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A REPORT ON METALLURGICAL TESTWORK

TO NOVEMBER 1985

MATHINNA GOLD TAILINGS DUMPS - TASMANIA

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CONTENTS

002

033003

SUMMARY

1. This report summarizes the metallurgical test work carried out to date on the Mathinna Dumps in Tasmania.

2. The results to date indicate that recoveries that might be expected are -

By heap leaching	0.55 gms/tonne
By agitated leaching	0.75 gms/tonne
By grinding and agitated leaching	0.85 gms/tonne

3. The results indicate that the only economical method of retreatment would be by heap leaching, but for that to be worthwhile, we need to improve the recoveries achieved in the 3 metre high test heap at Canbelego by about 25 - 30%.

4. We need to follow up our initial heap leach test by further experimentation involving metallurgical experts in that field to optimize our operating conditions. We also need to look at both capital and operating costs in detail to see if any saving can be effected that could make the operation more viable.

5. Based on results and information available to date the potential profit would be $1.25 tonne. At a retreatment rate of 50,000 tonnes per annum, that would be a return of only 41.6% per annum on capital invested. In my opinion such a return would be too low to justify development.

6. On present results for the Mathinna Dumps to be worth treating for heap leaching, a gold price of around A$550 per ounce would be required.

../2

003

033004

1. INTRODUCTION

1.1 The Gold Bearing Tailings Dumps at Mathinna, Tasmania have been the subject of three separate phases of metallurgical testing spread over the past 35 years. The initial testing was carried out by the CSIRO in 1950, the second phase by Tasminex in the early 1980's and the third phase by Epoch Minerals Exploration in 1984 and 1985.

1.2 Over the past three months Epoch have been carrying out a series of bulk metallurgical tests at their Canbelego pilot plant facility in N.S.W. on samples taken from eight separate sections of the tailings dump.

1.3 The results of this work, along with a summary of all the previous testwork results completed by others, have been incorporated in this report.

../3

004

033005

2. RECENT TEST WORK - ALL INVOLVING CYANIDATION TESTS

2.1 Grinding and agitated leach -

(1) Eight separate tests involving one drum of sample from each of eight sites. A ninth test involved a mixed set of splits from a drilling programme carried out by Epoch in 1984.

(2) Eight check tests involving about ½ drum of sample from each site. To provide enough samples for effective grinding in the pilot plant, some of the samples had to be combined.

(3) Eight tests involving a small 50 gm sample from each site were ground in a laboratory mill and leached in a mechanically stirred beaker.

2.2 Agitated leaching without grinding -

(1) Eight separate tests involving ½ drum from each site.

(2) Eight comparitive laboratory tests with small 50 gm samples.

2.3 Heap leaching -

(1) A 1 metre high heap leach column (½ drum of each sample).

(2) A 3 metre high heap leach column (1½ drums of each sample).

2.4 The test work still to complete -

(1) Agglomeration heap leaching - more samples have recently been acquired from 30 new holes drilled on the site and this test work is yet to be carried out.

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3. PAST TEST WORK

3.1 Past test work in chronological order has involved -

(a) Extensive testing by the CSIRO in 1950 on the samples from a very detailed drilling programme carried out in 1948, by the Tasmanian Department of Mines.

(b) Test work by Aberfoyle Services Pty. ltd. on behalf of Tasminex NL in 1983 carried out on two bulk samples obtained by Tasminex from the lease. One of these samples was a sand and one a residue slime from a previous retreatment attempt.

(c) Three 200 litre drums of samples were taken by Tasminex and cyanide tested by David Wright, Consultant Metallurgist.

(d) Agitated leaching tests carried out by Robertson Research (Aust.) Pty. Ltd. on behalf of Epoch Minerals Exploration NL on a split of the samples taken during the first Epoch drilling programme in 1984.

3.2 The results of all four of these programmes are incorporated with out recent results herein and conclusion drawn.

3.3 Epoch have divided the dump into two areas. (As shown on Plate 1).

(1) Area 1 - An area of medium to higher grade over the centre and most of the northern half of the dump.

(2) Area 2 - An area of medium to lower grade around the western and southern and northern limits of the dump.

CSIRO divided the Tas. Mines drillholes into three areas - (As shown on Plate 2).

Sample A - Higher grade (No. of holes - 20)
Sample B - Medium grade (No. of holes - 121)
Sample C - Lower grade (No. of holes - 22)

../5

006

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4. HEAD GRADE

4.1 From fire assays of holes drilled by Epoch in 1984, the head grade of Area 1 samples was 1.7 gms/tonne. The head grade of Area 2 was 1.2 gms/tonne.

4.2 From fire assays of the Tas. Mines 1948 holes the head grade was -

Sample A	1.98 gms/tonne	ave 1.66
Sample B	1.6 gms/tonne	
Sample C	1.38 gms/tonne	

4.3 The 1948 samples were also analysed for sulphur -

Sample A	0.2% (total sulphur)
Sample B	0.14%
Sample C	0.9%

Assays of hand picked sulphur rich ore, indicated that 14% of this sulphur was in the form of ansenopyrite and 37% was soluble sulphur.

4.4 The head grade of material tested by Aberfoyle was 2.0 gms/tonne for the sand sample and 0.8 gms/tonne for the slimes sample.

4.5 The head grade of the samples tested by David Wright were -

Drum 1	1.5 gms/tonne	
Drum 2	3.08 gms/tonne	Average 2.08 gms/tonne
Drum 3	1.66 gms/tonne	

4.6 The head grade of the sample tested by R.R.A. in 1984 was 1.2 gms/tonne. The estimated head grade of the bulk samples tested by Epoch Minerals in 1985 were around 2 gms/tonne. (Average 2.2gms/tonne).

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4.6 The Aberfoyle samples of sand and residue were analysed for a range of elements and minerals after cyanidation.

