927001 TCR: 02-4777

J.J. McDONALD & SONS MINING PTY LTD

ACN 051 399 261 ABN 29 051 399 261

EXPLORATION LICENCE NO. 17/98

MAYDENA, TASMANIA

ANNUAL REPORT

TO

04.09.2002

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AUGUST 2002

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ABSTRACT

Completion of a preliminary resource estimate was the trigger for a scoping study focused mainly on processing options for the production of high quality silica flour from naturally disaggregated raw feed material.

This indicated that a viable plant can be built, at moderate capital cost, using readily available and proven technology to produce silica flour at a rate of about 25,000 tonnes per annum for a mine life well in excess of ten years.

There remains uncertainty about the ultimate purity of the end product, although some encouragement was obtained from the significant reduction of contaminant levels achieved in the flour size bands when a bulk sample was processed through a commercial plant.

This aspect continues to be addressed through on-going investigations using old and new techniques in an effort to obtain a premium quality product on a commercial basis.

There is increasing market awareness of the deposit, resulting in several enquiries being dealt with.

Keywords:

Maydena; Pine Hill;
Silica flour; Processing;
Marketing; Resources.

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APPENDICES

ILLUSTRATIONS

1. INTRODUCTION

This report details activities by J.J. McDonald & Sons Mining Pty. Ltd. relating to Exploration Licence 17/1998 during the fourth year of tenure ended 04.09.2002.

Exploration licence tenure over an area of 7 sq. km was granted to J.J. McDonald & Sons Mining Pty. Ltd. for a period of five years from 04.09.1998.

E.L. 17/1998 surrounds and extends to the east of Pine Hill, located just south of the sealed Gordon River road approximately 4 km west south west of Maydena and about 90 km by road from Hobart (Fig.1). There is good access to and within the prospect area. Power, water, housing and basic facilities are readily available from within a short radius of the prospect. The rail-line from New Norfolk to Maydena is being progressively upgraded for passenger traffic. A 700m long gravel airstrip is located 3 km north west of the silica sand deposit.

The primary target for investigation and assessment is the deposit of silica sand located largely to the west of the Eastern Quarry, about 1 km south east of Pine Hill (Fig.2).

The overall aim of the investigations is to determine if a commercially viable operation can be established, based on products derived from the silica and resource in the tenement.

The main objectives of this year's activities towards this aim were:

* completion of a 1st-pass resource estimate, focused on silica flour
* completion of a scoping study with a focus on processing options for an operation yielding 25,000 t.p.a. of marketable silica flour
* continue with product upgrade investigations
* continue with market enquiries for silica flour and co-/by-products

2. PREVIOUS WORK

Exploration by Pioneer Silicon Industries Pty. Ltd. in 1988/89 identified a lag deposit of hard silica rock at the Western Quarry containing a small resource of material deemed suitable for the manufacture of silicon. From this, approximately 19,000 tonnes of crushed, screened silica rock was produced in 1991 and 1992 for shipment. 10,000 tonnes were consigned to Pioneer's silicon smelter at Electrona and about 9,500 tonnes went to Temco's Bell Bay ferrosilicon plant. Extraction, by Duggans Pty. Ltd. under M.L. 1396 P/M, virtually ceased upon closure of the Electrona smelter in 1992, although a small parcel of 850 tonnes of silica rock is reported to have been mined in 1995. Towards the end of the earlier exploration work, a deposit of white silica sand was located between Pine Hill and the Styx Road in an area now known as the Eastern Quarry Area. Pioneer investigated this deposit in the vicinity of the Eastern Quarry by 23 shallow RC drill holes. Preliminary estimates suggested a resource in the order of some 0.75 - 1.5 million cu. m. of mostly low iron silica sand containing about 10% of high grade lump silica.

Assay results from a number of subsequent, excavator generated pit samples by the North West Bay Co. Pty. Ltd. supported the high quality of the resource and, together with sizing determinations on a bulk sample, indicated that the sand might be suitable for the manufacture of table ware glass.

In the first year of tenure of E.L. 17/1998 J.J. McDonald & Sons Pty. Ltd., using the air-core drill sampling method, extended the sampling into the western segment of the deposit along more widely-spaced drill centres. 23 drill holes totalling 294m were completed which demonstrated that the deposit is more variable, complex and higher in iron oxides than previous data suggested.

The area around the Eastern Quarry was shown generally to have a matrix of fine grained sand, but with elevated levels of iron, titanium and alumina.

Laboratory sizing determinations indicated that the deposit is a possible source of silica flour as well as glass sand, while geological mapping pointed to a small resource potential for silica rock as well.

Bench-scale acid wash tests on a sample of the glass size fraction sand aimed at the removal of iron oxides showed that the material could easily be upgraded to a high quality product containing less than 50 ppm iron without major environmental impact, with levels of iron below 10ppm a possibility.

The second year's activities by J.J. McDonald & Sons Pty. Ltd. contributed to a better understanding of the geological setting of the silica sand deposit and identified a possible source of good grade limestone for use in acid neutralisation in relative proximity to the east of the silica sand deposit.

Marketing activities provided some encouragement for potential demand for the area's products, with particular interest and enquiries directed at the silica flour component and other fine fraction material.

