It is therefore recommended that two declines are developed in the East Mine.

**Conclusions**
Option 2 is the only option that complies with the above recommendations for the West and East Mines and therefore it is recommended that a COS based on Option 2 is prepared for consideration.
### TABLE 1

**COMPARISON OF ACCESS OPTIONS IN TERMS OF CAPITAL EXPENDITURE**

<table>
<thead>
<tr>
<th>Option</th>
<th>AD’s Rm</th>
<th>RD’s Rm</th>
<th>SD Rm</th>
<th>TC Rm</th>
<th>O/LC Rm</th>
<th>Totals Rm</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.6 (800m)</td>
<td>19.8 (1000m)</td>
<td>0</td>
<td>5.0 (1000m)</td>
<td>15.4 (3085m)</td>
<td>49.8</td>
</tr>
<tr>
<td>2</td>
<td>10.0 (909m)</td>
<td>23.8 (1200m)</td>
<td>19.8 (1000m)</td>
<td>11.0 (2200m)</td>
<td>17.5 (3500m)</td>
<td>82.1</td>
</tr>
<tr>
<td>3</td>
<td>12.3 (1100m)</td>
<td>23.8 (1200m)</td>
<td>19.8 (1000m)</td>
<td>11.0 (2200m)</td>
<td>15.3 (3070m)</td>
<td>82.2</td>
</tr>
<tr>
<td>4</td>
<td>9.6 (800m)</td>
<td>19.8 (1000m)</td>
<td>0</td>
<td>5.0 (1000m)</td>
<td>15.3 (3070m)</td>
<td>49.7</td>
</tr>
<tr>
<td>5</td>
<td>9.6 (1000m)</td>
<td>19.8 (1000m)</td>
<td>0</td>
<td>5.0 (1000m)</td>
<td>14.4 (2880m)</td>
<td>48.8</td>
</tr>
<tr>
<td>6</td>
<td>7.2 (600m)</td>
<td>19.8 (1000m)</td>
<td>0</td>
<td>5.0 (1000m)</td>
<td>21.4 (4290m)</td>
<td>53.4</td>
</tr>
<tr>
<td>7</td>
<td>7.2 (600m)</td>
<td>19.8 (1000m)</td>
<td>0</td>
<td>5.0 (1000m)</td>
<td>16.4 (3280m)</td>
<td>48.4</td>
</tr>
<tr>
<td>8</td>
<td>7.2 (600m)</td>
<td>19.8 (1000m)</td>
<td>0</td>
<td>5.0 (1000m)</td>
<td>19.1 (3820m)</td>
<td>51.1</td>
</tr>
</tbody>
</table>

**Notes**

AD’s = Access Declines  
RD’s = Reef Declines  
SD = Underground Strike Development  
TC = Underground Trunk Conveyors  
O/LC = Overland Conveyors

The above costs as presented is a coarse comparison only and no single cost can be considered to be definitive.
C.O.S DESIGN PARAMETERS

The following design parameters should be used for capex estimates; mining development only.

**West Decline**

- Sinking of an access decline 6m (wide) x 4m (high) for a distance of 410 metres from the portal brow. 9840
- One passing bay 20m long and 3m wide at the height of the decline of 4 metres. 240
- Four muck bays developed off the decline for 10m and 3m (wide) at 3m (high). 360
- Development for ventilation shafts is 30m x 6m (wide) x 1,8m (high). 324
- Three ventilation shafts to be raisebored; one at 3,6m diameter and two at 3,0m diameter and all 69m deep.
- A single orepass (1,5m x 1,5m) and 11 metres long. 25
- A travelling way 60m (long) x 3m (wide) x 3m (high) 540
- Four decline systems on reef. Three declines are 6,5m (wide) x 1,8m (high) and 430m long. One decline is 6,5m (wide) x 2,5m (high) and is 445m long. 22324
- Between the reef declines there are 24 holings of dimensions 6,5m (wide) x 1,8m (high) and 6,0m long. 1686
- The hanging wall slots for conveyor/equipment intersections are 6,5m (wide) x 2,0m (high) and are 20m long. 780
- Opening up development from the flank declines is defined as follows.
  - 38 rooms; 14m (wide) x 1,8m (high) x 6,0m (long) and a through road of 6,5m (wide) x 1,8m (high) x 430m long. 10780
- Provision for on reef dams and settling arrangements at bottom of reef declines. 500

**East and Central Declines**

Both these decline systems are identical and therefore the following refers to **only one decline system**.

