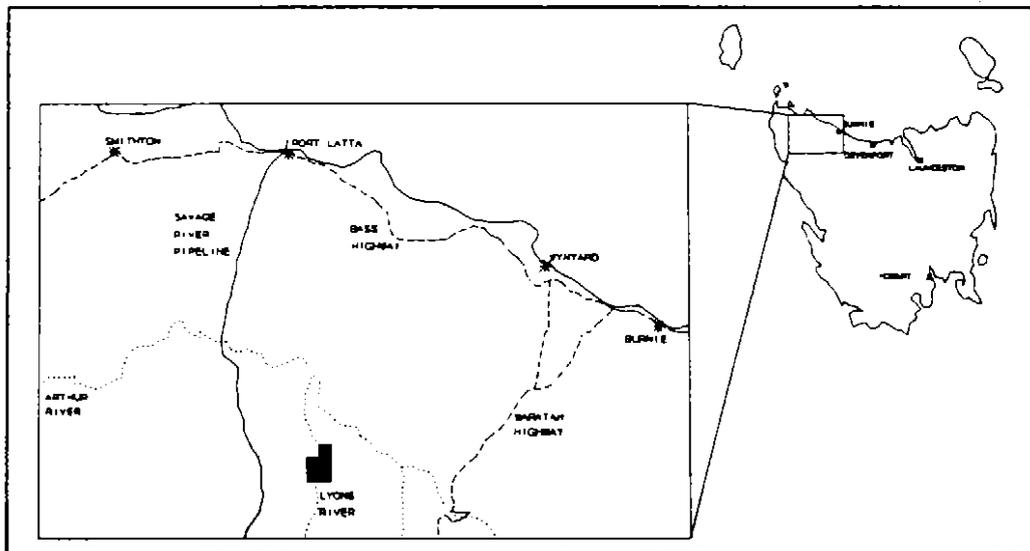
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1.0 INTRODUCTION

As part of a study being undertaken by CRA Resource Commercialisation, CRA Resource and Process Development (R & PD) requested Minenco to undertake a study into the Lyons River Magnesite deposit situated in north western Tasmania.

This study has established the operating and capital costs associated with the mining the Lyons River magnesite deposit. This includes the mining, crushing and screening, transport, storage and ship loading of a lump product of size range 20 mm to 75 mm. The product would be transported by road to Port Latta where it would be stockpiled and subsequently loaded into vessels using the existing Port Latta wharf facilities. Figure 1 shows the location of the Lyons River deposit in relation to north west Tasmania.

**Figure 1.1
Lyons River Location Plan**



Two production rates are envisaged, namely 600 000 product tonnes per year and 1 000 000 product tonnes per year. The yield of lump from a 'clean' run of mine magnesite feed is assumed to be 75%.

The study has estimated the cost of an underground and an open cut mining method at each of the two production rates. Thus the four base case options are:

- Option A - An open pit mine producing 600 000 tonnes per annum of raw lump magnesite product of size range 20 mm to 75 mm.
- Option B - An open pit mine producing 1 000 000 tonnes per annum of raw lump magnesite product of size range 20 mm to 75 mm.
- Option C - An underground mine producing 600 000 tonnes per annum of raw lump magnesite product of size range 20 mm to 75 mm.
- Option D - An underground mine producing 1 000 000 tonnes per annum of raw lump magnesite product of size range 20 mm to 75 mm.

Product haulage to the port will be via a new road to be constructed westward to the existing iron ore pipeline inspection road and then along that road to the Port Latta facilities. The iron ore pipeline and its 150 m wide easement are currently owned by Savage River Mines. The route of the new road has been chosen solely to minimise costs, as no environmental constraints have so far been identified. It has been assumed in the study that all required facilities presently owned by the Savage River Mine (the Pipeline Road and the Port Latta facilities) would be available to the project at no cost, though maintenance of the facilities would be the responsibility of the project.

This study is for an early 'sighter' study as a base case upon which value adding options may be considered. The accuracy for this study will therefore be less than that normally associated with a Minenco Type 1 Study of $\pm 25-30\%$.

As a variation to the original scope, Minenco has been requested to investigate and cost a value added alternative to the base cases, namely calcining the lump product to produce calcined magnesia. Consideration was given to the location of the calcining facility (Port Latta or Burnie) along with the means of shipping the fine ground product. The anticipated feed size to the calcining plant is assumed to be between 10 mm and 75 mm in size, and the yield of lump from the 'clean' run of mine magnesite feed is assumed to be 85%.

Upon calcining 50% of the feed stock is lost as flue gas. Accordingly, the options for this value added case are:

- Option E - An open pit mine producing 340 000 tonnes per annum of calcined magnesia
- Option F - An open pit mine producing 567 500 tonnes per annum of calcined magnesia
- Option G - An underground mine producing 340 000 tonnes per annum of calcined magnesia
- Option H - An underground mine producing 567 500 tonnes per annum of calcined magnesia

Table 1.1 below summarises the various options (A-H) considered in the study.

Table 1.1 : Options Summary

| Options | A | B | C | D | E | F | G | H |
|--|-----------------|-------|------|-------|-------------------|--------|--------|--------|
| CASE | BASE CASE | | | | VALUE ADDED CASE | | | |
| Mine Production (kt) | 600 | 1 000 | 600 | 1 000 | 680 | 1 135 | 680 | 1 135 |
| Mining Method* | OP | OP | UG | UG | OP | OP | UG | UG |
| Mining Product size fraction | + 20 mm - 75 mm | | | | + 10 mm - 75 mm | | | |
| Crusher product sizing oversize : undersize | 75 : 25 | | | | 85 : 15 | | | |
| Calcination | No | No | No | No | Yes | Yes | Yes | Yes |
| Final Product | Magnesite | | | | Calcined Magnesia | | | |
| Product Tonnage (kt) | 600 | 1 000 | 600 | 1 000 | 340 | 567.5 | 340 | 567.5 |
| Product Type | Lump | Lump | Lump | Lump | Powder | Powder | Powder | Powder |

* OP = Open Pit, UG = Underground

2.0 SUMMARY

This study has shown that the base case project is not financially viable at the anticipated lump magnesite product price of A\$50/tonne FOB. Calcination of the lump magnesite to form calcined magnesia results in an expected significant enhancement to the product price (A\$200/tonne FOB). A potentially viable project is possible at a production rate of 567 500 tonnes per annum of caustic calcined magnesia.

Table 2.1 below summarises the financial evaluation of the eight options investigated.

Table 2.1 : Summary of Financial Evaluation Results

| Option | A | B | C | D | E | F | G | H | |
|---|-----------------------|-------|------|-------|---------------------------------|------|------|------|--|
| Product Type | Lump Magnesite | | | | Calcined Magnesia Powder | | | | |
| Product Tonnage (kt) | 600 | 1 000 | 600 | 1 000 | 340 | 568 | 340 | 568 | |
| Mining Method : Open Pit or underground | OP | OP | UC | UC | OP | OP | UC | UC | |
| Lower Anticipated Value (A\$/t FOB) | 40 | 40 | 40 | 40 | 200 | 200 | 200 | 200 | |
| IRR (%) | -ve | -ve | -ve | -ve | 11.4 | 18.1 | 9.7 | 15.4 | |
| NPV @ 11.5% real ROR (\$m) | -106 | -77 | -116 | -122 | -1 | 113 | -20 | 56 | |
| Higher Anticipated Value (A\$/t FOB) | 50 | 50 | 50 | 50 | 250 | 250 | 250 | 250 | |
| IRR (%) | -ve | 8.8 | -ve | -ve | 18.2 | 25.6 | 16.6 | 23.4 | |
| NPV @ 11.5% real ROR (\$m) | -68 | -21 | -82 | -66 | 89 | 263 | 61 | 190 | |

The capital cost of each of the options is shown in table 2.2 below, along with the unit operating costs and size of the workforce.

Table 2.2 : Summary of Capital and Operating Costs

| Option | A | B | C | D | E | F | G | H |
|--|-----|-----|-----|-----|-----|-----|-----|-----|
| Capital Cost (\$M) | 93 | 116 | 89 | 99 | 177 | 236 | 173 | 217 |
| Operating Cost (\$/tonne product) FOB Port Latta | 35 | 27 | 42 | 38 | 96 | 80 | 107 | 99 |
| Total Workforce* | 170 | 255 | 135 | 160 | 230 | 320 | 195 | 225 |

* Excluding the contract workforce for the surface transport of the ore between the mine site and Port Latta.

The relatively small difference in capital and operating cost between open pit mining (options A, B, E and F) and their underground mining counterparts (options C, D, G and H respectively) suggests that underground mining would be preferred. The deposit is located in a remote and environmentally sensitive location and an underground mine offers advantages of minimal visual impact on the scenery compared with the major excavation, waste dumps and water run-off handling ponds which would be necessary with a large open pit.

A further advantage of an underground mine is that early access would be gained to areas of higher grade (ie containing lower levels of impurity). The production would not be prone to contamination from overburden as might the early stages of open pit production.

The present size of the world market in lump magnesite and calcined magnesia is approximately 20 million and 1 million tonnes respectively. The production rate of the options studied would result in a significant impact on the world market with up to 57% of world calcined magnesia being produced. A significant increase in the world market would be required to accommodate this level of production. Accordingly, the value of the products which have been advised by R & PD are conservative with recent prices (Industrial Minerals, October 1990) being £50-70 FOB Turkey for lump product and £125-270 CIF for calcined magnesia (industrial).

3.0 SURFACE MINING SCENARIOS

3.1 INTRODUCTION

The two base case scenarios selected for opencut mining evaluation only differ in the required tonnage output from the mining operations. The options are:

Option A - 600 000 tonnes of raw lump magnesite product per year

Option B - 1 000 000 tonnes of raw lump magnesite product per year

The mining operation envisaged is a conventional open pit bench mining method with broken ore and waste being excavated using front end loaders and trucks. Owing to environmental considerations some modifications would be made to conventional mining practice to reduce the impact of the mine. As part of the preliminary open pit design the following assumptions have been made:

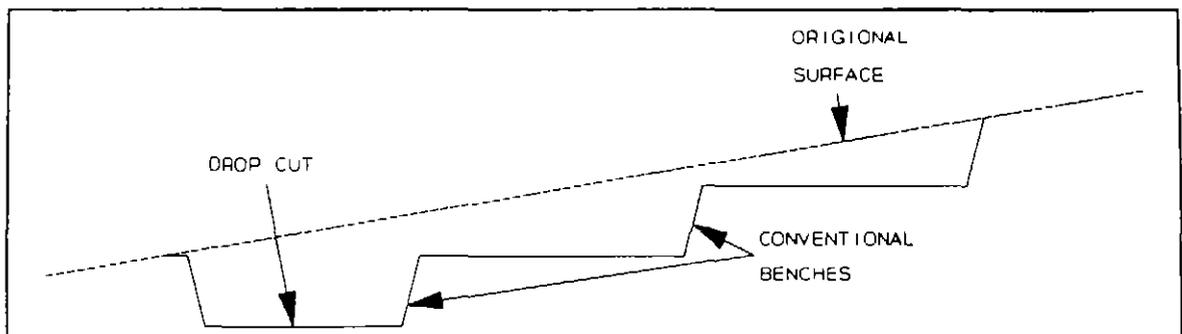
- No significant amount of soil/subsoil is present. Any present would be removed and dumped separately.
- The orebody extends along strike for 600 m and across strike for 200 m.
- All rock between surface and 50 m depth is unsuitable for use (high silica content) and is dumped to waste.
- Pit slopes of 50° have been used throughout.
- Of the ore body below 50m from surface 50% is dolomite or poor grade magnesite and is dumped to waste.

3.2 PRESTRIPPING

The prestripping of the deposit has been assessed to allow a timely and efficient lead into mine production. At the end of the prestripping phase an in-pit inventory of five months supply of ore would be exposed ready for production. This requirement determines the area to be initially excavated. Once tree clearing and soil has been removed from the designated area, drill and blast benches would be established. At an early stage the lowest bench would be established as a drop cut in order to prevent broken rock and soil being pushed outside the limits of the pit, and mine water from leaving the pit without being pumped to settling ponds to remove suspended matter.

Figure 3 shows this diagrammatically. Conventional open pit mining techniques would be used to extend the benches progressively lower. As the pit progresses a haulroad is incorporated into the design to allow waste rock to be hauled from the site. The pit would continue down until it reached an elevation where the purity of the ore is sufficient to allow the mining of an economic product (50 m below surface). Ore from a box cut would be stockpiled adjacent to the crushing and screening plant for use in the first year of production.

Figure 3.1
Section Through Pit Showing Reversed Bench



3.3 MINING

This would consist of a continuation of the bench system established during the prestripping operation and would progress deeper as required. As stated above it has been assumed that 50% of the orebody would be mined as ore with the remainder being sent to the waste dumps. It has been anticipated that the distinction between ore and waste would be made on a visual basis and that selective mining would take place. Accordingly the size of loading and haulage equipment has been limited to allow a degree of selective mining. Dependent upon further work it may be feasible to increase the size of the equipment thus reducing the number of units required. It is anticipated that 85 tonne capacity trucks will be loaded by 5 m³ capacity front end loaders.

3.4 HAUL ROADS AND WASTE DUMPS

A major factor in the design of the open pit will be in the location of the haulroads and waste dumps. In the steep terrain of the Lyons River area it will prove difficult to find a suitable location which will allow easy access and a stable dump site.

Consideration will also be required to prevent runoff from any of the dumps from entering a local water source. A potentially suitable location has been found for the establishment of the three waste dumps (waste rock, soil and undersize ore) at the head of the Pinner Creek valley, 2.5 km south-west of the open pit. Adequate measures could then be put into place to prevent runoff from the dumps causing pollution of the local water sources. This location would also be suitable for two other reasons.

- The flatter areas to the south and west of the dump site could be a suitable site for the location of the crushing and screening plant. The reject material would then be close to the dump location.
- Since the product is to be shipped from the site in trucks via the Savage River Mine Pipeline road, it would be necessary to construct a haul road near this location. From the dump location the remaining road to the pipeline road is only approximately 4 km with the majority of this being over fairly gently undulating terrain.