TABLE 1

HEAD ASSAY ANALYSIS OF MATHINNA TAILINGS

(AFTER ABERFOYLE 1983)

ELEMENTAL

	Sand Sample No. 7365	Slimes Sample No. 7366
Ag ppm *	15.9	14.6
Au ppm *	1.45	0.28
As %	0.26	0.26
Mo ppm	<5.0	10.0
Ni ppm	75.0	40.0
Pb ppm	150.0	200.0
S %	0.10	0.14
Sb ppm	<5.0	<5.0
Sr ppm	75.0	150.0
V ppm	60.0	90.0
Zn ppm	175.0	210.0
Zr ppm	75.0	100.0
B	830.0 ppm	0.23%
As %	0.28	0.28
Be ppm	<5.0	<5.0
Bi ppm	<5.0	5.0
Cd ppm	10.0	10.0
Co ppm	10.0	15.0
Cr ppm	50.0	60.0
Cu ppm	80.0	75.0
Hg ppm	<10.0	<10.0
Li ppm	35.0	40.0

* Assays by fire assay method.

All other assays by ICP

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4.6 (continued)

TABLE 2

HEAD ASSAY ANALYSIS OF MATHINNA TAILINGS

(AFTER ABERFOYLE 1983)

WHOLE ROCK ANALYSIS

	Sand Sample	Slime Sample
SiO_2 %	86.3	81.5
Al_2O_3 %	5.91	9.73
TiO_2 %	0.30	0.52
Fe_2O_3 %	2.54	3.59
MnO %	0.05	0.06
MgO %	0.44	0.69
CaO %	0.07	0.17
Na_2O %	0.16	0.16
K_2O %	1.27	2.08
P_2O %	0.60	0.30
C %	0.60	0.30
Te ppm	50.00	50.00

4.7 The Aberfoyle samples of sands and slimes were de-slimed and examined under a stereo binocular microscope.

The descriptions were as follows -

Sands

A small amount of clay and traces of black porous organic metter (carbonised woody material) are present in the washings.

4.7 (continued)

Coarser material consists dominantly of quartz, with small fragments of shale and carbonaceous/graphitic slates, iron-stained rock and quartz grains, compact geothite (probably representing oxidised sulphides) and occasional quartz-pyrite grains. The As present was not specifically accounted for, but very probably occurs as an arsenate (e.g. scorodite) in finely-divided form which is difficult to detect. No carbonates were detected.

Slimes

This sample is broadly similar to the sand, with minor differences, it contains a higher proportion of shale/slate fragments (as reflected in the Al_2O_3 assay), and a lower proportion of carbonaceous/graphitic rock fragments. Clays and carbonised organic matter reported in the washings.

The carbonaceous matter is almost certainly capable of absorbing gold from solutions and could in fact be the main source of both gold and silver.

4.8 CSIRO carried out sizing analysis on each of its 3 samples.

TABLE 3

SCREEN SIZING

(AFTER CSIRO 1950)

Sizing (microns)	% Weight of each sample		
	A	B	C
+ 600	3.7	5.2	1.7
600/400	6.5	9.3	3.6
400/300	10.3	15.1	6.8
300/200	10.0	13.2	6.5
200/150	10.5	12.6	6.4
150/100	8.4	9.0	5.6
100/75	6.8	7.5	4.5
- 75	43.8	28.1	64.9

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4.8 (continued)

Sample B representing the larger portion of the dump is coarser grained than either A or C.

4.9 A portion of the fractions of Samples A and B were assayed for gold and sulphur.

TABLE 4

ASSAY SIZING TEST

(AFTER CSIRO 1950)

SAMPLE A

Size (micron)	% weight	Gold ppm	% S	% Distribution Au	% Distribution S
+ 200	31.5	1.60	0.07	22.3	10.9
200/75	26.5	0.76	0.05	8.9	6.6
- 75	42.0	3.7	0.40	68.8	82.5

SAMPLE B

+ 200	44	1.33	0.08	35.8	30.4
200/75	28.5	0.97	0.07	16.9	17.3
- 75	27.5	2.82	0.22	47.9	52.3

The two tests indicate that about 50% of the gold is fine and about 20 - 40% is fairly coarse. The distribution of gold is also closely aligned to the distribution of sulphur.

4.10 Further evidence on the mode of occurrence of the gold is given in Aqua Regia leaching tests carried out by the CSIRO. In hot aqua regia, sulphide oxides carbonates, tellurides and natural gold ore all soluble. In general the residue comprises quartz and stable silicates. The aqua regia test therefore indicates whether the gold occurs in the sulphides, or is locked up in the silicates as is the case at Canbelego.

../10

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4.10 (continued)

The residue assays after leaching in aqua regia were -

Sample A	0.57 gms/tonne
Sample B	0.75 gms/tonne

In both cases the sample was treated without grinding. From these results the CSIRO concluded that unless the tailings were reground, no more than 1.42 gms/tonne could be extracted (72% of the gold present) by cyanidation of Sample A and no more than 0.85 gms/tonne (53%) from Sample B.

4.11 Aberfoyle also carried out sizing analysis on its bulk samples of sand and slimes.

TABLE 5

SCREEN SIZING

(AFTER ABERFOYLE 1980)

Size (Microns)	Wt (%)	Au (ppm)	Dist. (%)
Sand			
+ 600	9.61	0.5	2.4
+ 300/-600	19.91	1.6	15.9
+ 106/-300	27.23	2.0	15.3
+ 38 /-106	14.00	2.0	27.1
- 38	29.25	2.7	39.3
Head (Calc)	100.00	2.0	100.00
- 600 micron head - 1.9 ppm Ave			
Residue			
+ 600	11.74	0.5	7.4
+ 300/-600	10.44	1.1	14.4
+ 106/-300	16.66	0.8	16.3
+ 38 /-106	12.48	0.4	6.3
- 38	49.18	0.9	55.7

../11

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4.11 (continued)

Head (Calc)	100.00	0.8	100.00

- 600 micron head - 1.0 ppm Ave

Aberfoyle sizing analysis results are similar to CSIRO and again about half the gold was found in the fine grained fraction.

013

033014

5. AGITATION CYANIDE TESTS - WITHOUT GRINDING

5.1 CSIRO - Sample A : 4 agitation cyanide tests were carried out on Sample A and 2 cyanidation tests were made after the sample was amalgamated.

