APPENDIX C
Bateman Engineering Scoping Study

HOPE BAY JOINT VENTURE

(A 50:50 Joint Venture between Miramar Hope Bay Limited and Hope Bay Gold Corporation Inc.)

c/o Miramar Mining Corporation
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DORIS NORTH TRIAL OPERATION SCOPING STUDY

(Preferred Option)

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This report (Doris North Trial Operation Scoping Study) has been prepared for the Hope Bay Joint Venture in accordance with the scope of services and the terms of reference both of which were defined by the Hope Bay Joint Venture in their inquiry document.

Bateman followed standard professional procedures in preparing the Scoping Study Report, the contents of which is based in part on data, information and assumptions provided by the Hope Bay Joint Venture.

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1 INTRODUCTION

Bateman Engineering Pty Ltd (Bateman) received an invitation from the Hope Bay Joint Venture (HBJV) to complete a scoping study on its Hope Bay project. This study examines process options that would allow HBJV to fast-track the project by concentrating on processing Doris North ore at a design rate of 600 tonnes per day over an initial 2 year period. The intention would be to commence production in autumn 2004.

HBJV initially looked at two options to determine the best approach to gain fast approval for the project. The first option was essentially identical to the 1000 tpd modular plant option previously considered, producing gold dore from cyanide leached gravity and flotation concentrates on site. The second option aimed to produce gold dore from gravity concentrate on site and to produce a high grade flotation concentrate for shipping thereby eliminating the need for cyanide usage on site. During the course of the study, the second option was eliminated so that only a single option is included in the final study.

The selected option is very similar to the 1000 tpd circuit presented in the previous study, which had been costed to 25% accuracy. Therefore, the option presented in this study uses the previous model as a foundation, revising down to a 600 tpd treatment rate. The current option also incorporates water supply and tails delivery to the storage dam.

Additional test work has been completed on Doris North ore to establish key design parameters. Design criteria, PFDs and equipment list have been generated reflecting this new information. A capital estimate has been prepared for the option using this data. Operating costs have also been estimated for the option.

2 SCOPE OF STUDY

2.1 PROCESSING

Two scenarios were given preliminary consideration in this study:

- Option A - an integrated modular plant to produce gold dore on site using the base case configuration presented in Bateman's first scoping study for the HBJV earlier this year. This features rougher gravity and flotation concentration followed by intensive cyanide leaching, direct electrowinning and dore smelting

- Option B - this is a truncated flowsheet compared with Option 1. It features gravity and flotation steps only. The objective is to produce a high-grade gravity concentrate that can be converted to gold dore by direct smelting and a higher grade flotation concentrate for shipping out during the summer months to another facility for processing to dore.

Both options assume that a modular facility will be installed in the vicinity of the Doris ore tenements and that the facility can be built on a level bedrock base. The rock base is critical if expensive foundations to protect the permafrost are to be avoided.

In discussion with the client following an assessment of both options, Option B was eliminated from further consideration, with only Option A being given full consideration for the study.

This study covers the processing plant from the ROM pad through to the discharge to the tailings containment area, as well as supply of water from a nearby lake to the process plant. Other battery limits are reagent and stores delivery to the usage or mix point in the plant, the low voltage side of the power transformer and the bullion into the safe.

Preliminary engineering has been performed to a level sufficient to generate a ±25% capital cost and operating cost estimate for the selected process route. The plant is based on the design criteria and philosophy derived for the RFP and discussions with the client before and during the course of the study, and on the new test work on the Doris North ore. The process route consist of the following process steps:

- Crushing and fine ore storage
- Milling and classification
- Flash flotation
- Rougher gravity concentration
- Scavenger flotation

- Flotation concentrate regrind
- Intensive cyanide leaching
- Concentrate or residue filtration
- Gold room
- Cyanide destruction of leach tails
- Tails disposal
- Process plant services and utilities
- Water supply

2.2 TAILINGS

Bateman has provided for detoxified tails slurry to be delivered to a containment dam located 3 km away via insulated pipes. Emergency tails slurry dumping to lined ponds is also provided.

2.3 SCOPE DEFINITION

The Study was developed based on the following functional areas that together form the overall integrated facility:

- Two stage crushing circuit and fine ore stockpile.
- Primary ball mill circuit including gravity recovery and flash flotation.
- Scavenger flotation circuit.
- Flotation concentrate regrind
- Combined concentrate intensive cyanide leach circuit with residue solid/liquid separation.
- Direct electrowinning of filtrate and doré production.
- Leach residue/electrowinning bleed cyanide detoxification and combined tailings disposal.
- Plant services and reagents.
- Water supply.
- Some plant infrastructure generally within the plant area.

2.3.1 GENERAL

The project scope includes all the physical aspects of the respective areas including:

- Civil works.

- Structural steelwork.
- Platework.
- Tankage.
- Mechanical equipment.
- Piping, including external water supply and tailings disposal.
- Electrical equipment and power distribution.
- Instrumentation and control systems.
- Some site buildings including switchrooms.
- Allowance for spare parts and first fills.

All designs allow for a 10-year plant life and conform to the appropriate industry standards. The design allows for an extension of operation beyond the initial Trial Operation of 2 years. Alternatively the plant could be relocated to another site for further use.

