PRELIMINARY FEASIBILITY STUDY

FOR A 200,000 TPA

HEAP/VAT LEACH OPERATION

FOR THE GIGANTIC MINE

TENNANT CREEK

Client : Giants Reef Mining Pty Ltd
Date : 25 March 1988
Job No : DO88/015
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INTRODUCTION

Normet was requested by Nick Byrne of Giants Reef Mining to prepare a preliminary feasibility study for establishing a 200,000 tonne vat leach operation at the Gigantic Mine, Tennant Creek.

This study gives a general description of the process and the associated capital and operating costs.

The option selected for project operation includes contract earth-moving, contract crushing and heap/vat construction, contract operating personnel, and supervision.

Costs presented in the report are indicative only and are dependent upon many factors which are yet to be determined.
2 SCOPE

The original scope of the pre-feasibility for the Giants Reef project was to prepare approximate costs involved to establish a vat leach operation.

Design criteria for the study included:

i) Tonnage - 200,000 t

ii) Leaching in 20,000 t vats

iii) Mining and stacking completed within 12 months - assumed

iv) Leach recovery of 75%

v) Head grade - 1.5-2.0 g/t gold

vi) Leaching time 60-70 days

Based on limited metallurgical testwork and previous experience with vat/heap leach operations, two alternative approaches are presented.

a) Heap Leach
   - Continuous mining and stacking
   - Production of a single heap
   - Adsorption/desorption plant designed to treat 200,000 t/annum

b) Vat Leach
   - Four individual vats (50,000 t ea)
   - Adsorption/desorption designed to treat 50,000 t batches.
ADVANTAGES AND DISADVANTAGES OF HEAP AND VAT LEACHING

HEAP LEACHING

Advantages
- Continuous stacking and irrigation
- Minimal earthworks required for pad
- Flexibility to increase heap size
- Good aeration

Disadvantages
- High evaporation losses
- High maintenance of piping and sprinklers through scaling
- Requires more supervision in moving sprinklers and irrigation piping
- Suitable only to material with good percolation properties

VAT LEACHING

Advantages
- Evaporation losses are lower
- Lower maintenance of pipework (no sprinklers)
- Suits material with poor percolation characteristics
- No agglomeration generally required
- Rate of leaching is higher
- Possible to operate a one pond system
Disadvantages

- Substantial earth works necessary
- Higher liner/tonnage ratio
- Larger site area required to accommodate vats
- Poor circulation of solution in vats (difficult to "turn over" residual gold bearing solution)
- Restricted in size once built, ie cannot increase tonnage in vat
4.1 CRUSHING

Preliminary testwork has indicated that the ore requires crushing to minus 12 mm. This will involve a two stage crushing circuit and screens.

No agglomeration is necessary as percolation rates are high.

Lime will be added on to crusher discharge belt for pH conditioning of ore.

4.2 PAD PREPARATION

The pad will be designed to hold 200,000 tonne of ore. Area required totals approximately 27,000 sq m. Clearing will be required and possibly some earth moving and filling to prepare a suitable area for the pad.

A 50 mm layer of fine material will be laid on pad base. On top of this would be laid a PVC membrane. A thickness of 0.46 mm would be suitable as it has excellent physical properties and is proven in the heap leaching industry. To prevent puncturing a fine sand layer is placed on top of membrane and a trafficable surface over fine sand if machinery is to be run on heap.

4.3 HEAP BUILDING

The crushed material would be placed on the heap by an excavator. Trucking of ore from the crusher onto the pad surface would be required.

Compacted material caused by trucks and excavator should be ripped prior to solution application to minimise percolation problems.

The heap would be built to a height of 5 m.
Once the first section of the heap has been formed (approximately 30 m of pad length), irrigation pipes would be laid and spraying commenced. Additional pipes are added as stacking proceeds.

4.4 **IRRIGATION**

Barren solution will be pumped from the barren pond by a centrifugal pump capable of delivering approximately 100 cu m/hr.

- Operating spray area: 9,000 sq m
- Barren application rate: 12 L/sq m/hr
- Pregnant return rate: 9 L/sq m/hr

When the first section of the heap has been under spraying for a period determined by tests, the irrigation piping would be relocated to another section of the pad. Solution is distributed onto the heap by wobbler sprinklers.