The main outcomes in the third year of operation were the completion of the first-pass drill coverage of the Pine Hill silica sand deposit which outlined broadly its complex quality and textural characteristics and the identification of silica flour as potentially its economically most important component.

The fourth year's activities and results are described below.

3. ACTIVITIES FOR PERIOD

Attention and effort was largely concentrated on aspects related to the Eastern Quarry silica sand deposit in the Pine Hill area.

3.1 Work Done:

This comprised:

* compilation of the annual reports for year 2001 and year 2002 activities
* entry into a research contract with CODES for an honours student to characterise aspects of the Eastern Quarry silica sand deposit; orientation site visit with student and supervisors
* mineralogy on samples of magnetic contaminants
* collection and submission of a suite of samples to the MRT petrologist for inclusion studies
* more accurate re-estimation of the deposit's resource base, with focus on the silica flour fraction
* WHIMS clean-up tests and assays on some of the previous year's drill samples

* Fe-reduction investigations using:
  - . WHIMS clean-up
  - . acid wash
  - . Calgon re-agent & attrition wash
  - . ultrasound
* collection and processing by Index Mineral Processors, Brisbane, of a ± 30 tonne bulk sample at its Heybridge plant
* completion of a preliminary study of processing options for 25,000 t.p.a. of saleable high quality silica flour product
* review of limestone requirements for acid neutralisation and withdrawal of EL application over limestone area
* application for 13 sq km E.L. area adjacent to the west of current EL 17/1998
* generating product awareness and marketing

3.2 Statistical Summary:

Bulk sample	:	30 tonnes approx from trench at 5263760N 465990E
No. of samples assayed	:	94
No. of determinations	:	573
No. of samples to mineralogy	:	9
No. of samples to petrology	:	15

3.3 Expenditure:

Total expenditure for the year reviewed	:	$ 70,649
Cumulative expenditure to 30.09.2002	:	$203,770

4. RESULTS

4.1 Geology - CODES Project:

After scoping discussions with the Codes Director and relevant staff, a research agreement was signed in April 2002 to allow an honours student from the Geology Department, University of Tasmania, to undertake a research thesis on the Eastern Quarry silica sand deposit and the Pine Hill area.

The main objective of this project is to characterise the deposit by a better understanding of:

* the bedrock/source rock silicification process and the genesis of the deposit
* the physico-chemical environment of the bedrock silicification, its age and phase timings
* the origin, nature and composition of the silicifying fluids

CODES reports the following progress to-date:

* Literature search/reading thesis completed and under assessment
* Prospect maps nearing completion
* Geochemical laboratory work in progress
* Thin sections being examined
* Heavy mineral separations completed; determination of "heavies" and impurities, including use of SEM, in progress
* Study of fluid inclusions in progress

The project is said to be "on track" for completion at about year-end 2002.

4.2 Resource Estimate:

A preliminary resource estimate was attempted to assist with mine layout concepts, process design and as a basis to gauge project life, viability and possible returns.

Past drilling and assays clearly indicated that the better quality sector of the deposit lies to the west of a line joining holes DH 71 and 81. This segment, which comprises approximately two thirds of the deposit by area, is further sub-divided into a southern Block A and a northern Block B based on the % silica flour content and levels of Fe2O3.

A total of 30 air core drill holes were completed in this sector, of which 20 were incorporated in the resource estimate.

In summary:

	Total Tonnes	Silica* Flour (t)	Al203 ppm	Fe2O3 ppm	TiO2 ppm
Area A	1,325,000	611,000	297	442	205
Area B	834,000	303,000	244	520	142

* Note: Refers to naturally occurring material in the +25 to -250 micron band.

These resources are allocated to the drill indicated category on the basis of drilling coverage and "ore" continuity.

Area C lies to the east of the DH 71 - 81 dividing line.

It contains the Eastern Quarry and was investigated by 12 air core drill holes completed by J.J. McDonald & Sons Mining and by 24 RC holes by Pioneer. Assay information provided by the latter suite of holes is insufficient and the accuracy of the results is suspect. There is also no sizing data available for he purposes of this estimate from the Pioneer holes.

An estimate in the drill inferred category based on the J.J. McDonald data suggests:

	Total Tonnes	silica Flour (t)	Al_2O_3 ppm	Fe_2O_3 ppm	TiO_2 ppm	
Area C	1,100,000	590,000	625	830	182	v.approx.

Sizing determinations on material from the J.J. McDonald drill holes suggest that much of the material in Area C falls into the silica flour category, although the average quality is somewhat below that of Areas A and B.

The levels of Al_2O_3, Fe_2O_3 and TiO_2 in the resource calculation are, at best, only a very broad indication of quality of the unclassified and unprocessed material drilled. Fe_2O_3 and TiO_2 are probably overstated because of unavoidable contamination during the drilling process. It should be noted that the levels of these latter contaminats could be reduced by up to +80% (average 72%) for Fe_2O_3 and TiO_2 in some cases by 50% (average 27%) using WHIMS.Some lowering of Al_2O_3, CaO and MgO was also observed when using this clean-up process.

Much effort is being directed at determining whether or not the drill hole assays can be used as a guide to final product quality.