2.3.2 EXCLUSIONS

Items excluded from the project scope are:

- Process plant site preparation to form a level, rock base for construction.
- Provision of services and infrastructure to the plant battery limits.
- Other Owner's costs such as, permits, insurance, financing, patents, licenses and technology fees.
- Environmental monitoring systems.
- Environmental impact studies.
- Environmental reinstatement.
- Sustainability of water supply source.
- Potable water treatment plant.
- Water supply issues – environmental, sustainability, quality, logistics, etc.
- ROM ore pad.
- Mine haul roads.
- Site access roads.
- Tailing disposal access roads.
- All mining activities.
- Metallurgical testwork (although some cost allowance is made in Owners costs).

- Materials testing.
- Power station and HV protection.
- Heating of plant and infrastructure buildings. An allowance has been made for an indicative cost for heating the process buildings only.
- Workshop equipment, mobile equipment and wash-down facilities.
- Site construction camp.
- Tailing containment dams and ponds.
- Insurance spares.
- Land acquisition, rights of way and royalties.
- Financial analysis model.

2.4 BATTERY LIMITS

The battery limits for the process plant described in the study are:

- Receipt of the ore at the ROM bin.
- Discharge of tailings into the containment dam.
- Entry of water to the decant tower at the lake.
- HV terminal from the power station located at the plant site (by others).

Capital costs for the project are based on the purchase of all-new equipment and materials, with appropriate shipping costs being built in to equalise the costs "as landed" at Hope Bay. The use of second-hand equipment has not been investigated.

3 TEST WORK REVIEW

Considerable testwork for the Doris deposit has been undertaken prior to the current study by PRA Laboratories in Vancouver under instruction from the client. Much of this work relates to whole ore treatment by cyanide leaching, and as such is not directly applicable to the proposed modular plant flowsheet. Some preliminary flotation work has also been completed, including batch cleaner flotation evaluation, with only limited success being achieved due to the open circuit nature of these tests.

In consultation with the client, Bateman devised a new test programme of narrow focus which aimed at producing key process criteria to assist with design of the modular gravity/flotation/leach plant adopted for the option selected for this study.

A bulk composite of Doris North material was used for all aspects of this work, which was also completed by PRA Laboratories. This programme consisted of the following elements:

- Head analysis – gold, silver and sulphur
- Feed preparation – stage crushing and grinding down to a P_{80} size of around 150 um
- Gravity concentration – two passes through a Falcon SB40 batch concentrator without subsequent cleaning
- Flotation – rougher/scavenger flotation of gravity tails at natural pH, exploring the effects of different xanthate collectors, addition of a gold/pyrite activator and the addition of a gangue depressant.
- Cyanide leaching – timed intensive leaching of gravity concentrate (test F41), and leaching of flotation concentrates from three flotation tests (tests F42 to F44)
- Thickening and filtration – static tests on a combined flotation tails sample
- Cyanide detoxification – batch cyanide destruction of leach liquors using hydrogen peroxide

A completed testwork report has not been forwarded to Bateman for inclusion in the report, but selected results have been included in this report section as a basis for discussion.

3.1 HEAD ASSAYS

The composite sample provided for testing returned the following analysis, presented as average calculated values:

Gold	6.24 ppm
Silver	1.25 ppm
Sulphur	0.47%

The gold analysis for the sample was substantially lower than the design values of 15 to 20 g/t adopted for the study, although this does not appear to have adversely affected overall gold recovery to concentrate.

Silver content is only 20% of the gold content, meaning that adoption of Merrill-Crowe zinc precipitation should not be necessary.

Sulphur grade is quite low also, suggesting a correspondingly low sulphide yield to flotation concentrate.

3.2 GRAVITY CONCENTRATION

The bulk composite, after grinding to around 80% -150 um, was passed through a laboratory batch Falcon SB40 centrifugal concentrator to produce a rougher gravity concentrate, the intent being to subject this to intensive cyanide leaching rather than upgrading further to smeltable grade.

A very favourable upgrade of gold to gravity concentrate was achieved, with nearly 70% of feed gold being recovered in only 4.4% of feed mass. Silver recovery was somewhat lower, which could possibly be attributed to association with sulphides, whereas the majority of the gold content is likely to be either free or alloyed with silver as electrum. Mineralogy is required to confirm the silver and gold associations within the concentrate.

Relevant results are presented as Table 3.1.

Table 3.1 **DORIS NORTH BULK GRAVITY CONCENTRATE TESTWORK RESULTS**

	Feed	Concentrate	Tail
Mass Splits (%)	100	4.4	95.6
Assays			
Au (ppm)	6.24	101	1.97
Ag (ppm)	1.25	13.7	0.68
Metal Dist.n (%)			

	Feed	Concentrate	Tail
Au	100.0	69.9	30.1
Ag	100.0	48.2	51.8

3.3 FLOTATION

Four tests were conducted on gravity tails at "natural" pH (no pH modifier added to pulp), which was reported previously to be in the range 8 to 8.5, but was not reported by PRA for the tests discussed here. The matrix of conditions being summarised below as Table 3.2.