- Sinking of an access decline 6,0m (wide) x 4,0m (high) for a distance of 300 metres. 7200
- One passing bay 20m long and 3 metres wide at the height of the decline of 4 metres.
• Three muck bays developed off the decline at 3,0m (wide) x 3m (high) x 10m (long).  
• Development for ventilation shafts is 30 metres x 6m (wide) x 1,8m (high).  
• Three ventilation shafts to be raisebored (or drop raised) one at 3,6m diameter and two at 3,0m diameter and all 51 metres deep.  
• A single orepass (1,5m x 1,5m) and 11 metres long.  
• A travelling way 60m (long) x 3m (wide) x 3m (high).  
• Four declines on reef (average length 400m); three declines are 6,5m (wide) x 1,8m (high) and one decline is 6,5m (wide) x 2,5m (high).  
• Between the reef declines there are 24 holings of dimensions 6,5m (wide) x 1,8m (high) and 6m long.  
• Three hanging wall slots for conveyor/equipment intersections are 20m long x 6,5m (wide) x 2,0m (high).  
• Opening up development from the flank declines defined as follows.  
  38 rooms; 14m (wide) x 1,8m (high) x 6m (long) and a through road of 400m long x 6,5m (wide) x 1,8m (high).  
• Provision for on reef dams and settling arrangements at bottom of reef declines.  

Note: the following must still to be considered before finalisation of the C.O.S.

• An extra portal at the Central Mine.  
• An additional conveyor system at the Central Mine. Total conveyor length to portal brow is approximately 700 metres.  
• An additional overland conveyor to mine silo position from the Central Mine.

The information (Complim.)
given to C Foree (RCC)
on 27 November.
VOLUME 4

ANNEXURE 6.4

Waterval UG2 Project: Mining Design Criteria

K.A.Rhodes, June 2001
WATERVAL UG2 PROJECT: MINING DESIGN CRITERIA

DRAFT SKELETON DOCUMENT: REVISION A

1. PREAMBLE
This mining design criteria refers to the exploitation of the UG2 reef at Rustenburg Section (Waterval). In general at Waterval the middling between the UG2 reef and the Leader reef is too great and therefore precludes the mining of both together; refer to isopach plan Figure 1. It is therefore planned to mine only the UG2 reef with footwall waste to make up the 1,80 metres mining width which is considered necessary for total mechanisation of the project.

Room and pillar is the choice of mining method and all mining operations will be mechanised: face drilling, loading, roofbolting, charging up operations and materials transport. Transfer of ore to surface will be by conveyors.

2. PRODUCTION PARAMETERS
140 000 UG2 reef planned for
SG = 4,0
Channel width = 0,80m (0,73m)
F/W waste SG = 2,9
Waste width mined = 1,00m (1,07)

At 0,80m UG2
m³ mined = 140 000 ÷ (4,0 x 0,8) = 43 750
Tons waste = 43 750 x 2,9 x 1,0 = 126 875
Total TPM broken = 266 875

At 0,73m UG2
m³ mined = 140 000 ÷ (4,0 x 0,73) = 47 945
Tons waste = 47,945 x 2.9 x 1.07
= 148,773

Total tons mined = 288,773

It has been assumed that in fact 270,000 tons will be broken in total (or 140,000TPM) UG2 + 130,000TPM footwall waste.

At this stage the waste to be separated underground and packed has not been determined pending blasting trials currently in progress at Bleskop and at Boschfontein.

3. **MINE ACCESS**

Access to the resource will be from two declines: Central Decline and East Decline. Both these declines are positioned east of the Hex River fault and are 1000 metres apart; refer to layout footprint Figure 2. Access to the resource west of the Hex River fault has still to be finalised.

Each decline has provision for a conveyor (1050mm wide belt) and also a roadway for the passage of trackless mobile machinery. Decline dimensions are 6.32 metres (wide) x 3.80 metres (high); refer to drawing Figure 3. During the sinking of the two access declines muckbays will be established to a depth of 10 metres at decline dimensions in order to reduce LHD trammimg distances during the face cleaning cycle thereby enabling face drilling and final rock clearance to take place simultaneously.

4. **ROCK ENGINEERING**

Specific rock engineering parameters have been defined for this project which are based on the practical requirements of a room and pillar operation and rock engineering modelling work which confirm the recommendations made by Anglo Platinum's rock engineering consultant. *Discussions and reports still required from KRN before finalising this report.*
5. VENTILATION

Waiting for final ventilation report and therefore this section cannot yet be finalised.

6. GENERALISED MINE LAYOUT

All operations are planned to be on the reef horizon; the only exception being the main access declines and the necessary ore transfer arrangements at the bottom of each access decline.

**In terms of the overall underground infrastructure the following matters need to be addressed.**

- The timing and layout of underground TM3 workshops.
- Main pump station.