The results obtained were as follows -

TABLE 6

CYANIDE LEACHING TESTS CSIRO SAMPLE A

(HEAD GRADE 1.98 gms/tonne)

CSIRO Test	Leach Time hrs	Lime added kg/ tonne	Na CN added % solution	Lime used kg/tonne	Na CN used kg/tonne	Residue assay (ppm)	Extracted g/t	% Recovery
301	20	2.5	0.076	2.4	0.25	0.61	1.36	69
302	20	3.5	0.076	3.25	0.15	0.66	1.32	66.7
303	20	5	0.076	3.95	0.15	0.69	1.29	65.1
304	6	3.5	0.076	2.7	0.10	0.78	1.20	60.6
307	6	3.5	0.082	2.7	0.10	0.78	1.20	60.6

5.2 The pre-amalgamation of two portions of Sample A was carried out by pressing the pulp at a density of 20% solids over a corduroy strake set at a slope of 1 in 6. The concentrate was amalgamated by rubbing with mercury for 20 minutes in an iron morter. The gold amalgamated amounted to 0.25 gms/tonne (12.95 of gold present and about 20% of that soluble in cyanide).

The cyanidation tests after amalgamation gave the following results -

014

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5.2 (continued)

TABLE 7

CYANIDE LEACHING TESTS - AFTER AMALGAMATION

(CSIRO SAMPLE A)

CSIRO Test	Leach Time hrs	Lime added kg/ tonne	Na CN added % solution	Lime used kg/tonne	Na CN used	Residue assay ppm	Extracted g/t	% Recovery
305	20	3.5	0.073	0.039	0.070	0.66	1.32	66.7
306	6	2.5	0.077	0.026	0.071	0.69	1.29	65.1

These results show that if amalgamation preceeds cyanidation, the recovery is not markedly improved over 20 hours of leaching, but there is an improvement of 5% where only 6 hours leaching is used.

5.3 CSIRO - Sample B

Six agitation cyanide leach tests were carried out on Sample B and two after amalgamation.

TABLE 8

CYANIDE LEACHING TESTS CSIRO SAMPLE B

(HEAD GRADE 1.6 gms/tonne)

CSIRO Test	Leach Time hrs	Lime added kg/ tonne	Na CN added % Solution	Lime used kg/tonne	Na CN used	Residue assay ppm	Extracted g/t	% Recovery
321	20	2.5	0.076	2.25	0.1	0.99	0.61	38.2
322	20	3.5	0.076	3.25	0.1	0.99	0.61	38.2
323	20	5.0	0.076	3,65	0.1	0.94	0.66	41.1
324	6	3.5	0.076	3.25	0.1	1.25	0.45	28.0
330	6	2.5	0.077	1.8	0.1	1.11	0.49	30.8
331	6	3.5	0.077	2.25	0.05	1.15	0.45	38.0

../14

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5.3 (continued)

TABLE 8 (continued)

325 *	20	2.5	0.073	2.1	0.05	0.9	0.70	44.0
326 *	6	2.5	0.077	1.85	0.1	1.09	0.51	31.8

* Cyanided after amalgamation

Some improvement with amalgamation (0.2 gms/tonne removed). About 13% of total gold and 33% of soluble gold.

5.4 CSIRO - Sample C

Four agitation cyanide leach tests were made on original Sample C and a further two tests after amalgamation.

The results obtained were as follows -

TABLE 9

CYANIDE LEACHING TESTS CSIRO SAMPLE C

(HEAD GRADE 1.38 gms/tonne)

CSIRO Test	Leach Time hrs	Lime added kg/ tonne	Na CN added % solution	Lime used kg/tonne	Na CN used	Residue assay ppm	Extracted g/t	% Recovery
341	20	2.5	0.076	2.2	0.15	1.02	0.36	26.1
342	20	3.5	0.076	2.85	0.15	1.02	0.36	26.1
343	20	5.0	0.76	3.6	0.1	0.99	0.39	28.3
344	6	3.5	0.076	2.4	0.1	1.08	0.30	21.7
345 *	20	2.5	0.073	2.2	0.1	1.03	0.34	25.0
346 *	6	2.5	0.077	1.75	0.1	1.14	0.24	17.4

* Cyanided after amalgamation.

The gold amalgamation was 0.12 gms/tonne. (About 10% or 30% of soluble gold).

5.5 The CSIRO results indicate that there is not much difference in recovery with different lime additions. The amount of cyanide added and used appears to be very low. From Epoch's work we would have anticipated cyanide usage to be more like 1 kg/tonne. The 20 hour leach time gave an improved recovery of around 5% on Samples A and C and perhaps slightly higher for Sample B.

The residue assays after 20 hours of leaching were slightly higher for Sample C (Avg. 1.02 gms/tonne), than Sample B (Avg. 0.95 gms/tonne). The residues for Sample A were the lowest (Avg. 0.66 gms/tonne). The residue assays for C and B tie fairly well into other test work. The residues for Sample A appear a little light on and hence recoveries quoted for Sample A may be a little too high. The recoveries quoted for Sample B of around 40% tie in well with more recent test work on the dump.

5.6 Aberfoyle initially carried out a series of laboratory agitatic tests in a conical flask under strong oxidizing conditions using a magnetic bar stirrer on 2 portions of their sand sample and two portions of their slime sample. The tests were carried out on minus 600 micron material, the coarser fraction being screened out. The pulp density was kept at 30%. The leaching time was 48 hours for each sample.

The results are summarised as follows -

TABLE 10

CYANIDE LEACH TEST - ABERFOYLE SAND AND SLIME SAMPLES

(HEAD GRADE - Sands 1.9 gms/tonne)
Slime 1.0 gms/tonne)

	Test No.	Lime Consumption kg/tonne	Na CN Solution %	Residue Assay ppm	Solution ppm *	Calculated Head
Sand	1	3.0	0.25	1.15	1.7	2.85
	2	2.7	0.25	1.10	1.4	2.5
Slimes	3	2.3	0.25	0.5	0.35	0.85
	4	3.0	0.25	0.65	0.47	1.12

* corrected for pulp density

../16

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5.7 In these tests there is a significant disparity between the head grade as assayed for the sands and that as calculated from assays of final residue and solution. The slimes assays are much better. A similar disparity with sand samples was noted in Epoch test work.