Table 3.2 **SUMMARY OF PROCESS CONDITIONS FOR FLOTATION TESTS**

TEST	**F41**	**F42**	**F43**	**F44**
Feed P_{80} Size (um)	148	149	153	148
Time (mins)				
Conditioning (Rougher + Scavenger)	3	3	3	10
Rougher Flotation	15	15	15	15
Scavenger Flotation	15	15	15	15
Total	33	33	33	40
Reagent Additions (g/t)				
$CuSO_4$		80	80	
PAX	50	50		50
SIPX			50	
MIBC	30	30	30	30
CMC				75

Test F41 was designed to represent "base case" conditions, adopting a regime of a strong collector, PAX (potassium amyl xanthate), and a universal frother, MIBC (methyl iso-butyl carbinol).

Test F42 examined the effect of adding copper sulphate to Test F41 base conditions to activate pyrite and tarnished free gold.

Test F43 examined the effect of using a more selective collector, SIPX (sodium iso-propyl xanthate) in conjunction with copper sulphate activator in order to target free gold and sulphides associated gold, whilst rejecting barren gangue.

Test F44 reverted to the use of PAX as a collector in conjunction with a depressant, CMC (carboxymethylcellulose) to reject carbonate and graphitic gangue.

Table 3.3 summarises pertinent results of the bench scale flotation tests performed on gravity tail material, adopting the process conditions in Table 3.2.

Table 3.3 **SUMMARY OF FLOTATION TEST RESULTS**

	F41	F42	F43	F44
Mass Pull to Concentrate (% of new feed)	13.2	14.2	12.3	11.9
Recovery to Concentrate (% of flotation feed)				
Gold	94.4	92.4	88.6	93.0
Silver	78.1	88.6	75.9	88.4
Sulphur	97.1	97.8	96.6	97.7
Flotation Concentrate Assays				
Gold (ppm)	46.2	42.5	48.4	52.9
Silver (ppm)	3.5	6.8	6.9	9.0
Sulphur (%)	3.24	3.70	3.11	4.27
Flotation Tails Assays				
Gold (ppm)	0.12	0.16	0.23	0.16
Silver (ppm)	0.10	0.10	0.20	0.10
Sulphur (%)	0.01	0.01	0.01	0.01

Test F41

Base conditions provided an acceptable gold recovery of 94.4% to concentrate, which is the highest produced for this round of testing. This was achieved at the expense of a higher than desirable mass pull of 13.2% of new feed, implying a degree of non-selectivity occurred. Silver recovery was lower at 78%, which may be related to lack of activation of silver sulphosalts. Sulphur recovery was high at 97.1%.

Test F42

The addition of copper sulphate to the base conditions had the result of increasing mass pull to concentrate, due probably to increased yield of barren pyrite. Recovery was seen to drop slightly, which is puzzling, as copper sulphate is a common activator for free gold as well. Silver recovery improved to 88.6% over base conditions, implying that copper sulphate has assisted with activation of sulphide-associated silver. Sulphur recovery was high at 97.8%, but overall copper sulphate addition appears to have not had an overly beneficial effect on performance.

Test F43

Addition of SIPX in place of PAX as the collector improved selectivity, as evidenced by the reduction of concentrate mass pull to 12.3% of new feed, but gold recovery suffered as a consequence, dropping to 88.6%. Silver recovery also decreased below the level of the previous test, which indicates that a strong collector is required to achieve sufficient gold recovery. Sulphur recovery was down slightly to 96.6%, which is also attributed to the use of a weaker collector.

Test F44

The use of CMC as a depressant resulted in gold recovery being increased to 93%, which still sits below base case conditions. However, mass pull has been reduced to 11.9% through rejection of gangue. Silver recovery was 88,4%, which is equivalent to Test F42 and higher than that seen under base case conditions. Sulphur recovery is also on par with Test F42 and superior to base case conditions.

Overall, however, this limited test series indicates that high gold and sulphur recoveries can be achieved using a simple reagent regime of PAX and MIBC at natural pH conditions, with acceptably low mass pulls in the region of 12 to 14% of new feed. There is some concern as to the high pH of 8 to 8.5 measured by PRA without the addition of an alkali to the slurry, as optimal recoveries are normally seen at neutral pH. It is uncertain if the slightly alkaline conditions have adversely affected flotation performance. However, the results are definitely encouraging and form a solid foundation for optimisation in the feasibility study.

Cleaning tests have not been performed in this test series, as the main aim of these tests was to obtain high recovery to a rougher concentrate for leaching on site. It is likely that closed circuit cleaning would result in a significant drop in concentrate mass, which can pursued in the feasibility study if minimising concentrate mass becomes a critical factor.

3.4 CYANIDE LEACHING

Timed cyanide leach tests were undertaken on concentrates from the three variability flotation tests F42 to F44. An additional test was undertaken on gravity concentrate prepared for Test F41 to confirm that coarse gold can be leached within reasonable leaching durations. All tests adopted the following conditions:

- 48 hrs total leach duration
- pH target of 10.5
- free cyanide level of 3000 ppm
- pulp density of 30% solids w/w

The results of these tests are summarised in Table 3.4.