The haul roads to the waste dump/crushing plant area were designed to traverse the steep terrain in an efficient manner. The haul road profile established is shown in Table 3.1 below.

Table 3.1 : Haulroad Profile

| Leg | Start Point | End Point | Length (m) | Gradient (%) |
|-----|-------------|---------------|------------|--------------|
| 1 | Edge of Pit | Lyons River | 700 | -10 |
| 2 | Lyons River | Dump Location | 2 000 | +7.5 |
| 3 | Onto Dump | - | 500 | 0 |

In addition to this profile the haul includes a leg to get into and out of the pit. This leg varies and an estimate has been made of the average for each location.

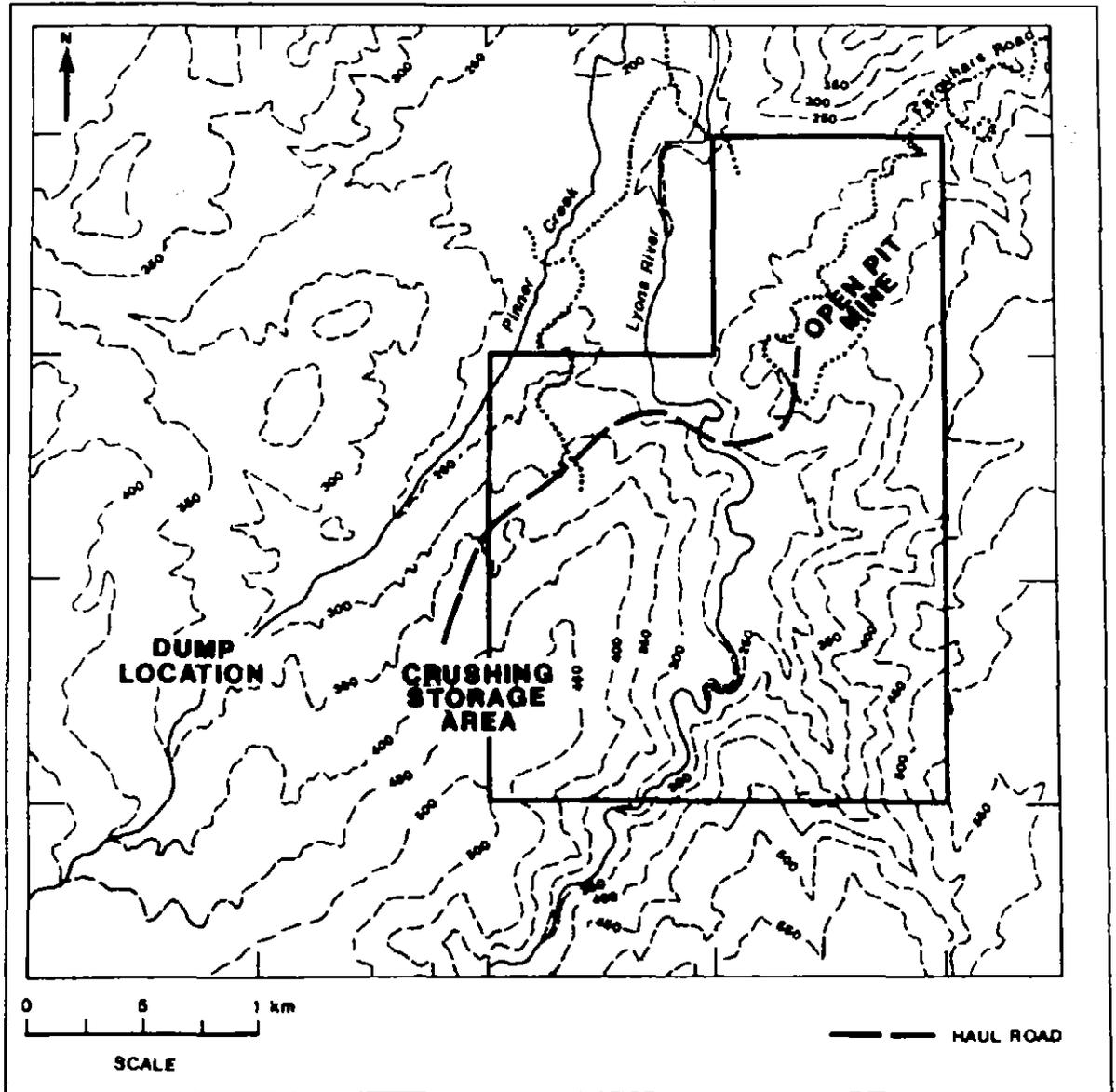
A simulation of the haulage from the mine was made using Caterpillar's VEHSIM computer simulation package. Inputs into this program include:

- Haulage profile, including road length, condition and grade
- Truck type (with customisation if required)
- Loading, dumping and manoeuvring times and efficiencies
- Volume ore/waste movement by periods

The output from the program includes the number of truck hours required and thus the number of units to handle the assigned task.

Figure 3.2 shows the possible haulroad mine and dump location.

Figure 3.2
General Arrangement of Haul Road and Dump Location



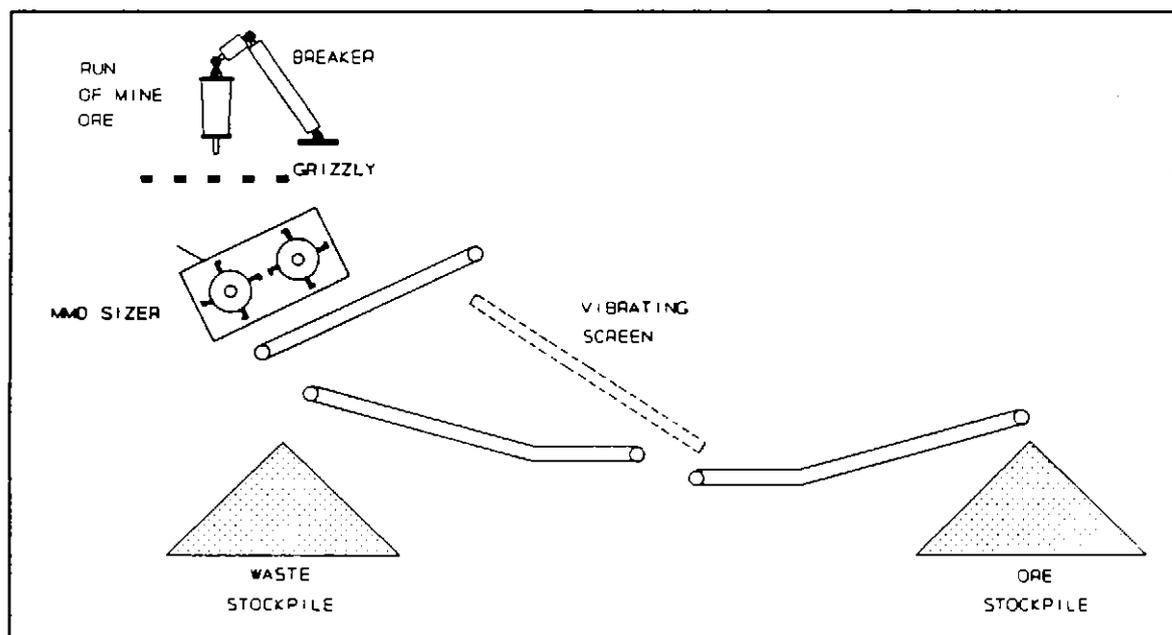
3.5 CRUSHING AND SCREENING PLANT

The crushing and screening plant would be located adjacent to the waste dump area. This provides two advantages:

- The undersize fraction (-20 mm) which makes up 25% of the crusher feed is close to the dump to be used for disposal, thus minimising rehandling costs.
- The product (+20 mm -75 mm) can be stockpiled on relatively flat ground prior to shipment from the site.

The crushing and screening plant would consist of a grizzly/breaker system ahead of a crusher. The crusher may be of the MMD Sizer type which minimises the amount of undersize material produced. The product from the sizer would be passed over a vibrating screen set to 20 mm with each product being stockpiled separately. The oversize material would then be loaded from the open stockpile by front end loader onto the road transport vehicles for transport from the site. Figure 3.3 shows a schematic diagram of the crushing screening and storage system. Undersize material would be periodically hauled from its stockpile to the adjacent dump site for disposal.

Figure 3.3
Schematic Diagram of Crushing, Screening and Storage Plant



3.6 OPTION A - 600 000 TONNES ORE PER YEAR CASE

Three stage pits were created to simulate the operation of mine over the first 20 years of operation. The total required productions are shown in Table 3.2 below.

Table 3.2 : Option A - Stage Pits

| Stage | Volume Ore Mined (bcm x 1 000) | Volume Waste Mined (bcm x 1 000) |
|--------------|-----------------------------------|-------------------------------------|
| Prestrip | - | 3 080 |
| Years 1 - 10 | 2 860 | 22 550 |
| Year 11 - 20 | 2 860 | 13 560 |

bcm : bank cubic metre (in situ volume)

Dependent upon the conditions and equipment available for the mining operation it may be viable to mine the prestrip waste over a period in excess of one year.

A schedule of mining for the open pit is shown in Table 3.3. The prestrip is assigned to take place in year -1 with site access being established in year -2. The capacity of the mining equipment selected should enable prestripping to take place in one year. The total volume of material to be dumped to is 40.6 million bcm over the first 20 years of production which equates to a total dump volume of 65 million loose cubic meters (lcm).

Three sizes of trucks (Caterpillar 769C, 773B, and 777B) were selected for evaluation using the VEHSIM program. Table 3.4 below shows the results for the selected truck, the Caterpillar 777B, 85 tonne capacity trucks. The selection of this size of truck was made as a compromise between the number of units required on site and the size of equipment allowing relatively selective mining.

Table 3.3 : Option A - Schedule of Production

| | YEAR -1 | YEAR 1-10 | YEAR 11-20 |
|--|---------|-----------|------------|
| PRESTRIP (000's bcm) | 3 082 | | |
| ORE MINED (000's TONNES) | | 800 | 800 |
| ORE MINED (000's bcm) | | 286 | 286 |
| ORE TRANSPORTED (000's TONNES) | | 600 | 600 |
| ORE TRANSPORTED (000's bcm) | | 214 | 214 |
| WASTE ORE - UNDERSIZE MATERIAL (000's TONNES) | | 200 | 200 |
| WASTE ORE - UNDERSIZE MATERIAL (000's bcm) | | 71 | 71 |
| WASTE MINED (000's bcm) | | 2 255 | 1 350 |
| TOTAL MINED (000's bcm) | 3 082 | 1 636 | 2 541 |
| STRIPPING RATIO WASTE : ORE (OVERSIZE + UNDERSIZE) | - | 7.9 | 4.7 |
| STRIPPING RATIO WASTE : ORE (OVERSIZE) | - | 10.5 | 6.3 |
| WASTE TO DUMP (000's bcm) | 3 082 | 2 326 | 1 421 |

Table 3.4 : Required Annual Operating Hours for Caterpillar 777B Truck

| Stage | Annual Truck Operating Hours for Waste | Annual Truck Operating Hours for Ore | Units Required |
|--------------|--|--------------------------------------|----------------|
| Prestrip | 45 700 | - | 11 |
| Years 1 - 10 | 39 500 | 4 400 | 11 |
| Years 11 + | 21 500 | 4 600 | 7 |

No direct allowance has been made in these calculations for the haulage and dumping of 200 000 t of undersize product per year. It has been estimated that this would add approximately 350 hours to the annual truck operating hours.

An analysis of the load and haul cycle and the size of truck suggest that the appropriate loader is in the 5.5 m³ class and the Caterpillar 988B has been selected for all options. Table 3.5 shows the type and number of major equipment selected for open pit mining in Option A.

Table 3.5 : Option A - Major Equipment Requirement

| Equipment Type | Number of Units (including spares) |
|-----------------------------------|------------------------------------|
| Tamrock Zoomtrak DHA600S | 2 |
| Caterpillar 777B Truck | 13 |
| Caterpillar 988B Front End Loader | 4 |
| Caterpillar 14G Grader | 1 |
| Caterpillar D8N Dozer | 1 |

3.7 OPTION B - 1 000 000 TONNES ORE PER YEAR CASE

Four stage pits were created to simulate the operation of the mine over the first 18 years of production. Table 3.6 shows the total volumes concerned.

Table 3.6 : Option B - Stage Pits

| Stage | Volume of Ore Mined (bcm x 1 000) | Volume of Waste (bcm x 1 000) |
|---------------|--------------------------------------|----------------------------------|
| Prestrip | - | 4 830 |
| Years 1 - 6 | 2 860 | 20 800 |
| Years 7 - 12 | 2 860 | 13 560 |
| Years 13 - 18 | 2 860 | 20 640 |

The schedule of mining for the open pit for the first 20 years is shown in Table 7. In order to reduce the initial equipment requirement for prestripping, this operation has been spread over years -1 to -2.

Table 3.7 also indicates that the total volume of waste that must be catered for on the dump is 69 million bcm which equates to a dump volume of 110 million lcm. The total annual operating hours for the selected truck (777B) was also calculated and is shown in Table 3.8 below. The number of units required to achieve this target is also shown. Again no direct allowance has been made for the rehandling of the undersize material between the crushing station and the waste dump. It has been estimated that this will add an additional 600 hours to the annual truck operating hours.