Based on the Aberfoyle results the indicated recovery is -

TABLE 11

ABERFOYLE LEACH TESTS - COMPARISON OF INDICATED RECOVERY

Test	From Assay results of head and residue only	From calculated head and residue
1 } Sands	39.5%	56.6%
2 } Sands	42%	56%
3 } Slimes	50%	40%
4 } Slimes	35%	41.4%

5.8 Among metallurgists the recoveries calculated from the assay of head and residue (LH column) are generally more acceptable. This being the case then the indicated recovery for the sands is around 40%, which is similar to that observed by CSIRO for Sample B. Indicated recoveries from the slimes are more variable, but average around 40% as well, somewhat higher than the 26 - 28% indicated for Sample C by the CSIRO tests. A higher concentration of cyanide was used in the Aberfoyle tests (around 5kg/tonne of solids compared to 1kg/tonne in the CSIRO tests). It should be noted that the CSIRO tests were carried out on a large number of drill samples, whereas the Aberfoyle tests were on two bulk samples only. As a result, the CSIRO results should be more representative of the dump as a whole.

5.9 Some bottle roll leach tests were also carried out by Aberfoyle using 200 gram samples of both thesand and slimes collected. Again the Na CN solution strength was 0.25% and the pH kept to 10.0. Varying leach times were tried.

../17

5.9 (continued)

The results were -

TABLE 12

ABERFOYLE LEACH TESTS - WITH VARYING LEACH TIMES

	Head	Residue			Solution *		
	ppm	24 hrs	48 hrs	72 hrs	24 hrs	48 hrs	72 hrs
Sands	1.35	1.1	0.8	0.7	0.39	0.55	0.55
Slimes	0.65	0.5	0.5	0.8	0.24	0.31	0.31

* Corrected for pulp density.

Recovery	Sands	Slimes
Based on residues (after 72 hrs)	48%	?
Based on solutions (after 72 hrs)	41%	48%

5.10 In his test, David Wright took 500 grams of dry sample from each of the 3 drums of sample sent to him by Tasminex.

The additions to the samples were -:

Lime	2 kg/tonne
Water	1,000 cc (pulp density 33%)
Na CN	2 kg/tonne
Carbon	205 grams

Samples were agitated with water for 1 hour and then the lime and cyanide were added. The samples were agitated for 22 hours and then carbon was added at this stage and the agitatio continued for 8 hours.

../18/

5.10 (continued)

The results were -

TABLE 13

CYANIDE LEACH TESTING

(D. WRIGHT'S SAMPLES)

Drum	Final pH	Na CN final %	Head Grade ppm	Solution Assay *	Gold *** Recovery	Carbon Assays Gold ppm	% Recovery
1	10.8	0.086	1.5	1.0	67%	0.9	60
2	10.1	0.050	3.08	2.5	82.2%	2.49	80.8
3	9.6	0.063	1.66	1.25	75.0%	0.72	43.7 **

* Solution assay corrected for pulp density.

** This sample contained a trace of oil detremental to carbon recovery. The recoveries should not be lower than the gold recovered onto carbon.

*** Comparison of solution assay with head grade.

5.11 In calculating his recoveries David Wright has used solution assay and head grade and has not assayed the residue. It is possible that the solution assay plus residue assay may be again higher than the head grade (as observed in Aberfoyle and Epoch's tests) and if this is the case, then the recoveries quoted may be overstated.

5.12 RRA carried out agitated leach tests on a carefully split representative sample of 1 kg collected in the first phase of drilling carried out by Epoch Minerals in 1984.

The sample was screened and the - 1 mm fraction pulped at 49% solids. 2 grams of lime and 2 grams of NA CN were added and the sample agitated in a bottle roll for 8 hours. Further additions of 1 gram of lime were made at $\frac{1}{2}$ hour and $2\frac{1}{2}$ hours.

../19

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5.12 (continued)

After the 16 hours the leach pulp was split into 2 portions and to one portion 10 grams of PICA 8 x 16 carbon was added. The solutions were then agitated for a further 16 hours. Sample were taken of solution at regular intervals.

In the results the calculated head assay given is based on the weighed average of the 2 residue assays, the carbon assay, the 24 hour leach and CIP solution assay plus the gold removed in the intermediate samples.

TABLE 14

CYANIDE LEACH TESTS - ROBERTSON RESEARCH SAMPLE

Leach solution after	Solution Assay (ppm) *
1 hour	0.36
2 hours	0.34
4 hours	0.43
8 hours	0.43
24 hours	0.48

* Solution assay corrected for pulp density.

Leach residue	0.86
Indicated recovery	35.8%

CIP solution after 24 hours - 0.01 ppm
CIP residue after 24 hours - 0.83 ppm
Carbon after 24 hours - 0.205 milligrams of gold

The RRA conclusion, based on fire assays of solids was that recoveries were around 34%. Based on solution plus residue the recovery was 36%.

5.13 RRA's sample was fairly low grade and the recoveries were slightly less than the 40 - 45% observed by others. The CSIRO tests on Sample C support the likelyhood of lower recoveries in lower grade material.

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5.14 Acid leach tests were carried out by RRA on a half split of a cyanide residue (head grade 0.86 ppm). The residue was leached with concentrated HNO_3, H Cl and water on a 1:1:1 ratio for ½ hour at boiling point. It was then filtered to see ifadditional gold could be extracted.

The results were as follows -

TABLE 15

ACID LEACH TESTS OF CIP RESIDUE - RRA SAMPLE

	mls/gm	Au Assay g/t	Au extraction g/t	%
Acid leach solution	1000	0.095	0.39	42
Acid leach residue	229.6	0.57	0.55	58
CIP residue (calc)	239.6	0.94		
CIP residue assay		0.83		

These results indicate that 42% of the gold in the residue could be extracted by acid leaching. The total recovery cyanide plus acid leaching would be 0.87 gms/tonne or 65%. The remaining gold is insoluble and impossible to extract. This compares with aqua regia tests on CSIRO samples A and B where the maximum possible extractable gold was 72% and 53% respectively.

5.15 Without grinding and assuming an average head grade of around 1.7 gms/tonne, then the maximum extractable gold one could expect would be around 1.0 gm/tonne. To test this situation, Epoch Minerals Exploration NL carried out bulk tests on one half of a 200 litre drum of samples from each of 8 different sites within the medium to high grade part of the dump. (Similar environment to CSIRO's samples A and B and Aberfoyle's sands).