Table 3.4 **SUMMARY OF CYANIDE LEACH TEST RESULTS**

	F41	F42	F43	F44
Feed Source	**Gravity Concentrate**	**Ro/Sc Concentrate**	**Ro/Sc Concentrate**	**Ro/Sc Concentrate**
Leach Feed Grade (g/t Au)	100.5	17.4	19.9	25.0
Au Recovery (%)				
6 hrs	85.5	75.7	85.8	74.5
24 hrs	98.1	94.9	90.7	86.9
48 hrs	97.9	87.1	93.6	85.3
Ag Recovery (%)				
6 hrs	87.4	56.6	87.0	60.4
24 hrs	99.4	64.4	76.2	58.9
48 hrs	98.5	73.5	79.4	60.9
Net Reagent Consumption (kg/t)				
Cyanide	3.30	4.99	3.77	5.85
Lime	0.24	0.33	0.35	0.65
pH				
Start	10.7	10.8	10.7	11.0
End	11.7	12.2	11.8	11.6

	F41	F42	F43	F44
Feed Source	**Gravity Concentrate**	**Ro/Sc Concentrate**	**Ro/Sc Concentrate**	**Ro/Sc Concentrate**
D.O. Level (ppm)				
Start	10.5	9.5	9.3	8.9
End	8.7	8.1	9.0	9.0

Gold leaching kinetics for the flotation concentrate leach tests were uniformly slower than expected, considering that the gold is mostly free or partially liberated, and fine in size. A single analysis of particle size of the flotation concentrate indicated a size of 86% passing 38 um, which is considerably finer than would normally be encountered in the plant. This may be attributed to either a fine crystal structure of the pyrite, or overgrinding in the laboratory mill. It is also uncertain if the concentrate has been reground prior to leaching.

The main cause for the slow kinetics is suspected to be coating by gypsum on gold surfaces, which acts as a diffusion layer, retarding the cyanide leach reaction. This gypsum is produced through the reaction between the lime added for pH modification and sulphate produced by the oxidation of sulphide in the pulp. It is likely therefore that if sodium hydroxide had been used, as is the intended practice in the plant to ensure compatibility with direct electrowinning, gypsum formation would be minimal and leach kinetics should improve considerably.

Kinetics were also seen to be slow for the gravity gold concentrate leach test as well, which is attributed to the gypsum coating problem discussed above, and the physical size of the coarser gold particles which take longer to dissolve. In the leach reactor intended for the modular plant, however, the internal baffles are effective in holding back coarse gold particles so that they receive extended leach residence time compared with the finer gold particles, hence maximising leach recovery.

Experience with other intensive leach circuits where the gold is not encapsulated in gangue or in solid solution with sulphides has been that the reaction should be mostly completed with 8 hours, versus the 24 to 48 hours indicated from the current test series. In the next series of tests, it is therefore recommended that caustic be used in place of lime for pH control.

In addition to this, operating at high pH levels can retard leach kinetics. Although a target pH of 10.5 was sought, terminal pH was 11.6 to 12.2 for the tests, which is excessive.

Cyanide consumptions of 4 to 6 kg/t were reported. However, these are net consumptions only, and assume that cyanide would be recovered from the leach liquor. In the plant, much of the cyanide will be destroyed in the electrowinning process, the rest being returned to the leach reactor for reuse. Therefore, correcting for, say, 50% loss of cyanide in final leach liquor, consumptions rise to the range of 6.5 to 8.3 kg/t leached. Assuming a mass split to leaching of 14%, consumption per tonne of new feed is 0.9 to 1.2 kg/t, which is in line with the value of 1.1 kg/t of new feed adopted for design.

3.5 THICKENING AND FILTRATION

Limited static testing on flotation tails material was conducted. No work has been undertaken on flotation concentrate or concentrate leach residue due to insufficient material being available at this time.

Thickening

Results are as flows:

Specific settling rate = 0.13 m2/t.d

Underflow density = 60% solids

Flocculant addition = 4 g/t Percol 351

Slurry pH = 10.0

Lime addition = 13 g/t

Initial pulp density = 30.6% solids w/w

Supernatant clarity = good

The settling rate achieved is lower than expected for this type of ore and for the coarse particle size of 80% -150 um adopted. Normally a higher flocculant addition in the region of 50 g/t is necessary to achieve sufficient flocculation for a high rate thickening application, versus the 4 g/t addition used which is more in line with conventional thickening.

It is also noted that lime has been added to modify the pH to 10. Lime is a good coagulant and promotes flocculation of fine and colloidal material. However, the use of pH modifiers is not consistent with the intended process route, where thickener overflow will be recycled to the process water tank and reused for repulping new feed. Hence, the net result would be that process water would become alkaline, which is expected to have a deleterious effect on gold and sulphide flotation. In practice, tails thickening would need to be undertaken at natural pH, probably pH 8, and an alternative coagulant can be added, such as polyacrylamide or aluminium sulphate, which will not interfere with the pH of the overflow solution.

On a positive note, the underflow density achieved was quite high at 60% solids w/w, which allows a high proportion of process water to be recovered from flotation tails.