4.3 Beneficiation Tests:

4.3.1 Drill Samples:

Silica sand intercepts of significant width in drill holes DH 101, 103 and 104 seemed visually to be of very good quality, but subsequent assays showed surprisingly elevated values of iron in particular. Contamination by iron during the drilling process was the suspected cause of this apparent discrepancy. This was in part also borne out by mineralogical examination of material from other samples.

16 drill samples from previously assayed intervals in holes DH 101, 103 and 104 were subjected to WHIMS-simulated magnetic (roll magnets, 15,000 gauss) separation and the cleaned fractions assayed. This treatment removed both the natural magnetic and artificially introduced iron.

Iron reduction achieved ranged from 46 - 85% and averaged 72% for the samples treated. However, residual levels of iron remained undesirably high and will need to be treated further to give a premium product. The form of the residual iron is not known. It may occur as thin oxide/hydroxide films on grain surfaces, crack fillings, as inclusions or in the crystal lattices of the silica, silicates and carbonates present.

The separation process also removed some of the titanium impurities, but to a lesser degree than iron. Reductions in TiO_2 achieved ranged from 2 - 51% but averaged only 27%. The nature of the titanium remaining is unknown.

The nature of the residual iron and titanium warrant investigation as this information could help determine if these can be removed economically to give a premium end product in both the silica flour and silica sand range.

It is also of interest to note that the process seems to have been effective in removing about 22% of the alumina in the samples processed, 32% of the calcium and 25% of the magnesium.

For assay details and comparisons see Appendix 2.

4.3.2 Calgon Tests:

Calgon is the trade name for sodium hexametaphosphate, a reagent commonly used as a deflocculant.

Its applicability to the removal of stain from zircon concentrates was investigated by Bear (1975).

CSIRO was contracted to undertake preliminary tests as to the possible usefulness of Calgon, in conjunction with auto-attritioning, for upgrading the silica sand and flour products. It was anticipated that Calgon would assist this process by facilitating the liberation of impurities, particularly clays, for subsequent removal by washing and/or other means. The reagent is also deemed to impact less on the environment than acid washing.

One sample of glass grade silica sand (+75 to -600 micron) and one of silica flour (+25 to -250) each weighing about 1.3 kg from drill hole DH 110 was provided for the tests.

The tests were only partly successful in that results achieved did not reach the low levels required for a premium product. For details see Appendix 3.

A significant decrease to 70 ppm Fe_2O_3 and 20 ppm TiO_2 was acheived with a 2% weight/vol. charge of Calgon. Most of the impurities were removed during the first 20 minutes of agitation, with no further decrease beyond an agitation time of 30 minutes on the silica sand sample.

Tests on the silica flour were less encouraging. Although significant amounts of impurities were removed, final levels were higher (about double) than those achieved with the coarse sand fraction, with iron remaining significantly above those acceptable for a premium product.

It was noted that the end products, after leaching, contained tiny black particles which were clearly not removed by WHIMS treatment of the "head sample". An investigation into their identity is discussed in Section 4.4 of this report and in Appendix 6.

4.3.3 Bulk Sample Processing:

Following acceptable results from a number of small samples at several sites, a bulk sample of about 30 tonnes was collected from a small trench and processed through the Heybridge plant of Index Mineral Processors.

Product in two standard size bands was generated:

1) Silica flour US mesh nominal 60 (+20 -250 micron)

2) Silica flour US mesh 200 (+35 - 75 micron)

The end products assayed:

	Fe2O3	TiO2	Al2O3	CaO	MgO	Na2O	Mn	Cu	Cr(AS)	Ni
Raw Feed	95	33	138	304	158	18	0.84	0.37	0.03	0.04
-60 micron	54	17	97	145	81	20	0.2	0.1	0.1	0.05
-200 micron	80	25	111	350	174	17	0.3	0.2	0.5	0.1

Note: All results in ppm

Both products showed some improvement with respect to the main contaminants when processed at the Heybridge plant. However, these reductions were insufficient for market acceptance of the products. Samples of the latter were reported to have been rejected by existing Index customers in the US and in Japan on account of high iron and alumina content when compared to the Corinna product.

Index advised that iron reduction investigations on this material are currently in progress in the US and results to-date are said to be promising.

4.3.4 Acid Leach Tests:

A sample of about 0.5 kg each of the two end products generated by the Index, Heybridge plant was cleaned of magnetic material through a WHIMS at 15,000 gauss at the Eriez laboratory, Melbourne.

The cleaned samples were forwarded to Osleach Pty. Ltd. for acid washing tests to determine if the remaining impurities, especially, iron and calcium could be reduced by chemical means using dilute sulphuric acid.

Preliminary reports suggest some improvements, but the lower levels reached may not be sufficient for the finished product to qualify as premium grade.

The work is currently in progress and a report is awaited. See Appendix 4.

4.3.5 Ultrasound Tests:

The possible usefulness of ultrasound was investigated as part of an effort to seek innovative ways to remove impurities from the silica sand and flour.

This approach was guided by the consideration that sonication might separate impurities from the silica or at least loosen the bonds between the materials and thereby facilitate separation by other, more conventional means.

Of four samples submitted to Agricola Consulting Services Pty. Ltd., two were selected for preliminary testing.