5.16 The eight samples were tested by leaching for about 36 hours in air agitated tanks with lime and cyanide. Two samples tested weighed 85 kg and six samples 50 kg, (corrected for moisture content in Table 16 below). 200 grams of cyanide

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TABLE 16

AIR AGITATED LEACH TEST - EPOCH MINERALS

Sample **	Wt of dry Sample kg	Pulp Density %	pH	Free Cyanide %	Free Lime %	Assay * Grade Solution ppm	Residue ppm	Calc. Head Grade ppm	% Recovery
1	70.7	24	10.6	0.075	0.002	1.28	0.78	2.06	62.1%
2	47.5	22	11.9	0.10	0.085	0.74	0.96	1.7	43.5%
3	48.4	22	11.3	0.10	?	0.54	1.60	2.14	25.2%
4	48.7	21.5	12.0	0.10	0.06	0.54	1.64	2.18	24.8%
5	46.2	25.5	10.7	0.10	0.005	0.57***	0.73	1.30***	43.8%
6	46.9	26.5	11.6	0.15	?	0.49***	0.69	1.18***	41.5%
7	70.7	19.7	11.9	0.09	0.028	3.47	1.21	4.68	74.1%
8	45.8	25.3	11.9	0.15	?	0.64	0.69	1.33	48.1%
Avg. (Excluding 1 and 7)						0.59	1.04	1.64	36%
Avg. (with 1 and 7)						1.03	1.04	2.07	49.7%

* Corrected for pulp density

** Samples 1 and 7 are slime samples.

*** Appear a little low

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../22

5.16 (continued)

and 600 grams of lime were added (for samples of 50 kg this is equivalent to 4 kg of cyanide per tonne and 12 kg of lime per tonne).

Assays of solution were by Epoch's Atomic Absorption Spectrometer at Canbelego and residue assays were undertaken by fire assay by Australian Laboratory Services.

The results obtained are presented in Table 16 on the following page.

5.17 Small samples of 50 grams each were lab tested by stirring in a beaker with cyanide and lime and leaving to settle overnight. The results were compared with those in Table 16.

TABLE 17

COMPARISON LAB BEAKER AGITATED AND BULK AIR AGITATED LEACH TESTS - EPOCH MINERALS

Sample No.	Solution Assay (ppm)	Solution bulk test
1 (slimes)	0.79	1.28
2	0.57	0.74
3	0.94	0.54
4	0.60	0.54
5	0.64	0.57
6	0.83	0.49
7 (slimes)	1.69	3.47
8	0.79	0.64
Avg.	0.86	1.03

5.18 The comparison indicates that for the slimes the bulk test was able to recover more gold than the lab test. The lab test indicated that leaching in the air tanks of sample numbers 2, 3 and 6 and to a lesser extent 8 may not have been complete and hence a higher recovery may be possible for these samples.

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5.19 The CSIRO screen sized the residue of their cyanidation test 307 (sample A). The screen fractions were assayed for gold and sulphur. See Table 18 on next page.

Although 68.5% of the gold in Sample A originally occurred in the - 75 microns fraction, 84.7% of the gold extracted was from this fraction, whilst for the + 200 micron fraction, the corresponding figures are 22.3% gold present and only 9.5% of the gold extracted. Comparison of gold and sulphur percentages extracted show a very close relationship and there is considerable variation in assay of gold/sulphur in the residue over the 3 size ranges indicating that little of the residual gold is associated with sulphur. This is supported by the aqua regia test results, where the 0.57 gms/tonne residue is only 0.045 gms/tonne lower than the lowest residue by direct cyanidation.

5.20 The residue of CSIRO cyanidation test 330 (Sample B) was also screen sized and the fractions assayed for gold and sulphur. See Table 19 on next page.

46.9% of the gold in Sample B occurs in the - 75 micron fraction and 63% of the gold extracted comes from fraction, whereas 35.8% of the gold occurs in the coarest fraction and only 21.0% of the gold was extracted.

The assay ratio of gold to sulphur in the residue are similar for each size range suggesting that some of the gold left in Sample B is associated with sulphides.

5.21 Expressed in another way 93% of the gold in Sample A which is soluble in aqua regia can be extracted by cyanide, whilst only 77% of gold in Sample B which is soluble can be extracted by cyanidation. The gold sulphide association is more prominant in Sample B and may account for the drop in percentage recoveries between the two sets of samples.

Table 18 - Screen Sizings & Gold Distribution - Residue CSIRO Sample A

Size Microns	% Wt	Gold in Residue ppm	Gold Extracted ppm	% S in Residue	% Gold in Residue	% Gold Extracted	% S Extracted
+ 200	31.5	1.15	0.45	0.07	47%	9.5%	10.9%
+75/-200	26.5	0.43	0.33	0.05	14.9%	5.8%	6.6%
-200/-75	42.0	0.70	2.00	0.40	38.1%	84.7%	82.5%

Table 19 - Screen Sizings & Gold Distribution - Residue CSIRO Sample B

Size Microns	% Wt	Gold in Residue ppm	Gold Extracted ppm	% S in Residue	% Gold in Residue	% Gold Extracted	% S Extracted
+200	44	1 .08	0.25	0.08	43.0	21.0	30.4
+75/-200	28.5	0.67	0.30	0.07	17.4	16.0	17.3
-200/-75	27.5	1.59	1.23	0.22	39.6	63.0	52.3

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6. HEAP LEACHING

6.1 Two heap leach tests were tried in a specially constructed heap leach test plant at Canbelego. The first test with a 1 metre high column was experimental, designed to test the effective operation of the pilot plant. The second test with a 3 metre high heap operated successfully and was continuedfor a total of 9 days.

6.2 The test plant comprised a 3 metre high vertical water pipe 850mm in diameter, sealed at the base. An outlet pipe near the base of the pipe was covered with a 100 mesh stainless steel screen. A bed of sand 300mm thick was placed at the bottom of the pipe as a filter medium. 3 metres of sample (2.2 tonnes), a composite of each of the 8 samples mixed with lime was placed in the pipe and flooded with cyanide solution. The pregnant solution drained into three 200 litre drums connected by 250mm pipe. A horizontal steel column filled with 2kg of fresh Pica Carbon was placed between the 1st and 2nd drum.