The preliminary result is encouraging, and additional work involving vendors can be undertaken in the feasibility study to firm up the required thickener size and process parameters. It should be noted, however, that testwork in this area is no longer considered as essential as tails thickening has been deleted from the current flowsheet. Unless water conservation becomes an issue, it is unlikely that it will be evaluated any further in the feasibility study.

Filtration Results

Results are as follows:

Initial pulp density = 66% solids w/w

Slurry pH = 10.1

Filtration area used = 200 cm^2

Cake thickness = 1.5 cm

Final cake moisture = 11.0%

Filtrate clarity = good

Filtration time = 50 secs

Dry mass of cake = 463g

Based on these results, a filtration rate of 1.56 t/m2.h is calculated, which represents a material that is very easy to filter. This value would need to be firmed up by vendors using dynamic test methods during the feasibility study, but the initial result suggests that filtering the flotation tailings is viable. As with the thickening tests, filtration of tailings is no longer considered relevant, as it has been omitted from the flowsheet.

Flotation concentrate was not filtered due to insufficient sample being available for testing.

3.6 CYANIDE DETOXIFICATION

A single cyanide detoxification test using hydrogen peroxide as the destruction agent was performed on leach liquor from the concentrate leach tests. The outcome of the test was unsatisfactory as unacceptably high levels of complexed metal cyanide species, in particular with copper and iron, were still present in solution, even after adding peroxide at 10 times the stoichiometric dosage. WAD cyanide destruction was achieved to a reasonably low level however.

To achieve acceptably low total and WAD cyanide levels, which is currently less than 1 ppm and 0.5 ppm respectively according to World Bank guidelines, the use of Caro's Acid (a stoichiometric mix of hydrogen peroxide and sulphuric acid) or the INCO method are required. If the use of cyanide is to be incorporated in the design for the feasibility study, this will need to be tested comprehensively to meet the required standards.

4 PROCESS DESIGN CRITERIA

Process design criteria for the Doris North Trial Operation Scoping Study were developed by interpreting supplied testwork reports for the Doris project and applying suitable process parameters from Bateman's design database where test values were not available. The projected plant feed grade and daily plant throughput were specified by Miramar Mining Corporation for the HBJV.

The plant design is based on the scope of work detailed in Section 3 and the design criteria. Mechanical, civil, structural and electrical designs allow for a 10-year plant life and conform to the appropriate Australian and industry standards. Provision for future plant capacity expansion has not been made.

Design criteria are listed in Appendix A. These criteria were derived from several sources as detailed in the document and came primarily from:

- Final Report on Preliminary Metallurgical Testwork, Doris Gold Project, (prepared for BHP Minerals International Inc. by International Metallurgical and Environmental Inc., 1998).
- Test Work Reports from PRA.
- Discussions and advice from the client.
- Bateman Engineering in-house data or recommendation.
- Vendor data.
- Calculations.
- Assumptions requiring further confirmation from other sources.

5 EQUIPMENT LIST

A block flow diagram and mass balance for the proposed plant design have been provided in Appendix B. These flow diagrams have been used with aspects of the design criteria to size the major process equipment items. An equipment list has also been developed for the option and is presented in Appendix C.

6 PROCESS DESCRIPTION

6.1 CRUSHING

Process flow diagram 300-B-DF-001 in Appendix D shows this circuit schematically.

Run of mine (ROM) ore is delivered from stockpiles by FEL to the ROM bin on an 18 hours per day basis. The ROM bin, vibrating feeder and jaw crusher are an integral modular unit built on the same sub-frame. A static grizzly screen to prevent oversize from entering the crushing circuit is located on top of the bin. A rock breaker can be used for any material not passing through the 600 x 600-mm openings. Grizzly undersize at –75 mm drops directly onto the discharge conveyor, whilst oversize is fed to the jaw crusher, set at 110 mm CSS, also discharging onto the conveyor.

To minimise dust generation from loading the bin with ore, and to separate the loading operation from the heated crushing plant dome, the ROM ore receival and primary crushing module are to be located inside a dedicated supported chamber that is exposed to the elements at the ROM bin end. The discharge conveyor passes through skirts into the main crushing dome. This conveyor arrangement includes tramp iron magnet to remove any scrap steel and a weightometer to monitor crushing production.

Conveyor discharge drops onto the product screen, configured with 38 mm apertures in the upper deck and 13 mm apertures in the lower deck, both in rubber construction. Screen oversize drops directly into the cone crusher, which discharges onto the first of two conveyors that recycles material back to the screen feed conveyor. Screen undersize at –13 mm is fed to a stacking conveyor which can be raised or lowered depending on the status of the stockpile height, thus minimising dust generation.

Insertable dust extractors are fitted to both crusher discharges, and suppression sprays are fitted to minimise dust emissions on fine ore product discharge to the stockpile.

6.2 MILLING, GRAVITY & ROUGHER FLOTATION

Process flow diagram 300-B-DF-002 in Appendix D shows this section of the circuit.

Fine ore is back-loaded from the surge stockpile by FEL into the reclaim hopper located over the ball mill feed conveyor. The ball mill, a shell supported hydraulic drive unit, will discharge ground slurry into the mill discharge sump. The duty gravity/cyclone feed pump (with one standby) pump slurry through a continuous in-line pressure jig to recover free coarse and medium sized gold particles. The jig handles the entire mill discharge stream, thus ensuring early capture of nuggety or flaky gold before it is broken up into finer particles or trapped in the circulating load. Hutch water is applied to assist the separation process. Jig concentrate gravity flows to the intensive cyanide leach reactor (ILR) feed hopper, whilst jig tails under pressure feed the cyclone cluster.