US 77 was a 1.6 kg unclassified composite sample from the 5 - 11 m interval in hole DH 77. Its colour was rusty brown and it was visually contaminated with iron oxides, hydroxides and clay material.

EQ 010 US was a 4 kg sample of silica sand, off-white in colour, collected from the Eastern Quarry stockpile.

Procedures and outcomes are given in Appendix 5.

The best result was obtained from the washed and sonicated -300 +28 micron fraction of the highly contaminated sample US 77. Fe_2O_3 levels were reduced from an initial 0.889% to 0.101% after 5 minutes' sonication. Significant reductions were also obtained with TiO_2 and Cr_2O_3.

The method had markedly less effect on the initially much cleaner sample EQ 010 US. Fe_2O_3 content was reduced from 0.024% to 0.019% after 5 minutes' sonication, representing an improvement of only about 21%. A somewhat better result was registered for TiO_2, which fell from 0.015% to 0.006%, a 60% improvement.

On the basis of these outcomes it seems clear that the method is much more effective when applied to highly contaminated material. It may be that there is a lower cut-off below which clean-up by sonication may not be practically or economically possible.

The consultant believes that a product of about 0.05% Fe_2O_3 or better may be achievable using sonication in conjunction with other reagents of techniques in the upgrade process.

The benefits of this technique may lie in its ability to elevate what is now regarded as "sub-ore" or waste to material which could be upgraded to quality product by other, more conventional means. The resultant environmental advantages could be lower useage of water and/or acid.

4.4 Mineralogy:

The beneficiation tests using Calgon and the Index end products provided material which, after processing , still contained noticeable amounts of fine, black particles.It was deemed desirable to identify the latter, as they were thought to contribute to the higher than anticipated end levels of Fe an Ti in the material processed.

Details of the mineralogical examinations are provided in Appendix 6.

A surprise outcome of this work is the identification of trace amounts of iron and copper sulphides in several of the samples submitted.

The source of the sulphides, especially those of copper, is enigmatic. Their spread across the range of samples leads to the tentative conclusion that they may not be artificially introduced contaminants as suggested by the consultant.

The magnetic, heavy mineral assemblage identified in samples AIS 20/250/B8 and AIS 35/75/B3, the two Index end products, (see section 4.3.3), suggests that further improvement in the quality of these products may be possible using magnetic separation.

Previous work by Osleach has shown that the black carbonaceous particles in the silica sands may contain minor amounts of iron. Removal of this material would further enhance the quality of the end product.

4.5 Processing Options:

Project activities over the last three years generated sufficient information for a scoping study into processing options to generate a high quality silica flour product from at least part of the silica sand material at the Pine Hill sand deposit.

The latter study concentrated primarily on plant design, but touches on aspects of mining as well, which is envisaged to be on a contract basis, given the relatively small annual volumes involved.

One of the important outcomes of this study is an indicative estimate of capital and operating costs of a project based on an initial output of 25,000 t.p.a. of marketable product in the +30 -200 micron size band.

In summary:

Capex : below $2 million, using largely new plant

Opex : below $50 per tonne of product to mine gate

These estimates are based on essentially conventional and proven technology involving low risk but at the expense of higher cost. The flow-sheet design envisages the use of screens for primary sizing, cyclones and WHIMS for the removal of magnetic and heavy minerals and finishing with a dilute sulphuric acid wash for final surface cleaning.

The end product will be dried and shipped in bulk bags.

Other, potentially lower cost options considered involved the application of spirals to the removal of heavy minerals and the use of a hydraulic classifier to perform the primary sizing function. The latter provides greater flexibility in throughput and for control and adjustment of product sizing. It also offers the promise of both lower capital and operating costs.

Some technical aspects of these last two options still require investigation in the context of the Pine Hill material.

Apart from the capital and operating cost estimates, the other most significant conclusions to emerge form this study are, quote:

"... * A viable plant can be built using readily available and proven technology to produce silica flour in the size range of -250+32 micron at 25,000 tonnes per annum.

* Purity of the final product is still uncertain,pending further work on upgrading methods, but less than 50ppm Fe_2O_3 would appear to be attainable.

* Significant areas of high capital cost are the magnetic separation and drying operations. Drying, bagging and product handling will probably account for by far the highest proportion of capital and operating costs for any area.

* Relatively small changes in product specification and customer requirements could cause very large increases in capital and operating costs ... "

Full details of the study on processing options are presented in Appendix 7.

4.6 Limestone:

On the basis of a perceived need for limestone for acid neutralisation purposes, application was made during the previous year for an exploration licence of 4 sq km immediatley to the east of the current E.L. 17/1998.

The application was withdrawn in view of the low consumption of lime indicated by the processing options study (see section 4.5) as well as environmental and heritage considerations.

4.7 Marketing:

4.7.1 Index Mineral Processors:

A bulk sample of approximately 30 tonnes, collected by the above company in December 2002 was processed in February 2002, with mixed results.

The outcomes are reported in the forgoing section 4.3.3 of this report.

Further testing and marketing efforts are reported to be continuing.

4.7.2 Kawatetsu Mining Company Ltd.

This company is the mining division of Kawasaki Steel Corp. of Japan.