6.3 The dry sample weighed 2.2 tonnes and 375 litres of solution were added. (Moisture content 15%).

The total volume of solution pumped back through the heap over the 9 days was 2,125 litres or 5.7 times the bed volume.

The results of the 3 metre heap are presented on the following page.

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Table 20 - 3 metre Heap Leach Test - Epoch Minerals

Time days	pH	Free Cyanide %	Free Lime %	Grade AA (T1)**	Grade AA (T2)**	Vol. pumped litres	Cyanide Added (kg)	Lime Added (kg)
½	9.2	0.035	0	0.21	0.04	125	3	6.2
1	9.0	0.065	0	0.39	0.04	125		0.2
1½	9.3	0.065	0	0.32	0.05	125		
2	9.5	0.065	0	0.22	0.05	125		
2½	9.5	0.065	0	0.19	0.05	125		
3	9.6	0.07	0	0.14	0.04	125		
3¼	9.4	0.055	0	0.14	0.06	125		
4	9.4	0.05	0	0.14	0.06	125		0.2
4½	9.3	0.05	0	0.10	0.04	125		0.2
5	9.4	0.05	0	0.10	0.03	125	1.0	0.6
5½	9.4	0.05	0	0.096	0.03			
6	9.3	0.05	0	0.072	0.03	125	1.0	1.0
6½	9.5	0.06	0	0.10	0.04	125		1.6
7	9.4	0.07	0	0.09	0.05	125		1.6
7½	9.6	0.09	0	0.07	0.04	125		
8	9.7	0.12	0	0.08	0.04	125		
8½	9.8	0.15	0	0.04	0.02	125		
9	9.7	0.16	0	0.07*	0.04*	125		
TOTAL							5.0kgs	11.6kgs

*N.B. From check assays from A.L.S. these grades were 0.05 and 0.03gms/tonne respectively

** T1- before Carbon Column T2- after Carbon Column

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6.4 After completion of the heap leach, two samples were taken from the head and tail of the carbon column and assayed. The results were -

Carbon assay at top of column: 925 gms/tonne
Carbon assay at base of column: 260 gms/tonne
Average 592.5 gms/tonne

Total gold collected on 2kgs of carbon - 1.185gms

This was recovered from 2.2 tonnes of solids - 0.54gms/tonne

6.5 Samples of the residue were taken from various parts of the heap and assayed by fire assay. The results as measured from the top of the heap were as follows.

Table 21 - 3 metre Heap Leach - Residue Assays

Distance from top of heap (metres)	Residue assay ppm
0 - 0.5	0.90
0.5 - 1.0	1.02
1.0 - 1.5	1.90
1.5 - 2.0	0.98
2.0 - 2.5	1.24
2.5 - 3.0	0.75
Average:	1.13

Calculated head grade from carbon and residue 1.67gms/tonne.
Estimated recovery by heap leaching 32.3%.

6.6 The heap leaching appears to have been more effective in the top and base of the leach than in the centre. The reason for this is uncertain at this stage.

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7. GRINDING AND AGITATED LEACH

7.1 C.S.I.R.O. undertook tests on 7 splits of Sample B with varying degrees of grinding time. To each sample 2.5kg of lime was added and the original Na CN solution was 0.070%.

Table 22 - Grind & Agitated Leach Test - CSIRO Sample B

Test No.	% -75 microns	Leach Time hrs	Residual Assay ppm	Extraction ppm	%
338	35.9	6	0.99	0.61	38.
339	46.1	6	1.03	0.57	35.
340	64.6	6	0.94	0.66	41.
347	35.6	20	0.99	0.61	38.
348	46.1	20	0.90	0.70	45.
349	64.6	20	0.82	0.78	48.
334 *	97.9	72	0.73	0.87	54.

* This was an exhaustive test. Cyanide strength was 0.104% and lime added was 3.5 kg/tonne.

7.2 The detailed screen sizing of each sample was -

Table 23 - Screen Sizings of Grind Samples - CSIRO Sample B

Microns	Test 338 & 347	Test 339 & 348	Test 340 & 349	Test 334
+400	0.9	0.1		
-400/+300	5.6	0.8		
-300/+200	15.6	5.6	0.5	
-200/+150	17.4	15.2	4.0	
-150/+100	14.2	15.1	12.9	0.2
-100/+75	10.4	14.1	18.0	1.9
-75	35.9	46.1	64.6	97.9

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7.3 The C.S.I.R.O. results indicate that the improvement in recovery by grinding to 65% finer than 75 microns seems to be about 0.17 gms/tonne in the 20 hour leach tests. Ultra fine grinding to 97.9% finer than 75 microns improves the recovery by only another 0.09 gm/tonne.

7.4 Aberfoyle initially undertook grinding tests in bottle rolls on their sand samples ground to 100% minus 75 microns. Specific results are unavailable but recoveries were quoted as -

Table 24 - Aberfoyle Grinding Tests - % Recovery

Leach Time	Recovery
24 hours	54%
48 hours	64%
72 hours	59%

These results indicate an improvement in the % recovery, from 45% to around 60%.

7.5 Later another test was undertaken on the sands. (Again 100% minus 75 microns). 200 gram samples were used.

Table 25 - Aberfoyle - 2nd Grinding Test

Pulp density	35%
Na CN solution	0.25%
pH	10 - 10.5
(a) Sands	
Head grade	1.7 gms/tonne
Residue (after 72 hrs)	1.0 gm/tonne
Solutions	0.76 gms/tonne

Recovery % quoted were -

Based on residues	43%
Based on solutions	45%

In this case recovery is about the same as that obtained without grinding

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(b) Slimes

Head grade	0.8 gms/tonne
Residue (72 hrs)	0.75 gms/tonne
Solution (72 hrs)	0.33 gms/tonne

% recovery (based on residues) 38%
(based on solutions) 42%

7.6 The pregnant solutions were exposed to activated carbon. Based on carbon assays, the recoveries were 42% and 46% respectively. Again there is little improvement in recovery as a result of grinding.

7.7 David Wright ground a 500 gram sample from his Drum No. 1 and added the same reagents as quoted earlier. His results were -

Table 26 - D. Wright's Grinding Test Results

Final pH	10.8
Final Na CN	0.083%
Solution Assay (Equiv to g/t)	1.5
Gold recovered per solution	100%
Actual gold recovered onto carbon	1.37 gms/tonne
Recovery %	91.7%

In light of other results these appear artifically too high a percentage recovery indicating that his head grade assays may not have been an accurate representation.