Cyclone underflow will gravitate to a distribution box where the split of circulating load returning to the ball mill can be roughly controlled between 0 and 100%. The design allows for 100% of the slurry to gravitate into a single flash flotation cell to recover the remaining coarse gold, free fine gold and fast floating sulphides, principally pyrite. Flotation reagents are added from head tanks to flash cell feed, these being activator (copper sulphate), promoter (3418A), collector (PAX) and frother (MIBC). Flash flotation tails discharges from the bottom of the unit and launders back into ball mill feed. Flash flotation concentrate launders into the regrind mill discharge sump.

The milling and gravity area has a floor sump and pump for spillage and clean up.

6.3 SCAVENGER FLOTATION

Process flow diagram 300-B-DF-003 depicts the scavenger flotation section of the plant in Appendix D.

Cyclone overflow is classified to P_{80} = 125 microns and flows directly to the scavenger flotation feed conditioning tank, where additional flotation reagents are added via the head tanks. The tank is agitated and has a residence time of 5 minutes. Slurry discharges from the tank and gravity launders into the first of four stepped tank cells, with a minimum total residence time of 30 minutes. Each cell is fitted with froth crowder rings to maximise recovery of lower grade froth expected in this part of the circuit. Scavenger tails launders into the final tails hopper, whilst combined scavenger concentrate is pumped via a vertical froth pump over to the concentrate regrind mill discharge sump.

The scavenger flotation area has a floor sump and pump for spillage and clean up.

Dedicated flotation blowers provide low-pressure air to the flash flotation cell and the scavenger flotation cells.

Cross-cut samplers have been included on scavenger flotation feed and tails streams to provide the means of monitoring metallurgical performance of this circuit. All other streams are considered to be of sufficiently low flow rate to allow hand sampling for metallurgical balance purposes.

6.4 CONCENTRATE REGRIND & INTENSIVE CYANIDE LEACHING

This circuit is shown schematically in process flow diagram 300-B-DF-004 in Appendix D.

The reground flotation concentrate and gravity concentrate meet at the feed settling cone of the ILR unit, where they are dewatered to 75% w/w solids pulp density. Settling cone overflow water drops into the floor sump and is pumped across to the ball mill discharge hopper, along with belt filter and general spillage. Depending on water volume and the nature of the spillage, this could also be pumped to the final tails hopper. Underflow feeds the ILR unit, which is a rotating drum of 8 hours residence time fitted with baffles and lifters to provide adequate mixing and to minimise short-circuiting. Cyanide addition is made to the feed chute to the unit in addition to recycled spent electrolyte from electrowinning.

Slurry discharges into a small sump and is pumped up to the residue settling cone. Leach liquor overflows from the unit and launders to the rich electrolyte tank located next to the gold room. Decant underflow feeds a small belt filter fitted with three stages of counter-current washing to maximise gold recovery whilst applying minimum wash water dilution (estimated to be 1 tonne wash water per tonne of contained cake moisture). Filtrate is pumped to the rich electrolyte tank. Belt filter discharge at 85% solids discharges into a launder and is repulped by spent electrolyte bleed solution before laundering into the cyanide detoxification reactor.

6.5 GOLDROOM

Process flow diagram 300-B-DF-005 in Appendix D shows the goldroom schematically.

Liquor containing gold produced from the intensive cyanide leach circuit is stored in the rich electrolyte tank. Solution is pumped to two electrowinning cells, configured in series, to recover gold. The majority of gold is extracted from the first cell, whilst the second cell serves to scavenge remaining gold values from the electrolyte thus ensuring high gold recovery per pass. The resulting barren electrolyte solution is split roughly 60:40 between a recycle to ILR feed and the rest to leach residue cake repulping ahead of cyanide detoxification.

The electrowinning cells contain steel wool cathodes to remove the gold from the electrolyte. Loaded cathodes are removed periodically from the cells using a hoist and replaced with fresh cathodes. The loaded cathodes are washed and dried in a calcining oven where steel is oxidised. The calcine is smelted in the barring furnace with a mixture of pre-weighed fluxes. Molten gold is poured into doré moulds, weighed and stored in the safe awaiting shipment.

Fumes from smelting and electrowinning are controlled through the installation of an extraction system.

6.6 CYANIDE DETOXIFICATION AND TAILINGS HANDLING

Process flow diagram 300-B-DF-006 in Appendix D shows this circuit schematically.

Bleed barren electrolyte from the goldroom is used to repulp cyanide leach residue, and is contacted in a small agitated reactor with Caro's Acid, a stoichiometric mix of sulphuric acid and hydrogen peroxide. Free cyanide and WAD cyanide complexes in solution are rapidly destroyed and the overflow from the tank is gravity discharged into the final tails sump. The combined flotation and leach tailings are pumped via a pair of insulated pipes to a containment dam located some 3 km away. Lined emergency ponds are provided for to allow automatic discharge of tailings in the event of a burst pipe further down the line, or transient excessive cyanide content in tailings thus ensuring the tailings in the main containment dam are not contaminated with cyanide.