Company representatives visited the Pine Hill silica sand deposit in May 2002 to familiarise themselves with the geological setting, to collect samples for inclusion studies and to assess the potential for supply of high quality silica sand.

Many fine grained inclusions of carbonate impurities in the quartz were reported by the company's petrologists . This negated any further interest by the company in the Pine Hill deposit.

4.7.3. Osthandel Chemie GmbH:

Interest was ignited by satisfactory assay results from samples collected at the Eastern Quarry by the comapny in February 2002 (Appendix 8). Comapny representatives met some members of MRT and the Department of Infrastructure, Energy and Resources and visited the deposit with a view, primarily, to source lump silica for silicon production. Loading facilities at the port of Hobart were inspected. There are on-going discussions with regard to both lump silica and silica flour for markets in Europe and Asia.

4.7.4. Supersorb Minerals:

Discussions were initiated with this comapny with the aim to supply "active" silica for soil improvement purposes.

Contact ceased when the company was recently placed in administration.

4.7.5 Glasstech Asia 2002:

A visit to this trade exhibition, held bienially in Singapore, resulted in several useful overseas contacts and leads for silica sand and flour.

4.8 Rehabilitation:

The short trench excavated for bulk sampling purposed by Index Mineral Processors at 5263760 mN, 465990 mE in an area cleared by forestry operations was backfilled, the area re-levelled and re-covered with top-soil.

5. CONCLUSIONS

5.1 A resource estimate, in the drill indicated category, suggests that there is sufficient material to support an output of 25,000 t.p.a. of silica flour in the +25 -250 micron size range for a period in excess of 20 years.

5.2 A preliminary study into processing options concludes that a viable plant can be built using readily available and proven technology to produce silica flour in the +32 -250 micron size range at 25,000 tonnes per annum.

Purity of the final product remains uncertain, but less than 50 ppm Fe_2O_3 would appear to be attainable.

5.3Although preliminary signs are generally positive, ways to improve product quality, focused primarily but not exclusively on Fe, Ti and Ca need further investigation in order to achieve sustainable price premiums in the market place necessary for the commercial success of the operation.

5.4 Although a number of product enquiries have been dealt with, more in-depth market research is now required to underpin confidence in the project and provide a guide to the direction, levels of activity and expenditure.

6. PROPOSED FUTURE ACTIVITIES

6.1 Exploration:

* Completion and assessment of CODES project
* Relevant flow-on activities

6.2 Beneficiation:

* Continue with on-going beneficiation tests aimed at improving end-product quality

6.3 Engineering:

* Targeted investigations into processing equipment performance in preparation for a feasibility study
* Define parameters and costing for a feasibility study

6.4 Marketing:

* Continue to generate product awareness and to identify potential customers world-wide
* Maintain contact and information exchange with interested parties

6.5 Tenure:

* Determination of flow-on tenure

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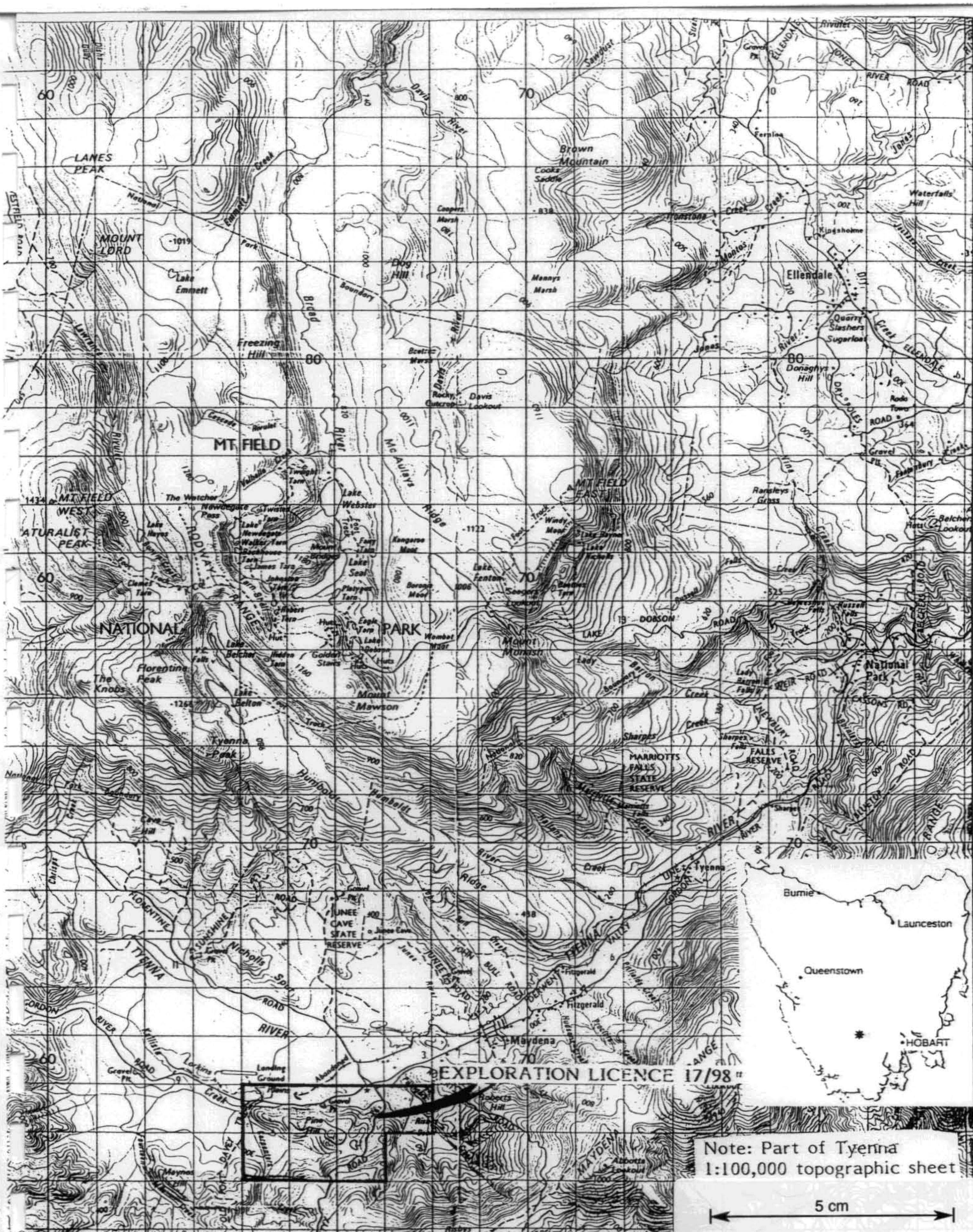