The general opening up of the mine will be from a 5 road reef decline system from which mining will take place on strike. The roadway dimensions are 6.5 metres x 1.80 metres high but the central conveyor roadway is 2.0 metres high. Reef declines at the East Mine will be on true dip but at the Central Mine the main on reef development will be on apparent dip (slightly off true dip) in order to maintain proximity to the Hex River fault and further, to open up down dip the distance between the main down dip development at both mines.

Production panels will be turned off at 5° above strike from the main dip development.

7. MINING METHOD AND PANEL GEOMETRY

The method of mining is room and pillar; the following parameters are relevant at this time but are currently being reviewed.

- There are no barrier pillars.
- Rooms are 14 metres wide.
- Initially panel pillars are 6 metres on strike and 5 metres on dip and increasing at depth.
- Access holings between pillars are 6.5 metres on dip.
Refer to Figure 4 for panel geometry.

8. CYCLE OF OPERATIONS
Mining is planned for 2 x 10 hour shifts for 6 days a week (TO BE CONFIRMED). In terms of a roster system personnel will work a 40 hour week necessitating two shifts on and one shift off.

A full suite of trackless equipment will operate in a height of 1.80 metres. This will necessitate the use of low profile machines which are available from OEMs.

Face Drilling
Single boom electric hydraulic drill rig; length of round drilled not less than 3.2 metres.

Blasting
Emulsion explosives are recommended. Exact details still to be determined; expected supplier is AEL.

Loading
Use of a 6 ton low profile loader.

Roofbolting
Low profile single boom (or double boom) low profile roofbolting; manual installation of bolts and rod handling.

Face Preparation
Mechanisation not yet considered.

9. EQUIPMENT
A TM3 equipment engineering document was issued in early April 2001. Following a commercial and technical adjudication on 29 May 2001 it was recommended for technical reasons and in order to manage technical risk, and later
agreed to that LHDs and face rigs would be purchased from Atlas Copco. The equipment selected for the project to date is therefore as follows.

LHDs ST600 LP: 18
Face Rigs Boomer 281L/S1L: 14

Initially Boomer 281L face rigs will be delivered but a new ultra low profile drill rig (S1L) will be available in September 2001 and at that time the remaining rigs still to be delivered can be S1Ls. The company also has the right to change any 281Ls already delivered to S1Ls if they so desire.

Full documentation which motivated the decision to purchase LHDs and face rigs from Atlas Copco is available.

The remaining equipment, specifically UVs and roofbolters has still to be decided upon. A new enquiry document for UVs will shortly be issued after the UV fleet has been clearly defined. The selection of roofbolters will be delayed until the end of the year as further investigation is necessary before a commitment is made; this delay is necessary because of the limited knowledge available at the time that LHDs and face rigs were being decided upon. At that time the first roofbolter had just commenced trials at Bleskop. Further trials will take place with other OEMs equipment later in 2001. This decision will necessitate that conventional roofbolting will have to be carried out initially. The target date for the final selection of roofbolting equipment is late 2001/early 2002.

10 BLAST DESIGN
The application of trackless equipment in a narrow reef room and pillar operation necessitates the mining of significant waste tonnages. In other similar operations in the Bushveld Igneous Complex underground waste scalping is common; in such operations the waste portion of the mining cut consists of a pyroxenite middling typically between the UG2 and the Leader seam or the LG6 and LG6A seams. In all these cases no holes are drilled in the pyroxenite middling but only in the chromitite above and below the pyroxenite. Due to close spaced near vertical jointing the pyroxenite middling breaks into blocks that can be segregated on the grizzly at the tipping point. However the lithology at Waterval is such that the
middling between the UG2 and Leader is too great and the mining cut is therefore UG2 with footwall waste to provide for a 1,8 metre mining width; such cut demands intensive drilling of the footwall waste portion in order for the round to break. In initial discussions with a blasting consultant it was suggested that waste scalping at the tip would be minimal (of the order of 5%); this being in contrast to the expected segregation of 45% as stated in the CBE document. In order to resolve this issue blast design trials have commenced at both Bleskop and Boschfontein.

11 UNDERGROUND WASTE PACKING
The final report of the blast design trials (referred to previously) will determine what waste can practically be left underground. It is axiomatic that the conclusion from these trials will impact on ROM grade.

12 GRADE AND DILUTION

*ROM grades cannot be finalised until the conclusions of the blast design trials have been interrogated.*

13 ENGINEERING MAINTENANCE

An effective maintenance programme is a pre-requisite for any successful trackless mechanised operation and demands teamwork between production and maintenance disciplines and includes the involvement of the OEM.