6.7 REAGENTS AND PLANT SERVICES

Reagents (300-B-DF-007)

Collector

Potassium amyl xanthate (PAX) is added to flash and scavenger flotation areas to provide strong hydrophobic collector ability for floating sulphides and free gold. It is usually non-selective, and useful for bulk concentrate production to maximise recovery. It is received in drums (100kg) and mixed in batches in an agitated mix tank to 10% strength using a drum tipper and hoist. Xanthate solution is transferred to a storage tank and pumped to a header tank and dosed via dosing valves into the flotation circuits, with header tank overflow returning back to the distribution tank.

Frother

Methyl iso-buytl carbinol (MIBC) is added to assist with froth formation which in turn facilitates sulphides and fine gold recovery. MIBC is a general purpose economical frother commonly used in gold flotation operations. It is received on site in 200L drums, and is pumped up to a header tank located in the flotation area and dosed neat to the flotation circuits with dosing valves.

Promoter

Aerophine 3418A promoter is added to enhance native gold and silver recovery, and combines well with the strong collecting power of PAX, although it can work against pyrite flotation efficiency. Although it is water soluble, given the small dosing rate, it will be pumped neat to a header tank located in the scavenger flotation area and dosed neat into the flotation circuit with dosing valves.

Activator

Copper sulphate is added to activate sulphides, in particular pyrite, and generally assists in speeding up kinetics. It will be mixed manually in a mixing tank to 10% solution strength, transferred to a storage tank and pumped up to a head tank for dosing into flotation areas, with tank overflow returning to the storage tank.

Sodium Cyanide

Sodium cyanide is received in bulk bags and stored for use in a reagent compound. Using a lift truck, hoist and bag breaker, cyanide is mixed with water in the cyanide-mixing tank. This solution is transferred to the cyanide storage tank for distribution to the ILR circuit. Two dosing pumps have been allowed for given the absence of a head tank feeding the ILR unit.

Sodium Hydroxide

Sodium hydroxide is used to adjust pH ahead of cyanide leaching, and to maintain electrowinning at a pH of 12.5 for optimal conductivity. It will be mixed manually in a mixing tank, transferred to a storage tank and dosed to the ILR feed chute.

An alkaline area spillage sump and pump, common to all alkaline reagent mixing operations, has been included to transfer spillage to the tailings hopper.

Caro's Acid Production

Sulphuric acid and hydrogen peroxide in 1 tonne bulka boxes will be dosed in accurate proportions through a Caro's Acid reactor box, a teflon block with a tortuous path through it to provide rapid high shear mixing. The two reagents mix together to make Caro's Acid (H_2SO_5), which is delivered under pressure to the cyanide detoxification reactor via stainless steel braided teflon lines, thus avoiding any batch makeup of corrosive chemicals by operators.

Plant Services (300-B-DF-008, 009)

Raw Water

Water supply for the plant is to be taken from a barren lake located 2.5 km from the proposed plant site. A high head borehole pump located in a decant well in the lake, accessed by a jetty or causeway, will allow all year round drawing of water from the lake as the intake to the pump will be located below any ice cap that forms. The water is pumped via an insulated pipeline to the process water tank, with a takeoff to potable water treatment.

Process Water

Raw water is delivered to the process water tank, activated by a float valve. Duty and standby pumps deliver process water to the plant for use in all process areas.

Potable Water

A dedicated plant (by others) treats raw water for use as potable water. This water is reticulated throughout the site for safety showers and general purpose.

Seal Water and High Pressure Water

Makeup for this tank is from the same raw water supply. High pressure water pumps (duty and standby) deliver water to hose down points and water suppression applications.

Gland seal water is delivered to slurry and belt filter vacuum pumps using water from the high pressure water tank. The gland seal water circuit has duty and stand-by pumps.

Plant and Instrument Air

Compressors will provide high-pressure air for instrumentation and general use. Duty and standby compressors maintain air pressure to an air receiver. Air from the receiver is then reticulated to the plant as plant air. The instrument air system consists of duty and standby high pressure compressors with a common filter and air drier feeding the plant instrumentation.

Low Pressure Air

Two low-pressure blowers, duty and standby, will supply air for the flash and scavenger flotation cells.

7 CAPITAL COST ESTIMATE

7.1 QUALIFICATIONS

The following qualifications are important to note:

7.1.1 MECHANICAL EQUIPMENT

In the time available, Bateman re-priced as much as possible of the mechanical equipment. Wherever no new price could be obtained Bateman carried forward the costs from the previous submission. Dust extraction at dry transfer points and dry processing areas was allowed for but the dust loading at these points is pure speculation.

7.1.2 CIVILS

The calculation is based on the stated fact that this plant will be built on a rock outcrop, which will be levelled and suitably compacted by the Clients' mining contractor. This eliminates the need to consider the effects of disturbing of the permafrost zone.