4.5 **PONDS**

Three ponds would be required – a barren, pregnant, and storm water catchment pond.

Approximate pond sizes:

- Pregnant pond: 1,000 cu m
- Barren pond: 1,000 cu m
- Stormwater pond: 4,500 cu m

Pregnant and barren pond sizes are calculated on a 10 hour solution retention time.

Pond dimensions:

- Pregnant & barren: 25 x 20 x 2 m
- Stormwater: 50 x 30 x 3 m
The lay out of ponds would be such that excess stormwater overflows pregnant and barren ponds into stormwater pond. Formation of these solution holding ponds requires excavating to specified dimensions, lining with fine sand, and fitting a PVC membrane.

4.6 ADSORPTION

Gold recovery from pregnant solution would be achieved by adsorption onto activated carbon.

The recommended adsorption circuit would be a closed top pressure system comprising approximately four columns in series. Solution is pumped through columns at approximately 75 cu m/hr and discharges into the barren pond.

Adsorption columns would be designed to hold 1,000 kg carbon per column. If stripping is conducted separately, then carbon transfer would be required. This involves coupling of quicklock flexible hoses and hydraulically transporting carbon.

In situ stripping would involve uncoupling one carbon column from adsorption train and recovering gold without removal of carbon or column.

4.7 DESORPTION

Two systems can be considered here:

- Zadra stripping
- AARL stripping

AARL system is proven and has the capability of stripping gold in a short time period. Acid washing, cyanide/caustic pre-treatment, and elution are all carried out in one vessel. Automation simplifies the operation of this system.
The Zadra system has a longer elution time but allows simultaneous stripping and electrowinning. This system can be constructed at lower capital cost but is generally less efficient and requires more supervision than the AARL system.

Both systems produce an electrolyte solution that is circulated through an electrowinning cell and gold recovered onto steelwool cathodes.

Loaded steel wool is removed from the cell and treated to remove iron followed by direct smelting.

Custom stripping is an alternative but will cost approximately $2,600/tonne (includes bullion production).

4.8 REAGENT ADDITIONS

Lime would be dosed onto the crusher product conveyor. This requires a silo and feeder system located adjacent to the conveyor belt.

Cyanide would be mixed and added to the barren pond via a conventional bulker bag handling system.

Either lime or caustic soda will be required for on-going pH control in the barren solution pond.

Antiscalent may be beneficial in reducing line and spray blockages. This would be added to the barren pond also.

4.9 SERVICES

Power Supply

As the Gigantic Mine is some distance from the grid system it would be necessary to install diesel powered generating sets.
To run plant equipment for this scale operation would require a unit greater than 120 kVA.

**Water Supply**

Water make up requirement would be 3 L/sq m/hr or 27 cu m/hr (9,000 sq m).

Plant operation would therefore require approximately 30 cu m/hr water.

A suitable water source would need to be located and provision made to set up a pumping station. This may need a remote power source if water is pumped long distances. All process water would be pumped into the barren solution pond.

If water quality is high then a potable tank for servicing offices, laboratory, and goldroom could be connected to this source.

4.10 **ASSAYS**

Solution assays should be carried out on site as full plant control is then possible. An atomic absorption spectrophotometer and basic cyanide/pH equipment are necessary.

Solid samples require a full time chemist to process, therefore would be better sent to a commercial laboratory. It may be possible to arrange with a nearby mine laboratory to carry out assays.

4.11 **COMMUNICATIONS**

The mine site would require some form of radio/telephone communication with Tennant Creek or Darwin. Most of administration and purchasing would be done from these centres.
4.12 BUILDINGS AND COMPOUNDS

A basic workshop/store would be required to carry out plant maintenance and provide secure storage for spare parts, tools, and equipment.

Cyanide and other reagents require a separate fenced compound that is accessible by mobile vehicles such as a forklift.

A male/female ablution block would be necessary in the plant area.

An office/laboratory/crib room should also be located in the plant area.

If security is considered important then the whole plant area including goldroom and buildings described above should be within a perimeter fence.