7.8 In Epoch's initial bulk tests, a drum of samples from each of 8 different sites was ground to 100% minus 100 mesh (150 microns) in a small pilot plant roller mill, at a pulp density of around 60%. From the mill the undersize was pumped to an air agitated leach tank. Additional water

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was added to achieve a pulp density of around 40%. Cyanide and lime were added at a concentration of approximately $^{3}/_{4}$kg of cyanide per tonne and 2kg of lime per tonne. The sample was agitated overnight and then the quantity of gold in the cyanide solution was determined by an Atomic Absorption Spectrometer on site. The solution assays were checked by Australian Laboratory Services.

7.9 A small check sample from each of the 8 sites was taken and ground in a laboratory mill, placed in a beaker with cyanide and lime and stirred repeatedly and allowed to stand overnight and stirred again.

7.10 A second set of about ½ drum of samples (most of which had to be combined to get sufficient sample) were tested because of some abnormal results with the initial tests.

7.11 The results of the initial tests are set out in Table 27 on the next page.

7.12 The average calculated head grade from solution assays and residue assays was 2.65 gm/tonne. The average head grade from the earlier leach tests was about 2.2 gms/tonne. From the calculated head grade the indicted recovery is 60%, but from the leach test head grades actual recoveries based on residues may have been more in the order of 50%, and improvement of some 38% on the comparative air agitation tests (average recovery was 36%).

7.13 As an initial check small 50 gram samples were ground and assayed in the lab. The results are set out in Table 28 on page 33.

7.14 The solution grades are considerably lower for each sample and possibly more accurate than those set out in Table 27.

Based on a head grade of 2.2 gms/tonnes, the indicted recovery from the lab tests was 48%.

Table 27 - Ground 250kgs Bulk Samples - Cyanide Leach Test (Epoch)

Test No.	Pulp Density	pH	Free Cyanide	Free Lime %	Assay Grades ppm	Check Assay ALS	Residue Assay	% Recovery	Calculated Head Grade
1	38½%	9.2	0.035%	NIL	2.0	2.0	1.02	67%	3.0
2	34%	10.4	0.1%	0.0025%	1.55	1.63	5.70*	22.%	7.3*
3	44%	9.2	0.03%	NIL	1.52	1.56	1.0	61%	2.56
4	43%	10.1	0.06%	0.002%	1.66	1.28	1.04	55%	2.32
5	55%	10.1	0.085%	0.0012%	1.39	4.73*	1.53	47.6%	2.92
6	42%	10.5	0.06%	0.0012%	1.46	0.11**	1.09	57%	2.55
7	43%	9.8	0.35%	0.0017%	4.0*	3.39*	?	?	?
8	32%	9.6	0.04%		4.46*	4.90*	0.72	87%	5.6*
9	39%	9.5	0.04%		2.22	2.29*	0.83	72%	3.1*
Avg. (excluding*)					1.68	1.62	1.03	61%	2.65

* These grades appear to be too high

** These grades appear to low to be accurate

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Table 28 - Lab Grinding & Cyanide Tests - Epoch

Sample No.	Solution Grade* (ppm)
1	0.9
2	0.75
3	1.13
4	0.83
5	1.20
6	1.28
7	1.89
8	0.60
Avg.	1.07 g/t

* corrected for pulp density

7.15 The results of the repeat combined tests were -

Table 29 - Repeat Grinding & Cyanide Tests - Epoch

Sample No.	Solution Assays* ppm		Residue Assay	Head Grade	Recovery %
	Site	ALS			
1	0.9	1.06	1.00	2.06	51%
2 & 3	0.75	1.20	0.76	1.99	60%
4 & 8	0.63	0.93	0.91	1.84	50%
5 & 6	0.64	0.93	0.63	1.56	59.6%
7	2.76	3.81	0.87	4.68	81.4%
Average	0.96	1.37	0.81	2.19	58.9

* corrected for pulp density

8. CYANIDATION AFTER CLASSIFICATION

8.1 Noting that 63% of the gold in Sample B is extracted from the finest fraction and that a much smaller percentage is extracted from the coarse fraction, the C.S.I.R.O. tried to classify out the coarse sand and then to agitate the slime portion only.

8.2 In the test a sample was pulped with cyanide solution in a cylindrical vessel, stirred and allowed to settle. The pulp above a certain level was decanted off, the process repeated several times till the samples was free of slimes. The decanted pulp was thickened and agitated for 6 hours.

8.3 Two tests were conducted and the results were -

Table 30 - CSIRO Classification & Cyanide Tests

	Test 332	Test 333
Depth decanted	254 mm	254 mm
Time of each decantation	45 secs.	30 secs.
No. of decantations	3	3
Wt of sand residue	77.7%	74.3%
Assay of sand residue	1.29 ppm	1.20 ppm
Wt of slimes	22.3%	25.7%
Assay of slimes	1.66 ppm	1.60 ppm

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8.4 Screen sizings were -

Table 31 - CSIRO Classification Sand & Slimes Sizings

Microns	Sand Residue		Slimes	
	Test No. 332	Test No. 333	Test No. 332	Test No. 333
+600	4.4%	3.7%		
+400/-600	17.7%	17.2%		
+300/-400	19,5%	19.3%		
+200/-300 *	18.2%	19.2%	0.2%	0.2%
+150/-200	14.6%	15.7%	0.2%	0.9%
+100/-150	11.5%	12.5%	2.3%	6.5%
+75/-100	5.2%	7.3%	97.3%	92.4%
-75	5.9%	5.1%		

* for slime test + 200

8.5 After cyanide agitation the composite tailing assay was 1.36 ppm for the sands and 1.30 ppm for the slimes. The gold extracted was 0.24 ppm (sands) and 0.30 ppm (slimes), being only 15.0 and 18.7% respectively of the head grade.