It is important to draw the Client's attention to the fact that, without a site visit and the opportunity of consulting with geo-technical experts in the area, only a very basic view of requirements for civil works in the area is possible. It is only allowed for bund walls and floors in the areas indicated on the layout drawing. A rate of C$1,200 per m^3 of concrete was used. No cast foundations or cast-in hold down bolts were allowed anywhere. It is also important to note that no surface concrete floors, walkways or foundations are envisaged other than those areas within the bund walls under the various processes.

Acting on advice from Erik Bruggink of Bateman Engineering it is not deemed necessary to allow for acid-proofing of concrete surfaces. It is sufficient to insert a layer of plastic sheeting under the concrete bed to prevent any possible leaching of chemicals into the soil.

7.1.3 INSTRUMENTATION

In the absence of any specifications we copied the instrumentation description and costs from a recently completed proposal. This is inclusive of PLC and SCADA. The following is a brief description of the instrumentation system proposed:

Control and Instrumentation Scope of Work

The scope of the control and instrumentation work for the proposed Hope Bay 600 tpd Modular Gold Plant shall include the detailed design, procurement works testing where applicable, delivery FOB Hope Bay installation/erection, supervision, cold/hot commissioning of the complete control and instrumentation system and hand over to the client for plant operation.

Specifications and Standards

The control and instrumentation system design shall be based on the prevailing ISA, and the latest South African Standard Specifications and Codes of Practice where applicable.

System Design

The design will be based on pneumatically actuated control valves and direct acting solenoid valves. Variable speed control of motors will be utilised for variation of process slurry flows.

Configuration of the system will be as follows: One control room housing the PLC and SCADA server. The control room PLC connected directly to I/O racks in the individual plant sections via a Profibus-DP network. Motor control is via Simocode intelligent motor protection and control devices connected to the PLC via a Profibus-DP field bus network.

The control room will be housed in an air-conditioned container

The PLC power supplies will be backed up by UPS.

The control & field installation shall consist of:

- Hot dip galvanised ladder type racking.
- 300/500 grade PVC PVC SWA PVC instrument power cable.
- 150/300V grade Dekabon type armour instrument signal cable.
- IP 65 (equivalent to NEMA 4) field junction and marshalling boxes.
- IP 65 field devices such as transmitters and instruments.

Exclusions

- Public address and telecom systems.
- Fire protection.
- Plant & Instrumentation air reticulation.

7.1.4 ELECTRICAL

The cost of the electrical installations includes trial assembly and testing ex-works, area lighting inside the sprung steel dome, special cold weather cables and site erection. TECK low temperature capability cable will be shipped to South Africa for incorporation in the plant. Since power is understood to be generated on site by means of diesel driven gen-sets, no transformers are required. Emergency lighting will be provided by self-contained battery back-ups in strategically located light fittings. A containerised MCC is included in the pricing.

The location of the diesel power generator module has not been identified and neither has any allowance been made for the heat exchanging and heat reticulation system.

7.1.5 PLATEWORK AND LINERS

Bateman have calculated the masses of plate work and liners required for the option.

7.1.6 STRUCTURAL STEELWORK AND 'SPRUNG STEELDOMES'

The structural steelwork quantity was derived from a previous similar design, and amounts to 64 tons.

The revised layout for option "A" significantly reduced the size of the main Sprung Steel building with a resultant reduction in price. The crushing/screening/stockpile building was left as before.

7.1.7 PIPING AND VALVES

The monetary value of this item was factored. Since the piping is mainly small bore plastic piping and the main automated valves are included under instrumentation, this figure is small and not considered to be a significant risk. Insulated piping for water supply and tails lines form a separate item in the cost estimate.

7.1.8 BUILDINGS

An allowance has been made for a containerised office during commissioning, which can be refitted later for other use by operations after demobilisation.

7.1.9 TRANSPORTATION

Transportation is factored at 15% of DFC (excluding the Sprung Steel structures for which transport and erection are allowed separately). Concrete has also been excluded from the transport allowance as an installed rate has been used.

7.1.10 OPERATING SPARES

These are at 4% of supply costs for mechanical, electrical and instrumentation.

7.1.11 CONTINGENCY

A 12% contingency has been allowed for additional minor items.

7.2 CAPITAL COST ESTIMATE

7.2.1 GENERAL

The objective of the study was to develop a ±25% capital cost estimate based upon available testwork information, client supplied criteria and assumptions derived from in-house experience. The methodology adopted is similar to the previous study. Documentation developed during the study used as a basis for the estimate is:

- Process Design Criteria.
- Equipment List.
- Flowsheets.
- Plant General Arrangements (in preliminary sketch form for internal capital estimating use).
- Plant Layout Drawing.

The above deliverables were produced in sufficient detail to achieve a cost for the process plant at the required accuracy.

Due consideration was given to the location and climate but site topography and ground conditions are assumed to be of hard rock composition suitable for standard foundations.

All values are expressed in Canadian dollars with a base date of 30th[th] November 2001. An exchange rate of 1.20 A$:CAN$ was used to convert Australian rates.

Capital costs for the project have been based on the purchase of all-new equipment and materials. The use of second-hand equipment may be considered once the project development commences.

Table 7.1 tabulates the estimate by commodity. Appendix E contains details of erection and assembly factors applied to base costs to arrive at total costs by commodity.