3-7
Table 7: Option B - Schedule of Production

| | YEAR -2 | YEAR -1 | YEAR 1-6 | YEAR 7-12 | YEAR 13-20 |
|--|---------|---------|----------|-----------|------------|
| PRESTRIP (000's bcm) | 886 | 3 942 | | | |
| ORE MINED (000's TONNES) | | | 1 333 | 1 333 | 1 333 |
| ORE MINED (000's bcm) | | | 476 | 476 | 476 |
| ORE TRANSPORTED (000's TONNES) | | | 1 000 | 1 000 | 1 000 |
| ORE TRANSPORTED (000's bcm) | | | 357 | 357 | 357 |
| WASTE ORE - UNDERSIZE MATERIAL (000's TONNES) | | | 333 | 333 | 333 |
| WASTE ORE - UNDERSIZE MATERIAL (000's bcm) | | | 119 | 119 | 119 |
| WASTE MINED (000's bcm) | | | 3 466 | 2 260 | 3 473 |
| TOTAL MINED (000's bcm) | 886 | 3 942 | 3 942 | 2 736 | 3 919 |
| STRIPPING RATIO WASTE : ORE (OVERSIZE + UNDERSIZE) | - | - | 7.3 | 4.8 | 7.2 |
| STRIPPING RATIO WASTE : ORE (OVERSIZE) | - | - | 9.7 | 6.3 | 9.6 |
| WASTE TO DUMP (000's bcm) | 886 | 3 942 | 3 562 | 3 585 | 3 585 |

Table 3.8 : Required Annual Operating Hours for Caterpillar 777B Truck

| Stage | Annual Truck Operating Hours for Waste | Annual Truck Operating Hours for Ore | Units Required |
|---------------|--|--------------------------------------|----------------|
| Prestrip | 71 100 | - | 17 |
| Years 1 - 6 | 53 400 | 7 300 | 15 |
| Years 6 - 12 | 35 900 | 7 600 | 10 |
| Years 13 - 20 | 56 200 | 7 800 | 15 |

In order to reduce the size of the prestripping fleet this operation would be carried out over a period in excess of one year.

As in Option A the loader selected for this operation is a Caterpillar 988B. Table 3.9 shows the type and number of major mining equipment selected for open pit mining in Option B.

Table 3.9 : Option B - Major Equipment Requirement

| Equipment Type | Number of Units (including spares) |
|-----------------------------------|------------------------------------|
| Tamrock Zoomtrak DHA600S | 3 |
| Caterpillar 777B Trucks | 18 |
| Caterpillar 988B Front End Loader | 5 |
| Caterpillar 16G Grader | 1 |
| Caterpillar D8N Dozer | 1 |

3.8 CALCINED MAGNESIA OPTIONS E AND F

With the calcined magnesia option no appreciable difference occurs at the open pit and crushing stage. This is because:

- (a) The mine production (total ore and waste) is unchanged.
- (b) The distance between the crushing/screening plant and the dump is small, thus having little difference in the rehandling of crushed undersize material.

Within the crushing and screening plant there is a 13% increase in the amount of ore (over 10 mm in size) than before and a corresponding 40% reduction in the undersize (under 10 mm in size) rock to be handled.

Thus option E is equivalent to option A and option F is equivalent to option B in terms of the open pit mining, with no appreciable difference in the mine equipment required.

4.0 UNDERGROUND MINING SCENARIOS

4.1 INTRODUCTION

As with the open pit scenarios the two options for the underground mining of the Lyons River deposit are for the following production rates:

Option C - 600 000 tonnes of raw lump product from the mine per year.

Option D - 1 000 000 tonnes of raw lump product from the mine per year.

From the information available, the underground mining method selected for evaluation of each option is sub level open stoping. The general requirements for this mining method to be successfully employed are as follows:

- Competent country rock
- Competent orebody
- Wide, steeply dipping and relatively regular orebody
- Grade distribution suitable for bulk mining.

From the information studied the Lyons River deposit should meet all of the above criteria.

The ore extracted from the stopes is hauled by Load, Haul and Dump (LHD) units to an adjacent underground crushing plant where it is crushed to the required product size (-75 mm +20 mm) and screened. The undersize material which makes up 25% of the total crusher throughput is removed and dumped in old stopes by underground truck whilst the ore is transported by conveyor to the surface. It has been assumed that an underground stockpile system will be employed utilising an old stope. This will reduce the requirement for stockpiling of ore on the surface, reducing it to a surge capacity of 250 tonnes.

4.2 UNDERGROUND MINING METHOD

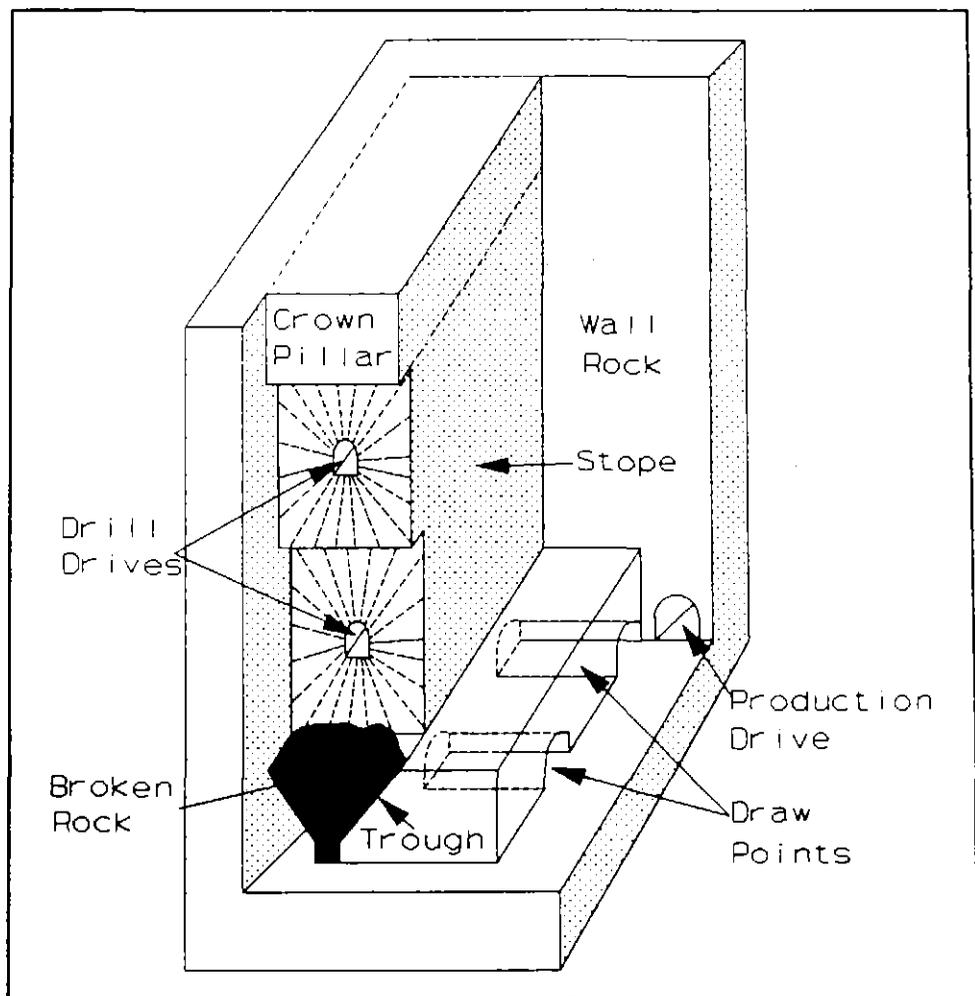
4.2.1 Introduction

Preliminary geological estimates have suggested that the resource may consist of 2 million tonnes per vertical metre of ore grading over 40% magnesite. This massive resource that extends along strike a length of over 2 km and over 200 m wide may contain high grade ore which would be the target for underground mining. As part of this study it has been assumed that the ore to be mined accounts for 230 000 tonnes per vertical metre.

4.2.2 Sub Level Open Stoping

The proposed mining method, sub level open stoping, would result in the extraction of 60% of the nominated ore block with the remainder being in rib and crown pillars for the permanent support of the underground workings. Figure 4.1 below shows a schematic layout of the mining method.

Figure 4.1
Sub Level Open Stoping



With sub level open stoping rings of holes are drilled from each of the drill drives and from the trough at the bottom of the stope. The ore is successively blasted with the broken ore gravitating to the bottom of the stope. Initially a slot is created at the end of the stope to create a free face to blast into. The broken ore is extracted from the stope through drawpoints which connects with the production drive. The production drive is located some distance into the country rock side wall. The depth of the

holes from the ring drill drives is dependent upon the size and nature of the orebody. They can either be drilled to a predetermined length or to a grade/geology cut off.

The ore is extracted from the draw point using mobile diesel powered LHD units which carry the ore to an adjacent crushing and screening plant.

Below is a list of the basic parameters of the mining method:

- Stope size 25 m wide, 100 m long by 50 m high
- Crown pillar 15 m thick
- Rib pillar 30 m between stopes
- Overall extraction ratio 60%
- Major levels 65 m apart
- Sub levels 20 m apart
- 300 000 tonnes per stope

4.3 CRUSHING, SCREENING AND ORE STORAGE SYSTEM

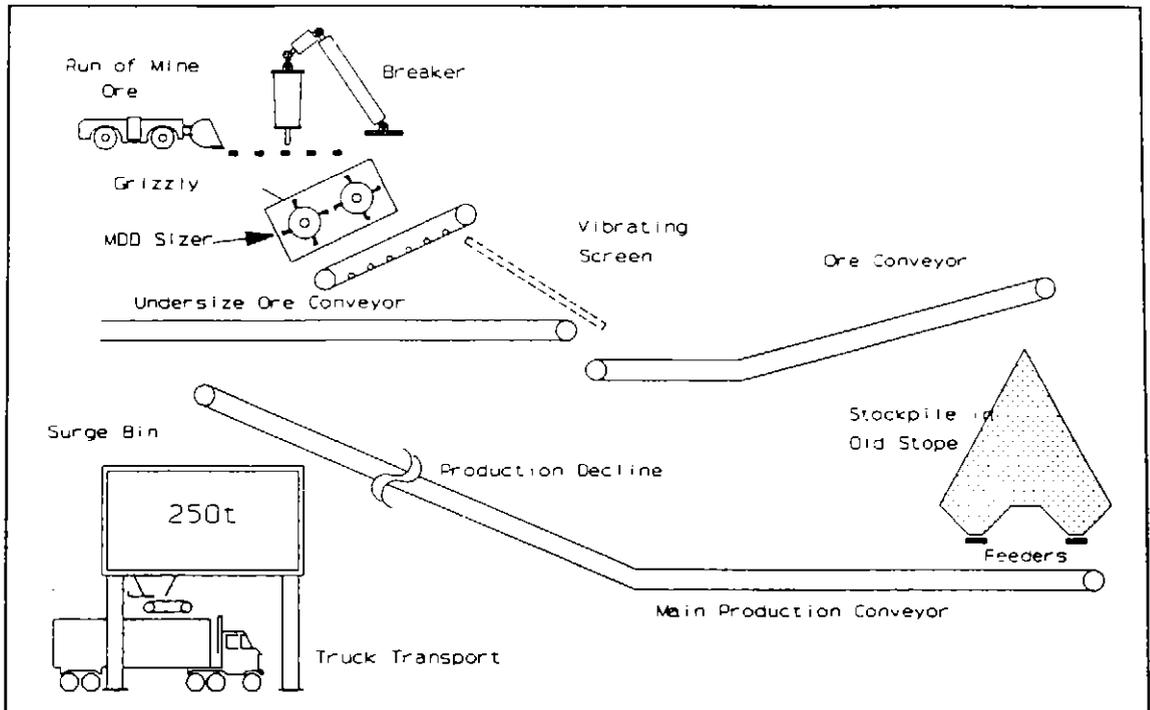
The crushing and screening plant is designed to be semi-mobile enabling it to be periodically moved. This allows the haulage distance between the production stopes and the crusher to be minimised, increasing the LHD haulage productivity.

Figure 4.2 shows a schematic view of the crushing screening and ore transport plant. The LHD unit tips onto a grizzly which prevents rock in excess of 600mm in size from passing through. Oversize rock is broken using an hydraulic rock breaker. The rock is then fed into an MMD sizer where it is reduced to the required size in one pass. The MMD sizer was selected for two reasons:

- It is compact in size and suitable for mounting as a semi-mobile unit underground.
- The product size distribution of the sizer is such that fines (material under 20 mm) are kept to a minimum.

The output from the sizer is conveyed to a vibrating screen set to 20 mm. Undersize material is conveyed to an undersize stockpile for later dumping in an old stope. It is transported to these old stopes by articulated dump truck.

Figure 4.2
Crushing Screening and Schematic Diagram Storage System



The oversize rock from the vibrating screen (which makes up 75% of the feed to the crusher) is taken by a steep angled conveyor to an old stope which has been set aside as an underground stockpile. Reclaim tunnels and feeder arrangements are situated in existing drawpoints. This will allow a considerable tonnage to be stored underground whilst the use of an old stope will reduce the capital cost of such a system.

From the underground stockpile ore is extracted by a feeder/conveyor system and conveyed to the surface by the conveyor installed in a decline. The conveyor discharges into an above ground bin of 250 tonne capacity. This bin loads the on road haulage trucks which are used to transport the ore to the facilities at Port Latta. The size of the bin allows a surge capacity and enables the main production conveyor to be operated more efficiently.

The use of a crushing, screening and stockpiling facility underground enables the surface facilities to be kept to a minimum, resulting in better surface environmental conditions and avoids several potential problems. The use of the old stopes for both waste disposal and the disposal of undersize material alleviates the requirement for the construction and maintenance of major surface waste dumps.

4.4 OPTION C - 600 000 TONNES ORE PER YEAR

Estimates have been made of the type and size of equipment used underground along with the required production/development schedules appropriate to a mine using sub level open stoping as the mining method and shipping 600 000 tonnes of ore per year. Table 4.1 shows a schedule of production and development over the first twenty years of the mine's life. The resource available within the deposit far exceeds the ore mined in the twenty year period, however from an economic viewpoint these initial years are most important with regard to project viability. At an assumed reserve value of 230 000 tonnes per vertical metre the initial main production level is exhausted after 10 years and so the schedule includes the establishment of a lower working level. With the 75% (-75 mm +20 mm) and 25% (-20 mm) split between the crushed product, a total of 800 000 tonnes of ore requires to be mined per year. The source of this ore is shown in Table 4.2 below:

Table 4.2 : Location of Ore Production

| Source | Tonnage (kt) | Percentage of Total (%) |
|--------------------|--------------|-------------------------|
| Primary Production | 668 | 83.5 |
| Trough Production | 88 | 11.0 |
| Development | 44 | 5.5 |
| TOTAL | 800 | 100.0 |

Allowance has been made for the various types of development (capital and operating) within a mine of this size along with necessary excavations for crusher chambers, workshops, etc.