4.13 VEHICLES

Minimum number of vehicles required include:

- One for supervisory staff

- One for general plant use including maintenance personnel and operator use.

- A general purpose crane/forklift/front-end loader would be necessary for duties around the plant.
4.14 MANNING

The following minimum level of manning has been determined.

**Supervisory**
- 1 x operations manager/metallurgist
- 1 x geologist

**Plant Operations**
- 2 x operators
- 1 x fitter/operator
- 1 x electrician/operator
- 1 x goldroom foreman

**Clerical**
- 1 x general duties
5 VAT LEACH DESCRIPTION

5.1 VAT PREPARATION

Four vats would be arranged in a square configuration with a pregnant solution drain directed between vats and gravitating to pregnant solution pond.

Each vat will be designed to hold 50,000 t of crushed ore.

Vat depth of approximately 3 m would be recommended. Excavation of floor should precede wall construction. Additional fill material may be required for completion of walls.

Protection of PVC membrane will be achieved by a similar method used in heap leaching.

5.2 VAT LOADING

Trucking of ore from the crusher into the vat would be necessary. Material stacking would be achieved by use of an excavator.

Complete ore loading of each vat must be attained before flooding can begin.

5.3 IRRIGATION

Barren solution will be pumped from the barren pond to the vat and distributed in various positions around the perimeter.

5.4 MANNING

It may be possible to reduce operating personnel by one.
5.5 OTHER

Each of the following areas will have similar requirements to those detailed in the Heap Leach Description, (Section 4).

Crushing
Tons
Adsorption
Desorption
Reagent Additions
Services
Assays
Communications
Buildings and Compounds
Vehicles
6 PROJECT MANAGEMENT - NORMET

Nomet would undertake the project and provide the following services:

**Project Manager**

Nomet would appoint a project manager for the Giants Reef operation. The manager would report directly to a Giants Reef representative. Consulting input and detailed engineering would come from Phil Hearse and Metplant Engineering Services, Perth.

**Additional Testwork**

Any testwork considered necessary for metallurgical confirmation, design, and operation would be undertaken in the Darwin laboratory.

**Environmental Study**

If Government Departments require an "Impact Statement" or "Notice of Intent", then Nomet would appoint an in-house environmental officer to prepare reports.

**Feasibility Study**

Included in this report is a preliminary plant costing exercise for heap leaching. Further work involving a conceptual study with input into plant design and a comprehensive costing exercise would be undertaken by Nomet.

**Design and Construction**

The detailed design/construction phase would follow approval of the feasibility study.

Detailed design would be undertaken by Metplant Engineering Services and plant fabrication and construction undertaken by Northern Territory based companies under Nomet's management.
Plant Operation

Normet would commission the plant as part of the design/construction phase.

Normet would then arrange an operating contract to operate the heap/vat leach plant.

Geology, Mining Engineering, Mining and Crushing

It is assumed that geology and mining engineering would be under Giants Reef control.

Mining and crushing would be undertaken on a contract basis. As part of the project management role Normet could call and evaluate tenders for mining and crushing.
## CAPITAL COST SUMMARY

**CONTRACT CRUSHING/STACKING GIANTS REEF TO OPERATE**

<table>
<thead>
<tr>
<th>ITEM</th>
<th>$k</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 LEACH PADS, PONDS, AND DRAINS</td>
<td>100</td>
</tr>
<tr>
<td>Including fill material, machinery for prep, piping, pad, and pond lining, 25% of liner cost, sand layer and trafficable surface.</td>
<td></td>
</tr>
<tr>
<td>2 IRRIGATION</td>
<td>70</td>
</tr>
<tr>
<td>Including pumps, piping, valves, fittings, sprinklers, installation, civils, etc.</td>
<td></td>
</tr>
<tr>
<td>3 ADSORPTION</td>
<td>80</td>
</tr>
<tr>
<td>Including pressure adsorption vessels, piping, valves, civils etc.</td>
<td></td>
</tr>
<tr>
<td>4 STRIPPING</td>
<td>250</td>
</tr>
<tr>
<td>Low cost plant, possibly Zandra system.</td>
<td></td>
</tr>
<tr>
<td>5 REAGENT APPLICATIONS</td>
<td>90</td>
</tr>
<tr>
<td>Including lime silo, cyanide mixing and storage, civils etc.</td>
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### Capital Cost Summary (continued)