**Workshops**

A surface workshop facility will be constructed on surface between the East and Central Declines. This workshop will be in use from the start of the project until the time underground workshops are established; this period is expected to be about two years.

**OEM Maintenance Contract**
It is proposed to enter into an agreement with the principle OEM for a maintenance service contract.
**Diesel Fuel and Lubrication**

The alliance fuel partners would supply the necessary infrastructure (surface and underground) in order to supply fuel and lubrication services to the fleet of equipment.

**Tyre Management**

A designated tyre supplier would take the responsibility for full tyre management of the trackless fleet controlled from the surface workshop initially and later from underground.

**14 TRAINING**

The training of operators (and supervisors) to acceptable levels of competence is vital for the success of any mechanised operation and it is therefore essential to set out, well in advance of commencement of operations, the necessary training programmes. The establishment of driver discipline is also necessary from the outset of the project and in this respect the early appointment of an experienced mechanical equipment overseer to take charge of trackless training matters is important.

**Selection of Operators**

The selection process for new operators must provide for a profile analysis of new candidates which should be based on the operators’ function defined by the mine company. This analysis has to be done by a qualified physiometrist. In addition mechanical ability must be assessed.

**OEM Training**

The OEM will offer training programmes for operators which are designed to promote the safe and efficient operating condition of the equipment with special focus on the prevention of abuse of machines. They will also carry out ongoing auditing of operating practices on a part time or full time basis.

**Supervisory Training**

It is not acceptable to provide training for operators unless similar training is given to their supervisors. Supervisors must be able to understand the basic functions of
equipment and be aware of the type of possible abuse to the equipment by operators.

**Management Responsibility**
Senior management must control and manage and it is therefore important that they acquire the necessary technical knowledge to enable them to carry out their functions. Specific trackless standards must be set out, documented and enforced.

It is important to put in place a surface training facility similar to Battery Reef TM3 Training Centre set up by JCI in 1986. In this way the first operators can receive their initial training on surface before the machines are sent underground. This is done by employing mock-ups at the surface training centre. Later follow-up training will be done underground.

**15 TRACKLESS MANAGEMENT**
Considering further the management of a trackless operation, a specific objective action plan should be drawn up to incorporate all the factors related to the availability of the equipment (the responsibility of the underground maintenance discipline) and the use of the availability of the equipment (this being the responsibility of the production discipline).

In terms of a maintenance service agreement with the OEM there will be increased responsibility on the OEM but certain factors remain important to both the mine company and the OEM, some of the more important being as follows.

- Planned maintenance system to provide for scheduling.
- Management information system
- Refurbishment policy
- Training programmes
- Audits of equipment
- Damage investigation
- Superior workshop facilities
Certain operational factors necessary to optimise the use of equipment and prevent abuse are as follows.

- Selection and training of operators and re-training programmes
- Appointment of the Mechanical Equipment Overseer
- Appreciation training for supervisors and management
- Ensure up to date standards of working
- Management commitment to follow up on damage
- Ensure cycling of equipment
- Maintain good ventilation conditions at all times
- Maintain roadbeds with specific attention to ramps (access declines)

16 LABOUR

The overall underground labour complement and breakdown needs to be re-addressed.
ANNEXURE 6.5

A Technical Report:

"Waste Fragmentation in Stoping UG2 Waterval"

by A.J.RORKE, 10 December 2000
Waste Fragmentation in Stoping

UG2

Waterval

Prepared For:

TWP
And Mr. K Rhodes

Prepared by:

A J Rorke
Technical Consultant, Blasting
P O Box 70243
Bryanston 2021

Date:

10/12/00 20:29

Reference: B3567/098
Waterval UG2 Stope Blasting

Contents

SUMMARY AND CONCLUSIONS ...................................................... 3

INTRODUCTION ........................................................................... 5

STOPING GEOMETRY.................................................................. 5

OPTION 1 – 250 CM WIDE STOPE ........................................... 5
ROCK PROPERTIES ....................................................................... 5
BLASTING .................................................................................... 6
OPTION 2 - 180 CM WIDE STOPE ........................................... 6
ROCK PROPERTIES ....................................................................... 7

EXPECTED RESULTS ................................................................... 7

UNCONTROLLABLE FACTORS ..................................................... 7
CONTROLLABLE FACTORS .......................................................... 8
PRELIMINARY DESIGNS AND FRAGMENTATION ESTIMATE ........... 8

Waiver
The information that is presented in this document is given with the intention of optimizing blast results. To this end, the best professional expertise and resources have been applied to the problem. Because of possible drilling and application variance, incorrect or incomplete data regarding the site and the problem and complex rock structure, the author of this document cannot assume liability for any alleged or actual damages arising directly or indirectly out of the recommendations and information given in this document.