The preproduction period has been used to allow all necessary development to take place, to allow an ordered commencement of a sustainable production. During this period ore produced would be stockpiled for later use.

In order to achieve this required production rate the major capital underground equipment has been sized. In some cases these are similar (in both size and number of units) to those selected in the 1 000 000 tonnes per year case with just the duty of the unit varying. Further studies could modify the chosen size and number of units to maximise the utilisation, however at this stage it is not justified.

Table 4.3 below shows the major mobile and semi-mobile equipment used in the underground mine. Ancillary and miscellaneous equipment has been excluded.

Table 4.1 : Option C - Production and Development Schedule

| | YEAR -3 | YEAR -2 | YEAR -1 | YEAR 1 | YEAR 2 | YEAR 3 | YEAR 4 | YEAR 5 | YEAR 6 | YEAR 7 | YEAR 8 |
|-------------------------------------|---------|---------|---------|--------|--------|--------|--------|--------|--------|--------|--------|
| PRODUCTION | | | | | | | | | | | |
| STOPE PRIMARY PRODUCTION (Kt) | | | 111 | 557 | 668 | 668 | 668 | 668 | 668 | 668 | 668 |
| STOPE TROUGH PRODUCTION (Kt) | | | 15 | 73 | 88 | 88 | 88 | 88 | 88 | 88 | 88 |
| DEVELOPMENT ORE (Kt) | | | 7 | 37 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| TOTAL ORE PRODUCED (Kt) | | | 133 | 667 | 800 | 800 | 800 | 800 | 800 | 800 | 800 |
| ORE LOST AS FINES (Kt) | | | 33 | 167 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| FINAL PRODUCTION (Kt) | | | 100 | 500 | 600 | 600 | 600 | 600 | 600 | 600 | 600 |
| DEVELOPMENT (NON CAPITAL) | | | | | | | | | | | |
| ORE DEVELOPMENT (m) | | | | 1 040 | 1 040 | 1 040 | 1 040 | 1 040 | 1 040 | 1 040 | 1 040 |
| LATERAL WASTE DEVELOPMENT (m) | | | | 1 400 | 1 400 | 1 400 | 1 400 | 1 400 | 1 400 | 1 400 | 1 400 |
| VERTICAL WASTE DEVELOPMENT (m) | | | | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 |
| DEVELOPMENT (CAPITAL) | | | | | | | | | | | |
| PRODUCTION DECLINE (m) | 200 | 700 | | | | | | | | 300 | 300 |
| SERVICE DECLINE (m) | 200 | 700 | | | | | | 300 | 300 | | |
| INTERNAL RAMPS (m) | | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 |
| ACCESS TO VENTILATION SHAFTS (m) | | 1 000 | 1 000 | | | | | | | | 1 000 |
| OREBODY ACCESS (m) | | 400 | 400 | 400 | | | | | | 400 | 400 |
| VENTILATION SHAFTS (m) | | | 300 | | | | | | | | 200 |
| CRUSHER/WORKSHOP EXCAVATIONS (cu m) | | 2 000 | 2 300 | | | | | | | | 2 000 |
| PREPRODUCTION DEVELOPMENT (m) | | | 1 000 | | | | | | | | |

| YEAR 9 | YEAR 10 | YEAR 11 | YEAR 12 | YEAR 13 | YEAR 14 | YEAR 15 | YEAR 16 | YEAR 17 | YEAR 18 | YEAR 19 | YEAR 20 | TOTAL |
|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-------|
|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-------|

| | | | | | | | | | | | | |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|
| 668 | 668 | 668 | 668 | 668 | 668 | 668 | 668 | 668 | 668 | 668 | 668 | 13 725 |
| 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 88 | 1 428 |
| 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 714 |
| 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 800 | 15 867 |
| 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 3 967 |
| 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 600 | 11 900 |

| | | | | | | | | | | | | |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| 1 040 | 1 040 | 1 040 | 1 040 | 1 040 | 1 040 | 1 040 | 1 040 | 1 040 | 1 040 | 1 040 | 1 040 | 19 760 |
| 1 400 | 1 400 | 1 400 | 1 400 | 1 400 | 1 400 | 1 400 | 1 400 | 1 400 | 1 400 | 1 400 | 1 400 | 26 600 |
| 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 150 | 2 700 |

| | | | | | | | | | | | | |
|-------|-----|-----|-----|-----|-----|-----|-----|-----|-------|-------|-----|-------|
| | | | | | | | | 300 | 300 | | | 1 500 |
| | | | | | | 300 | 300 | | | | | 1 500 |
| 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 200 | 4 000 |
| 1 000 | | | | | | | | | 1 000 | 1 000 | | 4 000 |
| 400 | | | | | | | | 400 | 400 | 400 | | 2 400 |
| | | | | | | | | | 200 | | | 500 |
| 2 300 | | | | | | | | | 2 000 | 2 300 | | 8 600 |
| | | | | | | | | | | | | 1 000 |

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Table 4.3 : Option C - Major Mobile/Semi-Mobile Equipment

| Application | Manufacturer | Type | Number of units (including spare) |
|------------------------------|--------------|-----------|-----------------------------------|
| Production drill | Tamrock | 606A | 1 |
| Development drill | Atlas Copco | H127/H128 | 2 |
| Development load, haul, dump | Toro | 300D | 2 |
| Production load, haul, dump | Toro | 300D | 3 |
| Crusher/sizer | MMD | S154 | 1 |
| Waste haulage | Caterpillar | D25D | 1 |

4.5 OPTION D - 1 000 000 TONNES ORE PER YEAR

With the one million tonnes of ore per year option a similar type of operation is envisaged with an accelerated extraction regime. Certain equipment sizes have been increased to reflect the increased duty.

Table 4.4 shows the planned schedule of production and development for this case. The increased rate of extraction of the orebody means that additional levels need to be established at six yearly intervals with a consequential compression of the development program. The ore mined during the preproduction period is stockpiled for use during the first year of production. Consequently, the primary production tonnage for the first year of full operation has been scaled back to allow for the preproduction tonnage. Since the mining method is identical to that put forward in option C, the 600 000 tpa case, the ratio between primary production, trough production and development ore remains the same at 83.5%, 11.0% and 5.5% respectively.

Table 4.4 : Option D - Production and Development Schedule

| | YEAR -3 | YEAR -2 | YEAR -1 | YEAR 1 | YEAR 2 | YEAR 3 | YEAR 4 | YEAR 5 | YEAR 6 | YEAR 7 | YEAR 8 |
|-------------------------------------|---------|---------|---------|--------|--------|--------|--------|--------|--------|--------|--------|
| PRODUCTION | | | | | | | | | | | |
| STOPE PRIMARY PRODUCTION (Kt) | | | 223 | 891 | 1 113 | 1 113 | 1 113 | 1 113 | 1 113 | 1 113 | 1 113 |
| STOPE TROUGH PRODUCTION (Kt) | | | 29 | 117 | 147 | 147 | 147 | 147 | 147 | 147 | 147 |
| DEVELOPMENT ORE (Kt) | | | 15 | 59 | 73 | 73 | 73 | 73 | 73 | 73 | 73 |
| TOTAL ORE PRODUCED (Kt) | | | 267 | 1 067 | 1 333 | 1 333 | 1 333 | 1 333 | 1 333 | 1 333 | 1 333 |
| ORE LOST AS FINES (Kt) | | | 67 | 267 | 333 | 333 | 333 | 333 | 333 | 333 | 333 |
| FINAL PRODUCTION (Kt) | | | 200 | 800 | 1 000 | 1 000 | 1 000 | 1 000 | 1 000 | 1 000 | 1 000 |
| DEVELOPMENT (NON CAPITAL) | | | | | | | | | | | |
| ORE DEVELOPMENT (m) | | | | 1 730 | 1 730 | 1 730 | 1 730 | 1 730 | 1 730 | 1 730 | 1 730 |
| LATERAL WASTE DEVELOPMENT (m) | | | | 2 330 | 2 330 | 2 330 | 2 330 | 2 330 | 2 330 | 2 330 | 2 330 |
| VERTICAL WASTE DEVELOPMENT (m) | | | | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 |
| DEVELOPMENT (CAPITAL) | | | | | | | | | | | |
| PRODUCTION DECLINE (m) | 200 | 700 | | | | | 300 | 300 | | | |
| SERVICE DECLINE (m) | 200 | 700 | | | | 300 | 300 | | | | |
| INTERNAL RAMPS (m) | | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 |
| ACCESS TO VENTILATION SHAFTS (m) | | 1 000 | 1 000 | | | | | 1 000 | 1 000 | | |
| OREBODY ACCESS (m) | | 400 | 400 | 400 | | | 400 | 400 | 400 | | |
| VENTILATION SHAFTS (m) | | | 300 | | | | | 200 | | | |
| CRUSHER/WORKSHOP EXCAVATIONS (cu.m) | | 2 000 | 2 300 | | | | | 2 000 | 2 300 | | |
| PREPRODUCTION DEVELOPMENT (m) | | | 1000 | | | | | | | | |

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| YEAR 9 | YEAR 10 | YEAR 11 | YEAR 12 | YEAR 13 | YEAR 14 | YEAR 15 | YEAR 16 | YEAR 17 | YEAR 18 | YEAR 19 | YEAR 20 | TOTAL |
|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-------|
|--------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-------|

| | | | | | | | | | | | | |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| 1 113 | 1 113 | 1 113 | 1 113 | 1 113 | 1 113 | 1 113 | 1 113 | 1 113 | 1 113 | 1 113 | 1 113 | 22 836 |
| 147 | 147 | 147 | 147 | 147 | 147 | 147 | 147 | 147 | 147 | 147 | 147 | 2 376 |
| 73 | 73 | 73 | 73 | 73 | 73 | 73 | 73 | 73 | 73 | 73 | 73 | 1 188 |
| 1 333 | 1 333 | 1 333 | 1 333 | 1 333 | 1 333 | 1 333 | 1 333 | 1 333 | 1 333 | 1 333 | 1 333 | 26 400 |
| 333 | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 333 | 6 600 |
| 1 000 | 1 000 | 1 000 | 1 000 | 1 000 | 1 000 | 1 000 | 1 000 | 1 000 | 1 000 | 1 000 | 1 000 | 19 800 |

| | | | | | | | | | | | | |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|--------|
| 1 730 | 1 730 | 1 730 | 1 730 | 1 730 | 1 730 | 1 730 | 1 730 | 1 730 | 1 730 | 1 730 | | 32 870 |
| 2 330 | 2 330 | 2 330 | 2 330 | 2 330 | 2 330 | 2 330 | 2 330 | 2 330 | 2 330 | 2 330 | 2 330 | 44 270 |
| 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | 250 | | 4 500 |

| | | | | | | | | | | | | |
|-----|-----|-------|-------|-----|-----|-----|-----|-------|-------|--|--|--------|
| | 300 | 300 | | | | | 300 | 300 | | | | 2 700 |
| 300 | 300 | | | | | 300 | 300 | | | | | 2 700 |
| 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | 350 | | | 7 000 |
| | | 1 000 | 1 000 | | | | | 1 000 | 1 000 | | | 8 000 |
| | 400 | 400 | 400 | | | | 400 | 400 | 400 | | | 4 800 |
| | | 200 | | | | | | 200 | | | | 900 |
| | | 2 000 | 2 300 | | | | | 2 000 | 2 300 | | | 17 200 |
| | | | | | | | | | | | | 1 000 |

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Table 4.5 shows the major mobile and semi-mobile equipment required for the production of one million tonnes of ore per year.

Table 4.5 : Option D - Major Mobile/Semi-Mobile Equipment

| Application | Manufacturer | Type | Number of units (including spare) |
|------------------------------|--------------|-----------|-----------------------------------|
| Production drill | Tamrock | 606A | 1 |
| Development drill | Atlas Copco | H127/H128 | 3 |
| Development load, haul, dump | Toro | 500D | 2 |
| Production load, haul, dump | Toro | 500D | 3 |
| Crusher/sizer | MMD | S154 | 1 |
| Waste haulage | Toro | 35D | 1 |

4.6 CALCINED MAGNESIA OPTION

As with the open pit options there is a negligible difference between the underground mining scenarios when the product is to be calcined. The main differences are:

- A 13% increase in the tonnage of rock to be conveyed to surface.
- A 40% reduction in the tonnage of undersize material (minus 10 mm) to be rehandled and dumped in old stopes.

From each of these differences there may be the opportunity to reduce the size (and duty) of the waste haulage truck, however this is counteracted by the requirement to increase the production conveyor size or duty.

5.0 SURFACE TRANSPORT AND STORAGE

5.1 INTRODUCTION

The remote location of the mine site means that the ore transport element of the project is a major factor in the overall project logistics. The haulage routes that were assessed were:

- A haul road along the side of the Savage River pipeline making use of the existing pipeline maintenance road.
- Upgrading the existing Forestry Commission road to the east of the project site and use of the road through West Takone, Takone and onto the Waratah Highway. From there the route could be along the Bass Highway either west to Port Latta or east to facilities in the Burnie area.

Several factors led to the selection of the former route for evaluation in this study. This route is discussed in more detail below.

5.2 HAULAGE ROUTE

From the mine location a road would be constructed west to intercept the Savage River Mines pipeline. In the case of the underground mining option this would require the construction of approximately 7 km of road and for the open pit mining options approximately 4 km. The difference being due to the envisaged location of the dumps and crushing facilities for the open pit mining options.