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9. FLOTATION TEST

9.1 C.S.I.R.O. carried out four flotation tests on Sample B, each with varying degrees of grinding.

Table 32 - csiro Flotation Test Results

	Test 404	Test 402	Test 401	Test 403
%-75 microns	28.1%	55.8%	87.4%	87.4%
Soda Ash kg/tn *	1.0	1.0	1.0	
CN SO_4 kg/tn *	0.25	0.25	0.25	
Na S				1.0
Reagent 208	0.05	0.05	0.05	0.05
Reagent 301	0.05	0.05	0.05	0.05
Eucalyptus	0.03	0.03	0.043	0.03
Flotation time	8 mm	8mm	8mm	8mm
pH	8.3	8.3	8.3	8.5
Wt of conc.%	1.1	2.7	3.5	3.9
Assay of conc.	4.5	29.4	24.9	22.5
% recovered	(22.7%)	45.8	53.9	53.0
Tailings % wt	98.9	97.3	96.5	96.1
Assay of tails	(1.24)	0.97	0.78	0.87
% recovered	(77.3)	54.2	46.1	47.0

* Added in ballmill

** Added in flotation stage

9.2 The screen sizings of the flotation tails were -

Table 33 - Tails, Sizings, Flotation Tests

Microns	Test 402	Tests 401 and 403
+ 200	3.2	0.1
200/150	12.3	0.7
100/150	13.6	3.2
75/100	15.1	8.8
-75	55.8	87.4

9.3 The recovery by flotation is poor where the sample has not been re-ground as in Test 404, but improves considerably with fine grinding. There seems little difference in recovery after grinding between cyandization and flotation.

9.4 Two flotation tailings were cyanided and the results are set out on Table 34 on the next page.

9.5 In test 403, the sample had been ground to 87.4% minus 75 microns. The overall recovery by flotation and cyanidation was 1.0 gm/tonne (62.7%).

9.6 In test 404 the sample had not been re-ground. The overall recovery of flotation and cyanidation was 0.55 gms/tonne (34.6%).

9.7 The recovery by flotation and cyanidation is only marginally greater than by cyanidation alone. (Less than 0.1 gm/tonne).

Table 34 - Cyanidation of Flotation Tails

Test No.	Time hrs	Lime added	Orig. Sol. % Na CN	Consumption kg/tonne lime	Consumption kg/tonne NaCN	Residue Assay ppm	Extraction ppm	% Recovered
403	6	2.5	0.077	1.6	0.15	0.6	0.27	31.1
404	6	2.5	0.077	1.5	0.15	1.05	0.19	15.7

10. SUMMARY OF RESULTS

10.1 The results of the various cyanide leach tests that have been conducted, where no prior grinding has taken place and where lime and cyanide additions have been kept at a reasonable level and where leach agitation has not exceeded 24 hours, can be summarized as follows. (based on fire assays of head grade and residue)

Sample	Head Grade	Extracted g/t	Residue g/t	Recovery
1. CSIRO A	1.98	1.36	0.61	69%
2. CSIRO B	1.60	0.61	0.99	38%
3. CSIRO C	1.38	0.36	1.02	26%
4. ABERFOYLE SAND	1.90	0.78*	1.12	41.0%
5. ABERFOYLE SLIMES	1.0	0.43	0.57	43.0%
6. D. WRIGHT	2.08	1.37	0.71	61.5%
7. RRA	1.34	0.48	0.86	35.8%
8. EPOCH	2.07	1.03	1.04	49.7%

Extraction

* corrected for head grade and residue assay

10.2 Although not all tests are necessarily as representative as others, if we take the average of all the above tests, the average for the head grades is 1.66 gms/tonne, a figure close to the average for both drilling programmes of 1.7 gms/tonne. The average for the extraction is 0.80 gms/tonne and the average for the residue 0.86 gms/tonne.

The average recovery is then around 48%.

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10.3 However, a figure I feel we could more comfortably use for extraction of gold by cyanide leaching would be 45% or 0.75 gms/tonne. In richer parts of the dumps. the recovery is likely to be higher (up to 80%) and in poorer parts of the dump it will be lower (down to 25%).

10.4 The only heap leach tests carried out so far are the recent tests by Epoch which indicated a recovery of around 0.55 gms/tonne or 32%. It would be unlikely that the heap leach recovery could exceed that of the agitated leach, but with experimentation and refinement it may be possible to get the recovery up to 0.6 or even 0.7 gms/tonne?

10.5 A summary of the results of agitated cyanide leach after grinding are -

	Head Grade	Extracted g/t	Residue g/t	Recovery
1. CSIRO B	1.98	0.78	0.82	48.8%
2. ABERFOYLE SANDS	1.7	0.7	1.0	41.1%
3. EPOCH	2.2	1.37	0.81	58.9%

10.6 Based on an average overall grade of the richer part of the dump, of 1.7 gms/tonne, it should be possible to extract 50% of the gold by grinding or 0.85 gms/tonne. Again the results indicate that in richer parts of the dump the percentage recovery is likely to be higher and in the poorer parts of the dump it is likely to be lower.

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11. CONCLUSION

11.1 Metallurgical test work to date indicates that the average gold extraction rate we might expect on the Mathinna dumps -

By heap leaching	0.55 gms/tonne
By agitated cyanide leaching	0.75 gms/tonne
By grinding and agitated cyanide leaching	0.85 gms/tonne

11.2 As heap leaching is by far the lowest capital cost method of retreatment, the object of further test work on the dumps must be to try and get the rate of recovery by heap leaching up to close to that achieved by agitated cyanide leaching.

11.3 Comparative costs for a 50,000 tonne per annum plant are

	Capital	Operating (per tonne)	Amortization per tonne over 4yrs	Gold Income at $450 per ounce	Potential profit per tonne
Heap Leaching	$150000	$6.00	$0.75	$8.00	$1.25
Agitated Cyanide Leaching	$400000	$10.00	$2.00	$10.87	NIL
Grinding & Agitated Leaching	$750000	$12.50	$4.75	$12.30	NIL

11.4 If we can extract 0.7 gms/tonne by heap leaching then the potental profit would increase to $3.40 per tonne ($170,000 per annum) which is around the optimum 100% return per annum on capital invested.

11.5 A further 30 holes have been drilled at Mathinna to provide samples for further test work to see if the recovery by heap leaching can be improved.

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11.6 At the same time we need to look closely at the capital and operating costs of heap leaching to see if they can be reduced in this instance to improve cashflow.