J.J.MCDONALD & SONS MINING PTY.LTD.

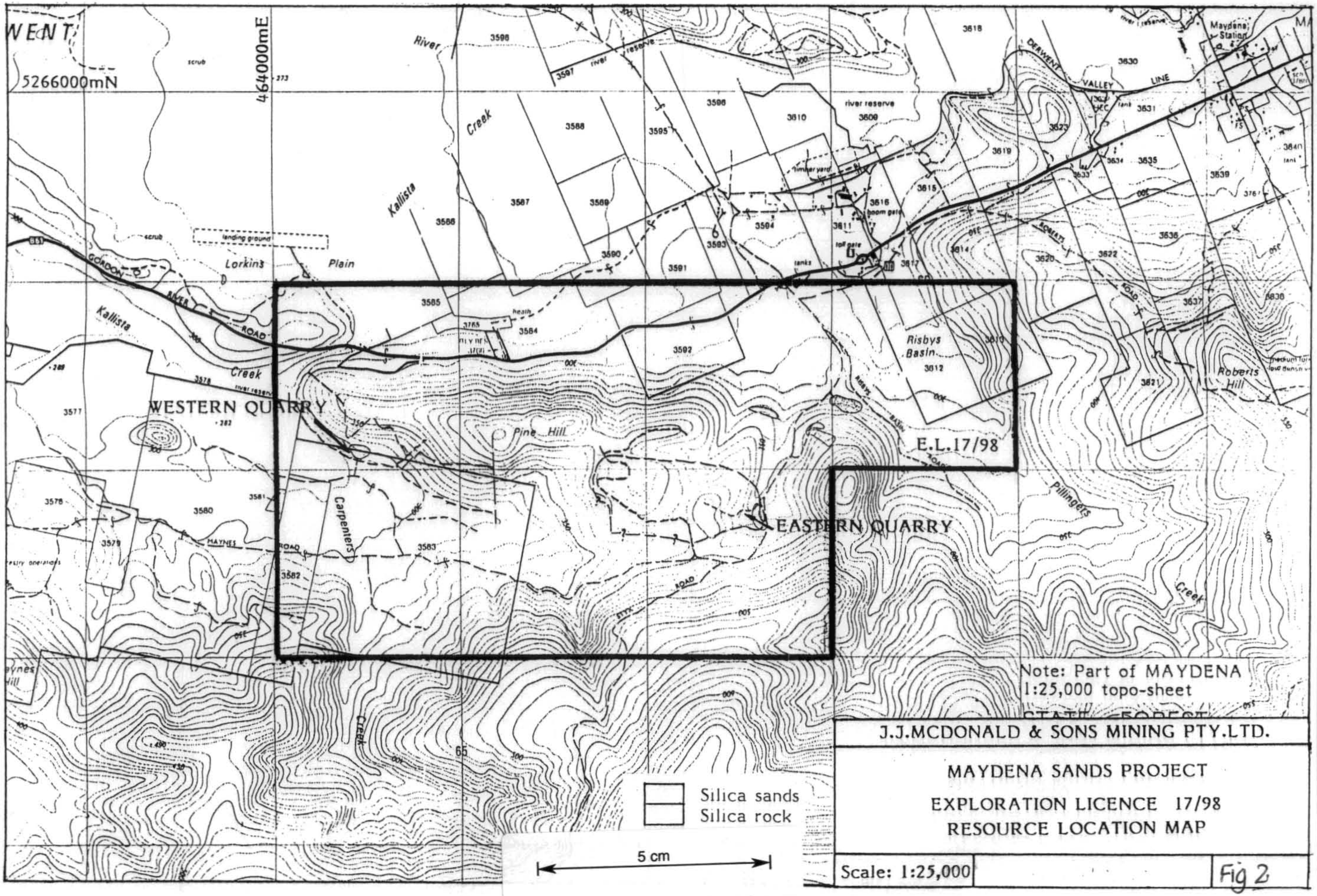
MAYDENA SANDS PROJECT

LOCATION MAP

EXPLORATION LICENCE 17/98

Scale: 1:100,000	6/99	FIG.1

927016



WENT
5266000mN
464000mE
River
Kallista
Creek
Lorkins
Plain
landing ground
scrub
GORDON
RIVER
ROAD
Kallista
Creek
river reserve
WESTERN QUARRY
Pine Hill
Carpenters
HAYNES
ROAD
STYX
ROAD
EASTERN QUARRY
E.L.17/98
Risbys Basin
Roberts Hill
Pillingers
Creek
ROBERTS
ROAD
DERWENT
VALLEY
LINE
Maydena Station
timber yard
boom gate
toll gate
river reserve
Creek
Haynes Hill
Note: Part of MAYDENA
1:25,000 topo-sheet
Silica sands
Silica rock
5 cm
J.J.MCDONALD & SONS MINING PTY.LTD.
MAYDENA SANDS PROJECT
EXPLORATION LICENCE 17/98
RESOURCE LOCATION MAP
Scale: 1:25,000
Fig 2

927017

APPENDIX 1

RESOURCE ESTIMATE - SUMMARY

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AREA	BLOCK	HOLE	From	To	CUT(m)	Al2O3	ppm Fe2O3	TiO2	%FLOUR	OVER BURDEN	VOLUME(m)	TONNEAGE	SILICA FLOUR (t)
A	AA	96	4	8	4	576	557	218	41.9	1			
		106	1	12	11	154	449	573	40.0	1			
		107	1	13	12	378	509	381	39.2	1			
		108	1	9	8	800	407	336	43.9	1			
		AVERAGES :			9	477	480	377	41.3	1	223,065	379,211	156,614
	AB	93	1	14	13	150	657	188	44.5	1			
		94	3	9	6	370	355	110	36.3	3?			
		101	1	14	13	190	179	163	49.5	1			
		AVERAGES :			11	237	397	154	43.4	1.7?	114,840	195,228	84,729
	AC	91	1	13	12	106	426	198	45.2	1			
		102	1	6	5	185	437	91	50.3	1			
		102	11	33	22	99	791	151	50.3	1			
		AVERAGES :			13	130	551	147	48.6	1	177,190	301,223	146,945
	AD	72	1	6	5	1011	349	199	N/A	1			
		83	1	10	9	312	236	189	42.6	1			
		90	1	12	11	163	215	69	49.4	1			
		103	1	13	12	132	371	105	47.1	1			
		104	2	14	12	107	519	152	58.6	1			
		AVERAGES :			10	345	338	143	49.4	1.2	264,240	449,208	221,909
AA+AB+AC+AD					11	297	442	205	45.7	1.2	779,335	1,324,870	610,197

Note: Silica flour: +25 to -250 micron size band

SG: 1.7

Significant contamination by Fe from drilling.
WHIMS separation can reduce Fe2O3 by 40-80%.