**ITEM**

<table>
<thead>
<tr>
<th>Item Description</th>
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<tbody>
<tr>
<td>FIRST FILL REAGENTS AND CONSUMABLES</td>
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</tr>
<tr>
<td>40 t lime</td>
<td>5.6</td>
</tr>
<tr>
<td>18 t cyanide</td>
<td>36</td>
</tr>
<tr>
<td>4 t caustic</td>
<td>3</td>
</tr>
<tr>
<td>4 t carbon</td>
<td>24</td>
</tr>
<tr>
<td>Goldroom chemicals, descaler</td>
<td>6</td>
</tr>
<tr>
<td>Tools, basic spares</td>
<td>25</td>
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</table>

<table>
<thead>
<tr>
<th>BUILDINGS AND COMPOUNDS</th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Office/lab/crib room</td>
<td>30</td>
</tr>
<tr>
<td>Ablution block</td>
<td>5</td>
</tr>
<tr>
<td>Office equipment</td>
<td>5</td>
</tr>
<tr>
<td>Workshop/store</td>
<td>10</td>
</tr>
<tr>
<td>Fencing</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SERVICES</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Drainage/sewerage</td>
<td>5</td>
</tr>
<tr>
<td>Power</td>
<td>80</td>
</tr>
<tr>
<td>Water</td>
<td>100</td>
</tr>
<tr>
<td>Roads</td>
<td>5</td>
</tr>
<tr>
<td>Communications</td>
<td>15</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>VEHICLES</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Forklift/crane</td>
<td>30</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>DETAILLED DESIGN</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>$k 1020</td>
</tr>
<tr>
<td></td>
<td>$t 5.10</td>
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</tbody>
</table>

**NOTE** Costs are indicative only
### OPERATING COST SUMMARY

**CONTRACT CRUSHING/STACKING, GIANTS REEF TO OPERATE**

<table>
<thead>
<tr>
<th>ITEM</th>
<th>$k</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LABOUR</strong></td>
<td></td>
</tr>
<tr>
<td>Manager/metallurgist</td>
<td>85</td>
</tr>
<tr>
<td>Geologist</td>
<td>60</td>
</tr>
<tr>
<td>Fitter/operator</td>
<td>35</td>
</tr>
<tr>
<td>Electrician/operator</td>
<td>35</td>
</tr>
<tr>
<td>2 x operators</td>
<td>60</td>
</tr>
<tr>
<td>Goldroom foreman</td>
<td>32</td>
</tr>
<tr>
<td>Clerical/general duties</td>
<td>21</td>
</tr>
<tr>
<td><strong>SALARY BURDEN/RECRUITING</strong></td>
<td>130</td>
</tr>
<tr>
<td>Including payroll tax, superannuation, leave, workers compensation, FBT etc 40% labour costs</td>
<td></td>
</tr>
<tr>
<td><strong>CRUSHING</strong></td>
<td></td>
</tr>
<tr>
<td>Contract $4/t</td>
<td>800</td>
</tr>
<tr>
<td><strong>STACKING</strong></td>
<td></td>
</tr>
<tr>
<td>Contract $0.95/t</td>
<td>190</td>
</tr>
<tr>
<td><strong>VEHICLES</strong></td>
<td></td>
</tr>
<tr>
<td>Lease/hire 2 light vehicles</td>
<td>30</td>
</tr>
<tr>
<td>ITEM</td>
<td>$k</td>
</tr>
<tr>
<td>------</td>
<td>----</td>
</tr>
<tr>
<td><strong>SERVICES</strong></td>
<td></td>
</tr>
<tr>
<td>Power</td>
<td>100</td>
</tr>
<tr>
<td>Water</td>
<td>5</td>
</tr>
<tr>
<td>Fuel</td>
<td>6</td>
</tr>
<tr>
<td>Buildings, roads etc</td>
<td>5</td>
</tr>
<tr>
<td><strong>MAINTENANCE MATERIALS</strong></td>
<td></td>
</tr>
<tr>
<td>Pads, ponds and drains, piping, irrigation &amp; maintenance- includes 75% pad/pond materials</td>
<td>180</td>
</tr>
<tr>
<td>Adsorption - 15% capital</td>
<td>12</td>
</tr>
<tr>
<td>Desorption - 10% capital</td>
<td>25</td>
</tr>
<tr>
<td><strong>EQUIPMENT HIRE</strong></td>
<td></td>
</tr>
<tr>
<td>Bobcats, cranes etc</td>
<td>5</td>
</tr>
<tr>
<td><strong>REAGENT CONSUMPTIONS</strong></td>
<td></td>
</tr>
<tr>
<td>Lime 3.5 kg/t</td>
<td>105</td>
</tr>
<tr>
<td>Cyanide 2 kg/t</td>
<td>800</td>
</tr>
<tr>
<td>Carbon 5 g/t</td>
<td>6</td>
</tr>
<tr>
<td>Antiscalent</td>
<td>10</td>
</tr>
<tr>
<td><strong>GOLDROOM CONSUMABLES</strong></td>
<td></td>
</tr>
<tr>
<td>Fuel, reagents etc</td>
<td>40</td>
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</tbody>
</table>
### Operating Cost Summary (continued)