The next leg of the haulage route would be a distance of 53 km along the upgrade pipeline maintenance road which runs adjacent to the pipeline throughout its length. The present condition of the road is not adequate for the truck haulage of ore with significant upgrading being required. The existing gravel road has acceptable grades but requires to be widened by approximately 4 m throughout its length. The requirement to consider the trucking of ore at the same time as the use of the pipeline by Savage River Mines dictates that the increase in width must be away from the pipeline. Over the length of the road it has been estimated that this will result in an increase of approximately \$8 million in the capital cost of the road upgrading.

In addition to the general road upgrading there is also the requirement to construct bridges across the Arthur and Black rivers and the provision for the crossing of ten creeks.

At present the pipeline maintenance road is dissected in numerous places by Forestry Commission roads. At each junction gates have been provided to restrict access onto the pipeline road. It will be necessary to reassign the priority of traffic at these junctions to allow continuous travel along the haulage roads.

At a location just south of where the pipeline passes under the Bass Highway a truck discharge station would be constructed. This avoids the need for an interaction between the haulage trucks and traffic using the Bass Highway. The ore would then be conveyed under the Bass Highway into the Port Latta facilities.

5.3 TRUCK HAULAGE

It is envisaged that the ore would be hauled from the mine site to the Port Latta facilities by contractor's vehicles. Consequently, a contract haulage operator was contracted for both the cost of haulage and an indication of the type of vehicles to be used. From the discussions held, the type of vehicle used would be as follows:

- tandem drive truck
- triaxial trailer
- tipper or bottom discharge
- gross weight 41 tonnes
- payload weight 25 tonnes

5.4 STORAGE

As part of the evaluation exercise it has been assumed that separate storage facilities will be provided at the Port Latta site with only the shiploading conveyors and facilities being common to both operators. Accordingly, stockpiling facilities have been allowed for, accepting ore from the dump hopper by conveyor. The use of separate storage facilities at the Port Latta site has obviously increased the cost of the operation when compared with the takeover and use of the Savage River Mines storage facilities after their closure. It has been noted SRM have in fact reduced their previous tonnage. It may be possible to consider the use of one of SRM's existing stockpiles for the ore storage. This should have the effect of reducing the capital cost of providing storage providing that contamination and other concerns can be adequately addressed.

6.0 INFRASTRUCTURE

6.1 INTRODUCTION

The infrastructural requirements of the project largely revolve around the requirements at the mine site. Since it is envisaged that no staff will live on site and that all will commute, the infrastructural requirements have largely been reduced to four main areas. These are dealt with separately below.

6.2 ACCESS

It has been decided that the main commuter access to the mine site should be via existing roads through West Takone. This has been done for the following reasons:

- Access from the east provides a larger population within commuting distance, with Bernie being within range.
- Safer operating conditions apply if commuter traffic is kept clear of the ore haulage road between Port Latta and the mine site.

An allowance has been made within the estimate to improve the condition of the last 5 km of the road between West Takone and the mine site to that suitable for major use in all conditions.

6.3 POWER

Electrical power will be obtained from a new power transmission line between the Savage River Mine and the mine site. It has been assumed that the reduction in capacity of the Savage River Mine will allow sufficient power to be available to operate the site. The transmission line would run adjacent to the slurry pipeline and then east to the mine site, a total distance of 40 km.

6.4 WATER SUPPLY

The mine site is in an area of high rainfall and as such it is not anticipated that there will be any difficulty in obtaining a suitable water supply. Provision has been made within the estimate for the supply and storage of water, though the mine requirements are minimal.

6.5 WASTE WATER CONTROL

Since the processing operation is simple and does not require the use of chemicals it is envisaged that the control of water borne pollution will be aimed at the following:

- Removal of suspended solids
- Removal of oil and debris.

All water produced on the site will be treated, primarily in settling ponds prior to discharge into the local water course.

Diversion channels will be provided to divert surface run off away from the mine and dump locations

7.0 FACILITIES AT PORT LATTA

7.1 INTRODUCTION

The Savage River Mines Port Latta facilities presently consist of the following:

- concentrate thickeners
- pelletising plant
- furnaces
- stockpile/reclaiming facilities
- shiploading equipment
- administration and storage.

Of these the stockpiling and shiploading facilities are potentially of major interest to the study and are dealt with separately below. Though the stockpiling/reclaiming facilities are of interest to the project they have not been used within the study.

7.2 STOCKPILE AND RECLAIM FACILITIES

The stockpiles are equipped with a rail mounted stacker and two electrically powered, two tracked bucket wheel reclaimers with a combined nominal capacity of 3 000 tph. The two stockpile areas have a capacity of 120 000 t each.

7.3 OFFSHORE LOADING FACILITY

The loading facility consists of two 1.372 m shuttle mounted shiploading conveyors, each with a 30.5 m retractable boom and each mounted on a bridge which slews through a 52° horizontal arc. Each conveyor can be shuttled 30.5 m, and the boom elevated 10° or lowered 15°. This arrangement allows the two shiploading conveyors to cover 165 m of the length of a ship at its centreline with one positioning of the ship.

The shiploading facility is 2 km offshore, and provides 15 m of water at low tide. Vessels of up to 114 000 dwt have been accommodated at the facility.

Presently, pellets are conveyed from the stockpile reclaim conveyor on shore to the shiploading conveyors at deep water by a 1.22 m approach conveyor. The pellets are discharged from the approach conveyor onto a two-way chute feeding either of two 42.7 m long cross conveyors which, in turn, discharge onto the two parallel shiploading conveyors. Gates in the two-way chute permit rapid switching to the flow to either the east or west shiploader conveyor.

The shiploading capacity is 2 750 tph. Whilst the existing conveyor system is constructed only for on-loading of vessels, the system could be adapted for offloading also if required for minimal capital investment.

8.0 CALCINED MAGNESIA OPTION

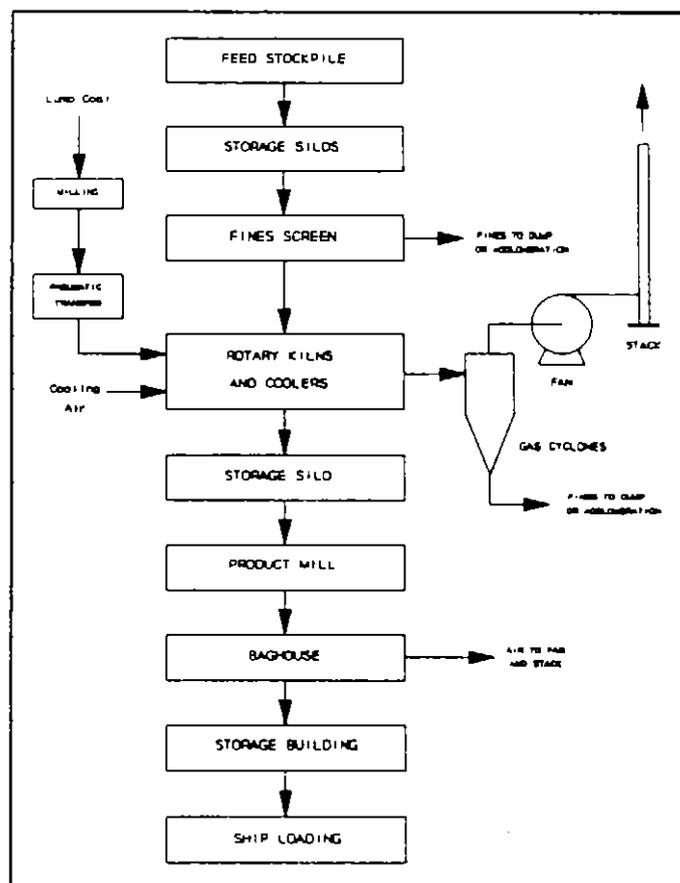
8.1 INTRODUCTION

Two basic options were considered in the production of caustic calcined magnesia. These being:

- 340 000 tpa of caustic calcined magnesia derived from 680 000 tpa of underground or open pit magnesite ore.
- 567 500 tpa of caustic calcined magnesia derived from 1 135 000 tpa of underground or open pit magnesite ore.

A flowsheet was derived for these options and is shown in Figure 8.1. Both options use the same flowsheet, only the equipment sizes (and costs) are altered to treat the different tonnages.

Figure 8.1
Caustic Calcination Process Flowsheet



8.2 PROCESS DESCRIPTION

Below is a process description which specifically relates to the 1.135 Mt magnesite feed producing 567 500 tonnes per year. For the lower production cases (680 000 tonnes feed producing 340 000 tonnes calcined magnesia) the rates described below should be reduced to 60% of the indicated figure.

Run of mine ore, sized at a nominal -75 +10 mm, would be drawn from the port stockpile by the reclaim system used for loading unprocessed ore. An inclined conveyor would then deliver the ore, via a weighscale and tripper car, at a maximum of 400 tph, to one of six storage silos. Each silo would hold 3 000 tonnes of ore, providing a total storage time of up to 130 hours.

Raw ore would be withdrawn from the silos by conveyor and weighscale at a rate of some 140 tph, and delivered to a sizing screen. The screen would divide the ore into more closely sized fractions suitable for kiln feed, and would also remove fines generated during transport and handling. Fines could be returned to the mining area and dumped, or agglomerated and calcined. Screened ore would be delivered to three (two for the lower production rate) rotary calcining kilns.

The rotary kilns would be some 4.0 m diameter and 150 m in length, each rated to treat approximately 50 tph of raw magnesite, depending on sizing. Milled coal would be used to fire the kilns to a temperature of approximately 900° to 950°C, producing a chemically reactive caustic calcined magnesia.

Hot calcine from each kiln would discharge directly into a rotary cooler, where ambient air would be blown in to reduce the calcine temperature and recover sensible heat. Heated air from the coolers would then pass directly to the rotary kilns to be used as combustion air. Cooled calcine would be conveyed to a single storage silo of 1 500 tonnes capacity.

Kiln offgases would be taken to hot gas cyclones to remove fines generated during calcining. Despite the use of a coal with the lowest available ash content, these fines are expected to contain a significant amount of ash, and would best be returned to the mine for disposal. Cleaned gases would be discharged to atmosphere by a single induced draught fan and a 50 m stack.

Calcine would be withdrawn from the silo at 75 tph by conveyor and weighscale, and delivered to the product mill. An air swept roller mill with integral classifier would serve to reduce the lump calcine to a size suitable for market, approximately 80% -100 micron. Milled product would be removed from classifier air by a baghouse and then pneumatically conveyed to storage. Cleaned air would be discharged to atmosphere via the fan and stack.

Milled product would be held in a flat storage building of 50 000 tonnes capacity. Flat storage consists of a sealed portal frame building, fitted with pneumatic feed

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lines at the top, and a fluidising floor and pneumatic transfer system to reclaim the material. A small baghouse and fan are provided in the roof to extract dust and discharge clean air. Operation is largely automated and is controlled from a central control room.

Flat storage offers significantly lower capital costs than conventional storage systems for fine materials.

Shiploading would be carried out by pneumatic conveying. Pneumatic lines would deliver milled material from the storage along the jetty and directly into ships' holds. Dusty air from the holds would be cleaned in a small baghouse located near the shiploader, and the dust delivered back to the ships.

8.3 SERVICES

Lump coal would be taken from the existing stockpile by front-end loader at approximately 100 000 tpa, and delivered to a feed bin. The coal would be milled at a controlled rate and then pneumatically transferred to the kilns for direct combustion.

Electric power for the plant (estimated demand 5 MW) would be drawn from nearby supply via a dedicated sub-station. Process water demands would be small, and process and potable supplies would be drawn from an existing line.

A single large process building has been allowed, fitted with an overhead crane, plus an administration building and a maintenance and warehouse building. A total establishment of some 65 persons has been estimated. Access roads and a car park would be provided, together with a security fence around the site.

9.0 SHIPPING AND MARKETING

9.1 INTRODUCTION

A brief description of the existing shiploading facilities is contained in Section 7, Facilities at Port Latta. Rather than discuss the physical arrangements for shipping and marketing in this section it is aimed at outlining some facts and indicating possible solutions where appropriate.

9.2 SHIPPING

9.2.1 Lump Magnesite

The shipment of lump magnesite provides no particular problem since it can be shipped as a bulk product. Offloading can be effected by grab and dependent upon the ship size this can be accomplished in any bulk handling port. Storage of the product can be in open stockpile providing few storage problems. Since the product is being sold as lump (with fines being removed) it would be advantageous to treat the product with care, though it is geologically massive and not particularly friable.

9.2.2 Calcined Magnesia

The shipment of caustic calcined magnesia poses several more potential problems than its uncalcined counterpart. This is largely due to two of its properties, namely

- Reactive to water though not particularly hygroscopic
- Produced as a ground powder of 100 micron in size.

These combined dictate that the product is stored and transported with care, within covered and in controlled conditions.

To date it appears that all calcined magnesia is bagged and transported as general cargo or in containers. The bags are generally up to 1 tonne in size though 50 kg bags are common. This mode of transport appears to be a function of small size shipments rather than an allowance for the economies of scale.

Since the options studied dictate the shipment of between 340 000 tonnes (options E and G) and 567 500 tonnes (options F and H) per year the optimum method of shipping is in bulk with either pneumatic or closed grab unloading. Indications are that calcined magnesia behaves similarly to cement which is transported and offloaded in this manner.

The alternatives of bulker bags or containers require the use of conventional port facilities and would result in a far higher transport cost.

9.2.3 Shipping Costs

Indications of the cost of shipping the product (lump or powder) as a bulk product have been obtained and are shown in Table 9.1 below.

**Table 9.1 : Bulk Shipping Rates
(excluding loading and unloading costs)
(A\$/tonne)**

| Trade | Bulk * | | | | Container † |
|------------------------|---------|----------|----------|----------|----------------|
| | 5 000 t | 15 000 t | 30 000 t | 50 000 t | |
| Tasmania/ Melbourne | 12.00 | 10.00 | 8.00 | - | 35.00 |
| Tasmania/ Japan | 40.0 | 30.00 | 25.00 | 15.00 | 50.00 |
| Tasmania/ Rotterdam | 50.00 | 40.00 | 36.00 | 18.00 | 80.00 |

* Bulk rates are basis free in/out, ie exclude loading/discharge costs.