TABLE 1

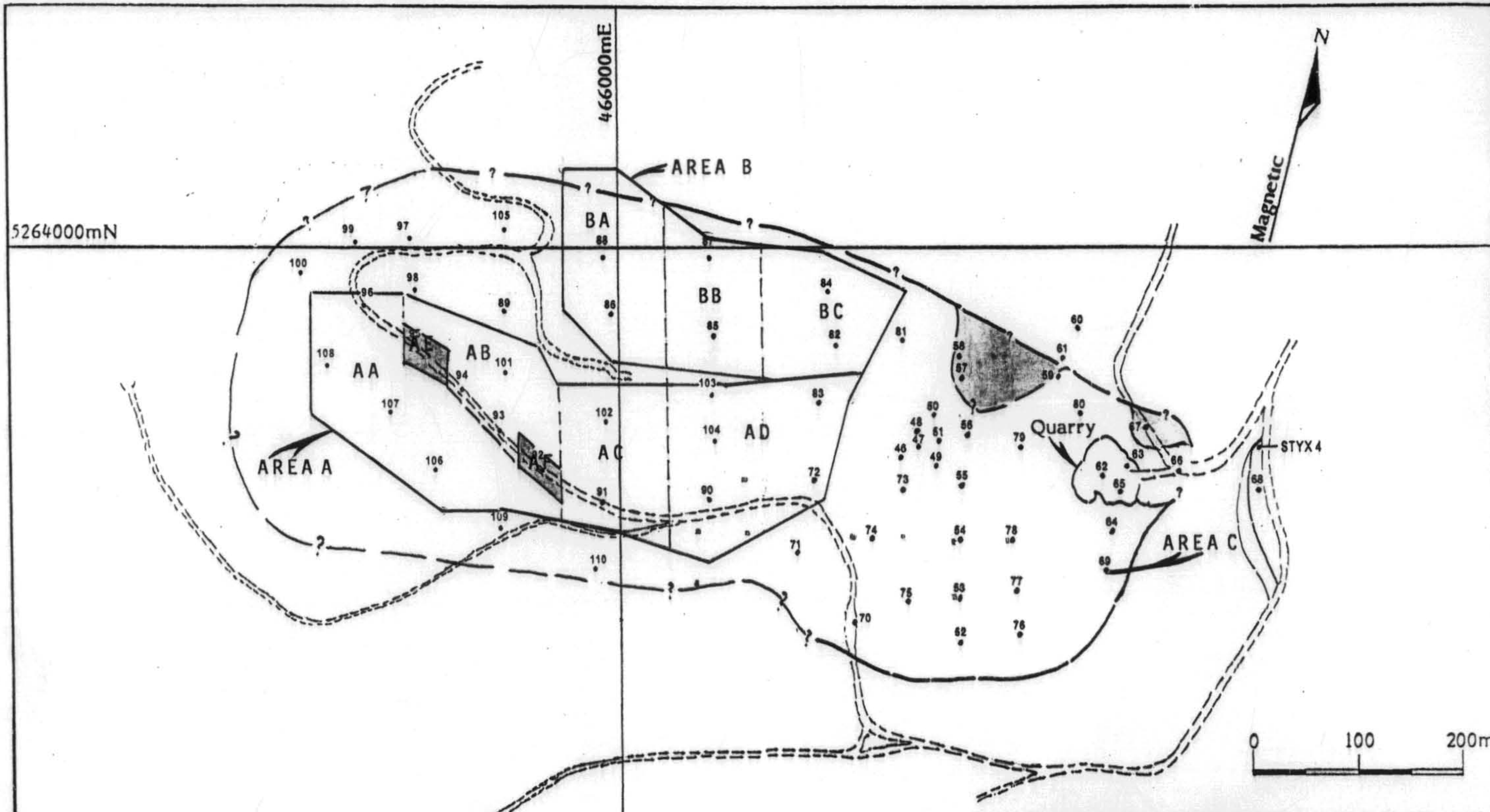
AREA	BLOCK	HOLE	From	To	CUT(m)	Al2O3	ppm Fe2O3	TiO2	%FLOUR	OVER BURDEN	VOLUME(m)	TONNEAGE	FLOUR (t)
B	BA	86	1	13	12	158	527	107	38.7	1			
		88	2	19	17	366	876	121	31.2	2			
		AVERAGES :			14.5	262	702	114	35.0	1.5	212,932	361,984	126,695
	BB	85	1	4	3	247	361	70	N/A	1			
		87	1	9	8	193	524	190	40.0	1			
		AVERAGES :			5.5	220	443	130	40.0	1	90,750	154,275	61,710
	BC	82	1	12	11	186	285	134	26.9	1			
		84	1	18	17	315	547	228	40.6	1			
		AVERAGES :			14	251	416	181	33.8	1	186,970	317,849	107,433
BA+BB+BC					11	244	520	142	36.3	1	490,652	834,108	302,781

Notes: Silica flour: +25 to -250 micron size band

S.G.: 1.7

Significant contamination by Fe from drilling.
WHIMS separation can reduce Fe2O3 by 40-80%.

TABLE 2



J.J.McDONALD & SONS MINING PTY. LTD.

MAYDENA SANDS PROJECT

EASTERN QUARRY AREA

SUMMARY MAP - RESOURCE BLOCKS

Scale: 1:5,000 | 4/99, 8/00, 9/01, 5/02, | Fig 1

APPENDIX 2

ASSAY COMPARISON: PRE & POST MAGNETIC SEPARATION

Batch: AM33142
Sub Batch: 0
Date of Issue: 01/10/2001
Client: .
Client Reference:

CERTIFICATE OF ANALYSIS