<table>
<thead>
<tr>
<th>ITEM</th>
<th>$k</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 MISCELLANEOUS</td>
<td></td>
</tr>
<tr>
<td>Travel, telephones, insurance, first-aid, stationery, freight etc</td>
<td>60</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>$k 2837</td>
</tr>
<tr>
<td></td>
<td>$t 14.18</td>
</tr>
</tbody>
</table>

**NOTE:** Costs are indicative only
9 PROJECT MANAGEMENT COST

Supply of operating personnel would be undertaken on an hourly basis.

<table>
<thead>
<tr>
<th>Position</th>
<th>Rate/hr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project manager/metallurgist</td>
<td>65</td>
</tr>
<tr>
<td>Geologist</td>
<td>55</td>
</tr>
<tr>
<td>Operators/tradesman</td>
<td>38</td>
</tr>
<tr>
<td>Secretarial service</td>
<td>35</td>
</tr>
</tbody>
</table>

Costs of travel, accommodation, telephone calls etc would be met by Normet and invoiced at cost.

The initial weeks of the project operation will be intensive and require a full manning crew. Following this a steady state operating period will be reached, with only minimal operating staff required.

Salary burden/recruiting costs will be met by Normet under an operating contract agreement.
10 RECOMMENDATIONS

To establish cost accurately and determine the economics of the project alternatives, it is recommended that further studies are carried out.

10.1 Additional Metallurgical Testwork

A single column leach test has been undertaken and provided preliminary data on cyanidation amenability.

In order to confirm results and provide a sound background on preferred treatment options, it is recommended that further testwork be carried out.

Testwork is required to establish if:

a) Vat leaching will result in significantly higher extraction rates than heap leaching.

b) Extraction rates and limits for high grade and low grade material differ significantly.

c) Minus 12 mm is the optimum crush size.

d) Reagent consumptions can be optimised.

Representative sampling of the deposit is essential for meaningful results.

Other areas requiring further work include:

a) Orebody - grade and tonnage fixation

b) Water source - location and production figures

This information will provide a project option to base detailed costings on, and will allow a financial analysis to be modelled.
11 NORMET BACKGROUND AND-ABILITIES

Normet has developed to the leading heap leach services company in Australia.

Major projects which Normet has been awarded are:

- Telfer 2 Mtpa Heap Leach Project, WA

  Proposed scope of works, conceptual design and engineering study, lump sum cost for project implementation, and capital and operating costs. Sept '87 - current

- New Celebration Conceptual Design Study WA 500,000 tpa

  Study awarded March 1988

- Bullabulling 1,000,000 tpa Heap Leach, WA

  Feasibility study, lump sum project cost. January 1988 - current

- Cosmo Howley 750,000 tpa Heap Leach, NT


Laboratory heap and vat leach testwork programs have been undertaken for:

  Boddington Gold Project
  Centenary International Mining
  Gabanintha Mines
  Galtee More
  Greenbushes NL
  Enterprise Gold
  Pacific Gold Mines