† Container rates are inclusive of loading/discharging but a further A\$5.00/tonne should be allowed for packing into the containers.

As can be seen, there is a dramatic reduction in the bulk shipping cost as the size of ship is increased. It was assumed that, for the sake of the study, the size of shipment was 15 000 tonnes.

As part of the study it was assumed that the destinations of the products are shown in table 9.2.

Table 9.2 : Product Destination by Region

| Location | Percentage of Output (%) |
|--------------------|---------------------------------|
| Europe | 40 |
| South East Asia | 40 |
| Mainland Australia | 10 |
| Tasmania (FOB) | 10 |
| TOTAL | 100 |

This results in a composite shipping cost from tables 9.1 and 9.2 of \$29/tonne for the bulk shipping of 15 000 tonne loads.

9.3 MARKETING

9.3.1 Natural Magnesite Market

The total world production of magnesite from natural sources is believed to be in the order of 20 million tonnes with table 9.3 showing the production in 1987 (the latest figures available). In the past control of the level of import into the EEC countries has been effected by the use of anti-dumping legislation which has been specifically aimed at the Chinese producers.

Table 9.3 : World Natural Magnesite Production for 1987

| Country | Production (000 t) |
|--------------------|-----------------------|
| Australia | 54 |
| Austria | 947 |
| Brazil | 650 |
| Canada | 150 |
| China* | 3 400 |
| Czechoslovakia* | 2 500 |
| Greece | 842 |
| India | 420 |
| Korea (DPR)* | 2 500 |
| Nepal | 50 |
| Poland | 22 |
| South Africa | 75 |
| Spain | 550 |
| Turkey | 1 190 |
| USA* | 100 |
| USSR* | 5 000 |
| Yugoslavia | 403 |
| Zimbabwe | 29 |
| WORLD TOTAL | 18 882 |

NB: Figures are mainly derived from the British Geological Survey's "World Mineral Statistics 1983-1987".

* Estimate

9.3.2 Calcined Magnesia Market

The calcined magnesia market is considerably smaller than that of magnesite market with the total world production accounting for only 1 million tonnes per year. This has significant ramifications since the two production rates would account for 34% (option E and G) and 57% (option F and H) of the total world production. There are suggestions that the calcined magnesia market will continue to grow at a significant rate (due to environmental considerations), though the output of these mines must have a significant impact on the market. Consideration should be given to assessing the world production cost curve to assess Lyons River's ability to withstand a significant lowering of the commodity price.

9.3.3 Product Prices

Table 9.4 and 9.5 below shows the latest prices for each of the magnesite products.

**Table 9.4 : Magnesite Product Prices
(from Industrial Minerals, October 1990)**

| Magnesite | £ |
|---|-----------|
| Turkish, raw, max 0.6% SiO ₂ , FOB Marmara | 55 - 70 |
| Calcined, agricultural, CIF | 80 - 90 |
| Calcined (natural), industrial, CIF | 125 - 270 |
| Calcined (seawater), industrial ex-works | 170 - 350 |
| Dead-burned, maintenance, ex-UK works | 125 - 140 |
| Dead-burned, brickmaking, ex-UK works | 150 - 250 |

**Table 9.5 : Chinese Magnesite Product Prices (December 1990)
(25 000 - 50 000 tonne shipments US\$/tonne)**

| Magnesite | I | II | III |
|--|----|-----|-----|
| Raw Magnesite (45-46% MgO) | 35 | 33 | - |
| Caustic Calcined Magnesia (85-88% MgO) | 67 | 70 | 66 |
| Dead Burned Magnesite (92-95% MgO) | 78 | 122 | 175 |

Free on Board Train - Yinkou, Shandong Province

10.0 ENVIRONMENTAL CONSIDERATIONS

The project area is located on Crown Land (designated State Forest), in steeply dissected terrain and supports a dense, wet-sclerophyll eucalyptus association. A description of the vegetation of the mine and plant area, and of the access route is warranted.

The overburden consists of unconsolidated clays and soil. The area is a high rainfall area and rainfall is consistent throughout the year, with an excess of precipitation over evaporation. A simple meteorological station should be established on site to collect data for future feasibility studies.

The mineralogy of the deposit and the process requirements, crushing and screening, indicate that the chemistry of wastes and their disposal are unlikely to be of major concern.

Water management would involve containment of overburden runoff, settlement of solids and discharge of excess clean water. Protection of vegetation along drainage lines, minimising water flow across disturbed areas and provision of proper drainage controls and settlement ponds, will be important from an early stage.

Rehabilitation will need to be addressed during the development stage of the project. Development of the prospect should consider utilising the timber resource. Both development and rehabilitation will need to be undertaken in close consultation with the Forestry Commission.

11.0 CAPITAL COST ESTIMATE

11.1 BASE CASE OPTIONS

11.1.1 Introduction

For this evaluation, the following definition has been used to determine whether elements of work should be categorised as capital or operating cost items.

Capital expenditure items cover the following:

- All works up to the time production commences.
- Major overhaul to plant and equipment.
- Development designed to extend the life of the operation and be used for a period of at least 2 years.

Excluded from the capital cost estimate are the following cost items:

- Owner's engineering and administration
- Owner's feasibility studies
- Site exploration and testing
- Finance
- Marketing and sales
- Land/lease costs
- Royalties and fees
- Insurance
- Commissioning
- Staff/operator training
- Owner's contingencies

All costs generated are in November 1990 Australian dollar terms.

11.1.2 Summary

Table 11.1 shows a summary of the capital expenditure by year for the four base case options.

Table 11.1 : Summary of Capital Expenditure for the Base Case Options

| Year | Capital Expenditure (\$ million) | | | |
|------|----------------------------------|----------|----------|----------|
| | Option A | Option B | Option C | Option D |
| -3 | - | 6.52 | 14.62 | 15.30 |
| -2 | 27.73 | 70.47 | 33.27 | 35.78 |
| -1 | 65.71 | 39.57 | 41.53 | 47.55 |
| 1 | 0.67 | 0.67 | 1.80 | 2.09 |
| 2 | 3.24 | 4.38 | 1.78 | 2.74 |
| 3 | 3.24 | 4.38 | 1.78 | 3.64 |
| 4 | 3.24 | 4.38 | 1.78 | 5.30 |
| 5 | 3.24 | 4.38 | 2.68 | 10.12 |
| 6 | 3.24 | 4.38 | 2.68 | 5.61 |
| 7 | 3.24 | 4.38 | 3.43 | 2.74 |
| 8 | 3.24 | 4.38 | 9.16 | 2.74 |
| 9 | 3.24 | 4.38 | 4.65 | 3.64 |
| 10 | 3.24 | 4.38 | 1.78 | 5.30 |
| 11 | 3.24 | 4.38 | 1.78 | 10.12 |
| 12 | 3.24 | 4.38 | 1.78 | 5.61 |
| 13 | 3.24 | 4.38 | 1.78 | 2.74 |
| 14 | 3.24 | 4.38 | 1.78 | 2.74 |
| 15 | 3.24 | 4.38 | 2.68 | 3.64 |
| 16 | 3.24 | 4.38 | 2.68 | 5.30 |
| 17 | 3.24 | 4.38 | 3.43 | 10.12 |
| 18 | 3.24 | 4.38 | 9.16 | 5.61 |
| 19 | 3.24 | 4.38 | 4.65 | 2.74 |
| 20 | 3.24 | 4.38 | 1.78 | 2.74 |

Option A - 600 000 tonnes per annum ore produced by open pit mining methods.

Option B - 1 000 000 tonnes per annum ore produced by open pit mining methods.

Option C - 600 000 tonnes per annum ore produced by underground mining methods.

Option D - 1 000 000 tonnes per annum ore produced by the mine by underground mining methods.

11.1.3 Option A - 600 000 tpa Case by Open Pit Mining

The first few years of the project are dominated by,

- Site establishment and access. This includes the improvement in the haulage road to Port Latta, the permanent access to the mine and the establishment of haul roads and settling ponds, crushing and ore storage facility.
- Purchase of equipment used for the mining operation.
- Prestripping overburden prior to mining ore.
- Renovation of the Port Latta facilities.

The major costs involved are itemised in Table 11.2.

Table 11.2 : Option A - Initial Capital Expenditure

| Item | Cost (\$m) | Comment |
|----------------------------|-------------|--|
| Access | 26.0 | Upgrading of haulage road to Port Latta and light vehicle access road through West Takone. |
| Power | 4.6 | From the Savage River Mine site. |
| Site Establishment | 8.0 | Including offices etc. |
| Prestripping | 12.2 | |
| Crushing/Ore Storage Plant | 4.7 | |
| Mine Equipment | 30.9 | |
| Port Latta Facilities | 7.0 | |
| TOTAL | 93.4 | |

Once the mine has been established an allowance has been made for ongoing capital requirements, primarily of the mining fleet. This has been taken as a percentage of the initial capital cost on certain items.

11.1.4 Option B - 1 000 000 tpa Case by Open Pit Mining

As with Option A, the capital expenditure in the initial years of the project are dominated by,

- Site establishment and access
- Equipment purchase,
- Prestripping, and
- Renovation of Port Latta facilities.

The major costs involved are itemised in Table 11.3 below.

Table 11.3 : Option B - Initial Capital Expenditure

| Item | Cost (\$m) | Comment |
|----------------------------|------------|--|
| Access | 26.0 | Upgrading of haulage road to Port Latta and light road to West Takone. |
| Power | 4.6 | From the Savage River Mine site. |
| Site Establishment | 11.0 | Including offices etc. |
| Prestripping | 19.0 | |
| Crushing/Ore Storage Plant | 4.7 | |
| Mine Equipment | 41.8 | |
| Port Latta Facilities | 9.6 | |
| TOTAL | 116.6 | |

Once the mine has been established an allowance has been made for ongoing capital requirements, primarily of the mining fleet. This has been taken as a percentage of the initial capital cost on certain items.

11.1.5 Option C - 600 000 tpa Case by Underground Mining

The capital expenditure in the initial years of this project can be broadly divided into the following major headings:

- Site establishment and access. This includes such items as upgrading and extension of the access and haulage roads, clearing of the decline and shaft sites and office/workshop area.
- Major underground developments including decline, level and ventilation shaft development.
- Equipment purchase including major mobile underground equipment and crusher/ore handling system.

The major costs involved are itemised in Table 11.4 which covers the capital expenditure during the preproduction period.

Table 11.4 : Option C - Initial Capital Expenditure Items

| Item | Cost (\$m) | Comment |
|--------------------------|-------------|--|
| Access | 26.0 | Upgrade of haulage road to Port Latta and access road through West Takone. |
| Power | 4.6 | From the Savage River Mine site. |
| Site Establishment | 11.6 | Including offices etc. |
| Mine Development | 21.1 | Up to the start of production. |
| Underground Ore Handling | 11.1 | Including crushing, storage and underground ore handling facilities. |
| Mine Mobile Equipment | 8.0 | |
| Port Latta Facilities | 7.0 | |
| TOTAL | 89.4 | |

Once mining has commenced an allowance has been made for the requirements for ongoing capital requirements including mobile equipment replacement and the establishment of a lower mining level.

11.1.6 Option D - 1 000 000 tpa Case by Underground Mining

The initial capital expenditure for the establishment of the mining operation is similar in nature to those of Option C above.

The major costs are itemised in Table 11.5 which covers the capital expenditure during the preproduction period.

Table 11.5 : Option D - Initial Capital Expenditure Items

| Item | Cost (\$m) | Comment |
|--------------------------|--------------|--|
| Access | 26.0 | Upgrade of haulage road to Port Latta and access road through West Takone. |
| Power | 4.6 | From the Savage River Mine site. |
| Site Establishment | 12.0 | Including offices etc. |
| Mine Development | 23.5 | Up to the start of production. |
| Underground ore handling | 11.1 | Including crushing, storage and underground ore handling facilities. |
| Mine Mobile Equipment | 11.9 | |
| Port Latta Facilities | 9.6 | |
| TOTAL | 98.63 | |

Once mining has commenced an allowance has been made for the requirements for ongoing capital requirements including mobile equipment replacement and the establishment of a lower mining level.

11.2 CALCINED MAGNESIA OPTIONS

11.2.1 Introduction

The capital costs associated with the calcined magnesia option represent a modification in the capital cost of the base case options (A, B, C and D) as follows:

- Refurbishment of the shiploading and bulk reclaimer system no longer required.
- Inclusion of calcining kilns.
- Inclusion of covered bulk storage of the calcined product.
- Inclusion of a fine grinding facility.
- Inclusion of a custom calcined magnesia transport facility.

11.2.2 Summary

Table 11.6 shows a summary of the capital expenditure associated with the four calcined magnesia options.

Table 11.6 : Summary of Capital Expenditure for Calcined Magnesia Options

| Year | Capital Cost (\$m) Option E | Capital Cost (\$m) Option F | Capital Cost (\$m) Option G | Capital Cost (\$m) Option H |
|------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
| -3 | - | 6.52 | 14.62 | 15.30 |
| -2 | 102.61 | 141.83 | 83.42 | 83.35 |
| -1 | 74.41 | 87.13 | 74.96 | 118.90 |
| 1 | 0.67 | 0.67 | 1.80 | 2.08 |
| 2 | 3.24 | 4.38 | 1.78 | 2.74 |
| 3 | 3.24 | 4.38 | 1.78 | 3.64 |
| 4 | 3.24 | 4.38 | 1.78 | 5.38 |
| 5 | 3.24 | 4.38 | 2.68 | 10.12 |
| 6 | 3.24 | 4.38 | 2.65 | 5.61 |
| 7 | 3.24 | 4.38 | 3.43 | 2.74 |
| 8 | 3.24 | 4.38 | 9.16 | 2.74 |
| 9 | 3.24 | 4.38 | 4.65 | 3.64 |
| 10 | 3.24 | 4.38 | 1.78 | 5.30 |
| 11 | 3.24 | 4.38 | 1.78 | 10.12 |
| 12 | 3.24 | 4.38 | 1.78 | 5.61 |
| 13 | 3.24 | 4.38 | 1.78 | 2.74 |
| 14 | 3.24 | 4.38 | 1.78 | 2.74 |
| 15 | 3.24 | 4.38 | 2.68 | 3.64 |
| 16 | 3.24 | 4.38 | 2.68 | 5.30 |
| 17 | 3.24 | 4.38 | 3.43 | 10.12 |
| 18 | 3.24 | 4.38 | 9.16 | 5.61 |
| 19 | 3.24 | 4.38 | 4.65 | 2.74 |
| 20 | 3.24 | 4.38 | 1.78 | 2.74 |

- Option E - 340 000 tpa of calcined magnesia product from an open pit mine.
- Option F - 567 500 tpa of calcined magnesia product from an open pit mine.
- Option G - 340 000 tpa of calcined magnesia product from an underground mine.
- Option H - 567 500 tpa of calcined magnesia product from an underground mine.

11.2.3 Option E - 340 000 tpa Calcined Magnesia by Open Pit Mining

The first few years of the project are dominated by,

- Site establishment and access. This includes the improvement in the haulage road to Port Latta, the permanent access to the mine and the establishment of haul roads and settling ponds, crushing and ore storage facility.
- Construction of the calcining, fine grinding and storage facilities.
- Purchase of equipment used for the mining operation.
- Prestripping overburden prior to mining ore.
- Renovation of the existing Port Latta facilities.

The major costs involved are shown in Table 11.7.

Table 11.7 : Option E - Initial Capital Expenditure

| Item | Cost (\$m) | Comment |
|---|------------|---|
| Access | 26.0 | Upgrading of haulage road to Port Latta and light road through West Takone. |
| Power | 4.6 | From the Savage River Mine site. |
| Site Establishment | 8.0 | Including offices etc. |
| Prestripping | 12.2 | |
| Mine Equipment | 30.9 | |
| Port Latta Facilities | 7.0 | Lump storage. |
| Crushing/Ore Storage Plant | 4.7 | |
| Calcining, fine grinding and storage facilities | 83.6 | |
| TOTAL | 177.0 | |

Once the mine has been established an allowance has been made for ongoing capital requirements, primarily of the mining fleet. This has been taken as a percentage of the initial capital cost on certain items.

11.2.4 Option F - 567 500 tpa of Calcined Magnesia by Open Pit Mining

As with Option E, the capital expenditure in the initial years of the project is dominated by,

- Site establishment and access,
- Equipment purchase,
- Calcining facilities,
- Prestripping, and
- Renovation of Port Latta facilities.

The major costs involved are itemised in Table 11.8 below.

Table 11.8 : Option F - Initial Capital Expenditure

| Item | Cost (\$m) | Comment |
|--------------------------------------|------------|--|
| Access | 26.0 | Upgrading of haulage road to Port Latta and light road to West Takone. |
| Power | 4.6 | From the Savage River Mine site. |
| Site Establishment | 11.0 | Including offices etc. |
| Mine Development | 19.0 | |
| Mine Equipment | 41.8 | |
| Port Latta Facilities | 9.6 | |
| Crushing/ore Storage Plant | 4.7 | |
| Calcining, fine grinding and storage | 118.9 | |
| TOTAL | 235.5 | |

Once the mine has been established an allowance has been made for ongoing capital requirements, primarily of the mining fleet. This has been taken as a percentage of the initial capital cost on certain items.

11.2.5 Option G - 600 000 tpa Case by Underground Mining

The capital expenditure in the initial years of this project can be broadly divided into the following major headings,

- Site establishment and access. This includes such items as upgrading and extension of the access and haulage roads, clearing of the decline and shaft sites and office/workshop area.
- Construction of the calcining, fine grinding and storage facilities.
- Major underground developments including decline, level and ventilation shaft development.

- Equipment purchase including major mobile underground equipment and crusher/ore handling system.

The major costs involved are itemised in Table 11.9 which covers the capital expenditure during the preproduction period.

Table 11.9 : Option G - Initial Capital Expenditure Items

| Item | Cost (\$m) | Comment |
|---|--------------|--|
| Access | 26.0 | Upgrade of haulage road to Port Latta and access road through West Takone. |
| Power | 4.6 | From the Savage River Mine site. |
| Site Establishment | 11.6 | Including offices etc. |
| Mine Development | 21.1 | Up to the start of production. |
| Mine Mobile Equipment | 8.0 | |
| Underground Ore Handling | 11.1 | Including crushing, storage and underground ore handling facilities. |
| Port Latta Facilities | 7.0 | Lump storage. |
| Calcining, fine grinding and storage facilities | 83.6 | |
| TOTAL | 173.0 | |

Once mining has commenced an allowance has been made for the requirements for ongoing capital requirements including mobile equipment replacement and the establishment of a lower mining level.

11.2.6 Option H - 567 500 tpa Case by Underground Mining

The initial capital expenditure for the establishment of the mining operation is similar in nature to those of Option G above.

The major costs are itemised in Table 11.10 which covers the capital expenditure during the preproduction period.

Table 11.10 : Option H - Initial Capital Expenditure Items

| Item | Cost (\$m) | Comment |
|---|--------------|--|
| Access | 26 | Upgrade of haulage road to Port Latta and access road through West Takone. |
| Power | 4.6 | From the Savage River Mine site. |
| Site Establishment | 12.0 | Including offices etc. |
| Mine Development | 23.5 | Up to the start of production. |
| Mine Mobile Equipment | 11.9 | |
| Underground ore handling | 11.1 | Including crushing, storage and underground ore handling facilities. |
| Port Latta Facilities | 9.6 | Lump storage. |
| Calcining, fine grinding and storage facilities | 118.9 | |
| TOTAL | 217.6 | |

Once mining has commenced an allowance has been made for the requirements for ongoing capital requirements including mobile equipment replacement and the establishment of a lower mining level.

12.0 OPERATING COST ESTIMATE

12.1 BASE CASE OPTIONS

12.1.1 Introduction

The operating cost from the four base case options have been estimated by one of two methods. Either:

- (a) By synthesis from first principles estimating equipment and consumable usage and labour requirement for the project.
- (b) From Minenco's in-house database of costs.

As with the capital cost estimate the requirements for the mine were established by undertaking the following steps:

- (a) The conceptual design of the mining method and facilities, making assumptions as required.
- (b) Schedule the operation based upon the conceptual design.
- (c) From the schedule, estimate the size and type of equipment required along with the operating labour to undertake such work.

The operating cost has been defined as the cost of delineating, developing, extracting processing and transporting ore on a day to day level including the normal maintenance of all facilities and equipment. Specifically the operating cost excludes the cost associated with major developments. In the case of the underground mining this includes development which has been estimated will be in use for more than two years. This includes,

- Production and service declines
- Major ore body access
- Ventilation shafts and access to them
- Pumping facilities

All costs are based on November 1990 Australian dollars.

12.1.2 Summary

Tables 12.1 and 12.2 show a summary of the operating cost for the production, transportation, storage and shiploading of lump magnesite from the Lyons River Mine.

Table 12.1 : 600 000 tpa Base Case Operating Cost Summary

| Years | Operating Cost (\$/t)* Option A - Open pit Mining | Operating Cost (\$/t)* Option C - Underground Mining |
|---------|---|--|
| 1 - 6 | 35.25 | 41.50 |
| 11 - 20 | 30.25 | 41.50 |

* Includes the mining, crushing, screening, transport, storage and shiploading of the lump (+20 mm -75 mm) magnesite product.

Table 12.2 : 1 000 000 tpa Base Case Operating Cost Summary

| Years | Operating Cost (\$/t)* Option B - Open pit Mining | Operating Cost (\$/t)* Option D - Underground Mining |
|---------|---|--|
| 1 - 6 | 27.50 | 38.25 |
| 7 - 12 | 24.25 | 38.25 |
| 13 - 20 | 28.00 | 38.25 |

* Includes the mining, crushing, screening, transport, storage and shiploading of the lump (+20 mm -75 mm) magnesite product.

Each case is itemised individually below.

12.1.3 Option A - 600 000 tpa Case by Open Pit Mining

The operating cost for the various elements of work associated with base case Option A are shown below.

Table 12.3 : Option A - Operating Cost by Element

| Item | Cost per tonne of product (\$/t) Yr 1-10 | Cost per tonne of product (\$/t) Yr 11-20 |
|--------------------------|--|---|
| Mining and Processing | 20.25 | 15.25 |
| Magnesite haulage | 9.25 | 9.25 |
| Storage and Ship Loading | 5.75 | 5.75 |
| TOTAL | 35.25 | 30.25 |

12.1.4 Option B - 1 000 000 tpa Case by Open Pit Mining

The operating cost for the various elements of work associated with base case Option B are shown below.

Table 12.4 : Option B - Operating Cost by Element

| Item | Cost per tonne of product (\$/t) Yr 1-10 | Cost per tonne of product (\$/t) Yr 11-20 | Cost per tonne of product (\$/t) Yr 13-20 |
|-----------------------------|--|---|---|
| Mining and Processing | 15.25 | 12.00 | 15.75 |
| Magnesite haulage | 8.50 | 8.50 | 8.50 |
| Storage and Ship Loading | 3.75 | 3.75 | 3.75 |
| TOTAL | 27.50 | 24.25 | 28.00 |

12.1.5 Option C - 600 000 tpa Case by Underground Mining

The operating cost for the various elements of work associated with base case Option C are shown below.

Table 12.5 : Option C - Operating Cost by Element

| Item | Cost per tonne of product (\$/t) Yr 1-20 |
|--------------------------|--|
| Mining and Processing | 26.50 |
| Magnesite haulage | 9.25 |
| Storage and Ship Loading | 5.75 |
| TOTAL | 41.50 |

12.1.6 Option D - 1 000 000 tpa Case by Underground Mining

The operating cost for the various elements of work associated with base case Option D are shown below.

Table 12.6 : Option D - Operating Cost by Element

| Item | Cost per tonne of product (\$/t) Yr 1-20 |
|--------------------------|--|
| Mining and Processing | 26.00 |
| Magnesite haulage | 8.50 |
| Storage and Ship Loading | 3.75 |
| TOTAL | 38.25 |

12.2 CALCINED MAGNESIA OPTIONS

12.2.1 Introduction

The operating costs for the four calcined magnesia options have been obtained in a similar manner to that for the base cases.

12.2.2 Summary

Tables 12.7 and 12.8 show a summary of the operating cost for the production, transportation, storage and shiploading of lump magnesite from the Lyons River Mine.

Table 12.7 : 340 000 tpa Calcined Magnesia Operating Cost Summary

| Years | Operating Cost (\$/t)* Option E - Open pit Mining | Operating Cost (\$/t)* Option G - Underground Mining |
|---------|---|---|
| 1 - 10 | 126.50 | 137.00 |
| 11 - 20 | 117.75 | 137.25 |

* Includes the mining, crushing, screening, transport, calcining, milling, storage and bulk shiploading of the calcined magnesia product. CIF shipping costs have been included.

Table 12.8 : 567 500 tpa Calcined Magnesia Operating Cost Summary

| Years | Operating Cost (\$/t)* Option F - Open pit Mining | Operating Cost (\$/t)* Option H - Underground Mining |
|---------|---|---|
| 1 - 6 | 110.50 | 129.50 |
| 7 - 12 | 104.75 | 129.50 |
| 13 - 20 | 111.25 | 129.50 |

* Includes the mining, crushing, screening, transport, calcining, milling, storage and bulk shiploading of the calcined magnesia product. CIF shipping costs have been included.

Each case is itemised individually below.

12.2.3 Option E - 340 000 tpa Case by Open Pit Mining

The operating cost for the various elements of work associated with calcined magnesia Option E are shown below.

Table 12.9 : Option E - Operating Cost by Element

| Item | Cost per tonne of product (\$/t) Yr 1-10 | Cost per tonne of product (\$/t) Yr 11-20 |
|-----------------------------|--|---|
| Mining and Processing | 40.00 | 26.75 |
| Magnesite haulage | 18.00 | 18.00 |
| Calcining and fine grinding | 33.25 | 33.25 |
| Storage and Ship Loading | 8.75 | 8.75 |
| Shipping CIF | 30.50 | 30.50 |
| TOTAL | 126.50 | 117.75 |

12.2.4 Option F - 567 500 tpa Case by Open Pit Mining

The operating cost for the various elements of work associated with calcined magnesia Option F are shown below.

Table 12.10 : Option F - Operating Cost by Element

| Item | Cost per tonne of product (\$/t) Yr 1-10 | Cost per tonne of product (\$/t) Yr 11-20 | Cost per tonne of product (\$/t) Yr 13-20 |
|-----------------------------|--|---|---|
| Mining and Processing | 27.00 | 21.25 | 27.75 |
| Magnesite haulage | 17.00 | 17.00 | 17.00 |
| Calcining and fine grinding | 30.00 | 30.00 | 30.00 |
| Storage and Ship Loading | 6.00 | 6.00 | 6.00 |
| Shipping CIF | 30.50 | 30.50 | 30.50 |
| TOTAL | 110.50 | 104.75 | 111.25 |

12.2.5 Option G - 340 000 tpa Case by Underground Mining

The operating cost for the mining various elements of work associated with the calcined magnesia case Option G are shown below.

Table 12.11 : Option G - Operating Cost by Element

| Item | Cost per tonne of product (\$/t) Yr 1-20 |
|-----------------------------|--|
| Mining and Processing | 46.50 |
| Magnesite haulage | 18.00 |
| Calcining and fine grinding | 33.25 |
| Storage and Ship Loading | 8.75 |
| Shipping CIF | 30.50 |
| TOTAL | 137.00 |

12.2.6 Option H - 567 500 tpa Case by Underground Mining

The operating cost for the various elements of work associated with the calcined magnesia Option H are shown below.

Table 12.12 : Option H - Operating Cost by Element

| Item | Cost per tonne of product (\$/t) Yr 1-20 |
|-----------------------------|--|
| Mining and Processing | 46.00 |
| Magnesite haulage | 17.00 |
| Calcining and fine grinding | 30.00 |
| Storage and Ship Loading | 6.00 |
| Shipping CIF | 30.50 |
| TOTAL | 129.50 |

13.0 REVERSE ECONOMIC STUDY

13.1 INTRODUCTION

The world trade in magnesite products is not sufficiently reported in the public domain to permit reliable estimates of product prices. The financial model of the magnesite project therefore was used to estimate prices that would yield CRA's minimum rate of return.

As a supplementary exercise the project's value was estimated with prices believed to be near to those that might be expected.

All of the above cases rely on extensive penetration of existing markets and so a "small mine" option was approximated.

13.2 RESULTS

The minimum prices required for the magnesite project to yield an 11.5% real rate of return (using 19.5% tax) after 20 years under the eight options are shown in Table 13.1. The prices are shown in FOB terms and CIF levels can be calculated simply by adding an estimated average freight and insurance cost of A\$30 per tonne. The underlying capital and operating assumptions are included.

In Tables 13.2 and 13.3 the Internal Rates of Return of the project are shown with two sets of prices that are believed to be near the level that might be expected. These prices were set at : \$40 FOB for raw magnesite lump, and
A\$200 FOB for calcined magnesia powder
for the first set of valuations and then at A\$50 FOB and A\$250 FOB respectively for the second and more optimistic set of valuations.

The assumed yields of useable material from the run-of-mine ore were arbitrarily set, and so the impact of reducing yields from the quarry by 15% for both processing routes is shown in Table 13.4.

The results of the small mine approximation in Table 13.5 should be seen as an indication of the minimum prices needed to make a small mine viable.

13.3 DISCUSSION

The results are of a preliminary evaluation of the project and so should be seen as indicative rather than definitive. They indicate that a calcined magnesia project may be viable for CRA if the large volumes of product can be sold in the market without weakening prices.

13.3.1 Reverse Economics

The reverse economics study shown in Table 13.1 indicates that FOB prices of approximately A\$70 per tonne of raw product or A\$190 per tonne of calcined powder are required to achieve CRA's minimum investment criteria. If the market and environmental authorities permit a large open cut mine to be operated then the minimum FOB prices can be reduced to A\$54 and A\$162 respectively. By contrast a less optimistic market and conservative environmental requirement may dictate a smaller underground mine for which the minimum FOB prices would be close to A\$80 and A\$210 per tonne respectively.

We understand that in general these raw magnesite prices are likely to be above present levels, whereas the calcined powder prices may be near to current levels. It is possible that if the Lyons River project was brought on stream and managed to dominate world trade, that existing producers may react to protect their market share by reducing prices. CRA may need to match prices because the Lyons River magnesite is not of special quality and the project's returns would diminish.

13.3.2 Current Price Estimates

The results in Tables 13.2 and 13.3 give the project returns if the large volumes can be sold at what is believed to be current prices. Both sets of prices indicate that the raw magnesite route is below the CRA threshold level, although the large open cut (option B) is in the region of interest. On the other hand the calcined route has an attractive rate of return for both sets of prices, suggesting that further investigation is worthwhile if the marketing assumptions are reasonable.

13.3.3 Lower Screening Yields

Table 13.4 confirms that the yield of useable product from the quarry is a critical variable. The study assumed yields of 75% for the lump magnesite and 85% for the calcined magnesia, but it is possible that testing of the ore may reveal lower yields are more likely. The results of an arbitrary decrease to 60% and 70% respectively are substantial. The raw magnesite options require unrealistically high prices. The calcined magnesia options reduce to prices around what are believed to be present levels, and so would be close to the threshold level of viability.

13.3.4 Small Mine Approximation

The parameters estimated for the small mine are indicative and so the result should be regarded only as a guide. They suggest that a mine producing 100 000 t of raw magnesite product or 50 000 tonnes of calcined powder is not likely to be a satisfactory investment. In both product routes the margin on sales is likely to be small or even negative.

13.4 CONCLUSION

The large scale calcining of Lyons River magnesite may present a satisfactory investment for CRA if the marketing assumptions can be achieved. On the other hand the shipment of raw magnesite is unlikely to be a viable project.

The result generally represents a minimum level of viability over 20 years. CRA may require a higher return over 10 years to offset the perceived risk.

Table 13.1 : Lyons River Magnesite - Minimum Prices Required

| Option | | A | B | C | D | E | F | G | H |
|--|--------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| IRR Real (%) | (19.5% tax) | 11.5 |
| FOB Price Required in 1990 \$ Terms | | | | | | | | | |
| - Lump (10 x 75 mm) product | \$US | 51 | 39 | 56 | 46 | - | - | - | - |
| | \$A | 70 | 54 | 77 | 64 | - | - | - | - |
| - Calcined magnesia powder | \$US | - | - | - | - | 145 | 117 | 154 | 130 |
| | \$A | - | - | - | - | 200 | 162 | 213 | 180 |
| Costs | | | | | | | | | |
| Initial Capital Cost | A\$M | 93.4 | 116.6 | 89.5 | 98.6 | 177.0 | 235.5 | 173.0 | 217.6 |
| Construction Time | Years | 2 | 2 | 3 | 3 | 2 | 2 | 3 | 3 |
| Operating Cost | A\$/t* | 34 | 27 | 42 | 38 | 95 | 80 | 109 | 100 |
| Processing | | | | | | | | | |
| Raw Magnesite | ktpa | 600 | 1 000 | 600 | 1 000 | - | - | - | - |
| Calcined Powder | ktpa | - | - | - | - | 340 | 567 | 340 | 567 |
| Mining Method | | OP | OP | UG | UG | OP | OP | UG | UG |
| Screening Yield | % | 75 | 75 | 75 | 75 | 85 | 85 | 85 | 85 |
| Calcining Loss | | - | - | - | - | 48% | 48% | 48% | 48% |
| Product Loss | | 0% | 0% | 0% | 0% | 4.5% | 4.5% | 4.5% | 4.5% |

* Average \$ real/t product

Table 13.2 : Lyons River Magnesite - Project Returns Using Perceived Lower Prices

| Option | | | | A | B | C | D | E | F | G | H |
|---|------------|-------------------------------|------------|------|-------|------|------|-------|-------|------|-------|
| IRR After 20 Years | | % real | | -ve | -0.1% | -ve | -ve | 11.4% | 18.1% | 9.7% | 15.4% |
| NPV After 20 Years at 11.5% real | | \$M | | -106 | -77 | -116 | -122 | -1 | 113 | -20 | 56 |
| PRICE | FOB | Lump Magnesite | US\$/t FOB | 29 | 29 | 29 | 29 | - | - | - | - |
| | | | A\$/t FOB | 40 | 40 | 40 | 40 | - | - | - | - |
| | | Powdered Calcined Magnesia | US\$/t FOB | - | - | - | - | 145 | 145 | 145 | 145 |
| | | | A\$/t FOB | - | - | - | - | 200 | 200 | 200 | 200 |

Table 13.3 : Lyons River Magnesite - Project Returns Using perceived Upper Prices

| Option | | | A | B | C | D | E | F | G | H |
|---------------------------|-------------------------------|------------|-------|-----|-----|------|-------|-------|-------|-------|
| IRR After 20 Years | % real | | -0.3% | 8.8 | -ve | 0.6% | 18.2% | 25.6% | 16.6% | 23.4% |
| NPV After 20 Years | \$M | | -68 | -21 | -82 | -66 | 89 | 263 | 61 | 190 |
| PRICE FOB | Lump Magnesite | US\$/t FOB | 36 | 36 | 36 | 36 | - | - | - | - |
| | | A\$/t FOB | 50 | 50 | 50 | 50 | - | - | - | - |
| | Powdered Calcined Magnesia | US\$/t FOB | - | - | - | - | 181 | 181 | 181 | 181 |
| | | A\$/t FOB | - | - | - | - | 250 | 250 | 250 | 250 |

Table 13.4 : Lyons River Magnesite - Project Returns with 15% Lower Yields from the Mine

| Option | | | A | B | C | D | E | F | G | H |
|-----------------------------------|-------------------|--|------|------|------|------|------|------|------|------|
| IRR After 20 Years | % real | | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 | 11.5 |
| NPV After 20 Years | \$M | | - | - | - | - | - | - | - | - |
| PRICE FOB Lump Magnesite | US\$/t FOB | | 63 | 49 | 70 | 57 | - | - | - | - |
| | A\$/t FOB | | 87 | 68 | 97 | 79 | - | - | - | - |
| Powdered Calcined Magnesia | US\$/t FOB | | - | - | - | - | 176 | 142 | 187 | 157 |
| | A\$/t FOB | | - | - | - | - | 243 | 196 | 258 | 217 |
| Screening Yield | % | | 60 | 60 | 60 | 60 | 70 | 70 | 70 | 70 |

Table 13.5 : Lyons River Magnesite - Small Mine Approximation

| Raw Magnesite Lump | | | |
|---------------------------------|-----|-------------------------------|---------------|
| | | 10 Yrs | 20 yrs |
| IRR Real | % | -ve | -ve |
| NPV @ 11.5% | \$M | -45 | -50 |
| Assumptions | | | |
| Raw Magnesite | | US\$36/t FOB A\$50/t FOB | |
| Tonnes sold | | 100 000 tpa | |
| Capex | | \$25M | |
| Opex | | \$77/t | |
| Calcined Magnesia Powder | | | |
| | | 10 Yrs | 20 yrs |
| IRR Real | % | -ve | -ve |
| NPV @ 11.5% | \$M | -47 | -44 |
| Assumptions | | | |
| Calcined Magnesia Powder | | US\$181/t FOB A\$250/t FOB | |
| Tonnes sold | | approx 55 000 tpa | |
| Capex | | \$54M | |
| Opex | | \$203/t | |

14.0 ADDITIONAL COMMENTS

14.1 INTRODUCTION

This section has been included as a repository for various thoughts and information which do not form an integral part of this project. It is largely aimed at alternative ideas which may have advantages in capital and/or operating cost terms but for some reason have not formed part of the base case study.

14.2 ALTERNATIVE METHODS OF UNDERGROUND OPERATION

14.2.1 Introduction

Whilst it is believed that sub level open stoping is the most appropriate method of mining for this study there are several alternatives with regard to handling and transportation of the ore. Section 4.0 details a preferred option, primarily on environmental grounds of minimising surface facilities, however, it is likely to be higher in both capital and operating cost terms. Some of the alternatives considered are briefly discussed below. The potential advantages and disadvantages are also indicated.

14.2.2 Surface Stockpile with Trucks Loaded by Front End Loader

This alternative would have the crushed and screened product directly removed from underground by conveyor. It would be dumped on an open surface stockpile from where it would be reclaimed and directly loaded into each truck, as required, by front end loader.

ADVANTAGES

- Probably the lowest capital cost storage option.
- Main storage on surface and therefore less affected by problems with the production conveyor.

DISADVANTAGES

- Higher operating cost.
- Largest area on surface required.
- Fines/waste from the stockpile would need to be controlled.

14.2.3 Surface Stockpile with Reclaim Conveyor

This would consist of a surface stockpile, again being fed by the underground production conveyor. Ore from the stockpile would be extracted by means of feeders in a reclaim tunnel onto a conveyor which would discharge into an above ground bin ready for truck loading.

ADVANTAGES

- All storage is above ground.
- Truck filling can be automated thus reducing the operating cost.

DISADVANTAGES

- Higher capital cost
- Larger surface area required than with FEL reclaiming.

14.2.4 All Ore Conveyed to Surface for Crushing/Screening

This assumes that all ore for development and stoping is conveyed to surface, where it is processed in a conventional crushing and screening plant. Undersize material would then either be dumped on the surface or returned to underground via a system of boreholes.

ADVANTAGE

- Crushing/screening plant not moved throughout the mine's life.

DISADVANTAGE

- Larger production conveyor required.
- More surface facilities on the site.
- More liquid and solid waste to be disposed of.
- Grizzly/breaker required prior to the production conveyor.

14.2.5 Truck Haulage of all Ore to Surface

In this option all ore from the stopes and development is loaded by LHD into low profile articulated dump trucks for transport to the surface via a decline. All processing would take place on the surface with the waste (undersize) material dumped on the surface or being returned to old stopes via a system of boreholes.

ADVANTAGES

- Lower capital cost with preliminary estimates suggesting that two Toro 35D trucks being able to handle 600 000 tonnes per year case (800 000 tpa hauled) and three trucks for the 1 million tonnes per year (1 350 000 tpa hauled).
- All storage on surface.

DISADVANTAGES

- All facilities on the surface.

An initial estimate suggests that this approach may result in a similar operating cost with a reduction in capital cost of \$5.4 million (neglecting the cost of the rehandling of undersize materials).

14.3 USE OF THE SAVAGE RIVER PIPELINE

Should the mining of the Lyons River deposit take place after the closure of the Savage River Mine the existing pipeline could be used for the transport of the ore between the mine site and the Port Latta facilities using magnetite as a transport medium for the lump magnesite. A brief scenario for this is as follows;

- The existing pipeline is diverted to connect between the mine site and Port Latta. The existing pumps at the Savage River mine would be reinstalled at the mine site.
- A second pipeline (possibly of a smaller diameter) would be laid between Port Latta and the mine with a pump set installed at the Port Latta end.
- Lump ore would be mixed with a magnetite water mixture, which acts as the transport medium, for pumping to Port Latta. It has been roughly estimated that this will enable transportation at a rate of 150 tonnes/hour at an operating cost in the order of \$1.80 per tonne.
- At the Port Latta facility simple screening could be used to extract the lump magnesite ore for further processing or direct shipment.
- The transport medium is then pumped back to the mine site in the newly installed return line, either at the existing specific gravity or possibly higher. The capital cost of this option represents an additional cost of \$18.3 million to the project but with the lower operating cost gives a payback period of under 3 years.