927023

SAMPLE	Element Unit Method LOR	Al2O3 ppm M289 10	Fe2O3 ppm M289 10	TiO2 ppm M289 10	CaO ppm M289 10	MgO ppm M289 10	MnO ppm M289 10	Cr2O3 ppm M289 1	V2O5 ppm M289 10				
70299M NON MAG		248	171	171	212	83	<10	1	<10				
70300M NON MAG		170	225	141	140	68	<10	2	<10				
70301M NON MAG		125	272	326	153	55	<10	1	<10				
70325M NON MAG		106	203	94	183	92	<10	1	<10				
70326M NON MAG		212	144	75	180	109	<10	2	<10				
70327M NON MAG		132	102	80	102	57	<10	<1	<10				
70328M NON MAG		78	91	102	217	102	<10	1	<10				
70329M NON MAG		90	121	57	85	47	<10	<1	<10				
70330M NON MAG		68	113	71	158	83	<10	<1	<10				
70331M NON MAG		85	389	162	55	34	<10	2	<10				
70332M NON MAG		79	120	192	85	35	<10	<1	<10				
70333M NON MAG		123	60	94	187	75	<10	1	<10				
70334M NON MAG		128	68	68	133	56	<10	<1	<10				
70335M NON MAG		52	103	79	119	31	<10	<1	<10				
70336M NON MAG		64	52	113	102	41	<10	1	<10				
70337M NON MAG		58	74	79	142	42	<10	<1	<10				

ALS

Page-no: 1

STAFFORD

Attention: MR G KRUMMEI
YourOrder: FAX
SampleType: PULP
Project:

Batch-no: 33142
Sub-batch: 0
No-samples: 16
Received: 20/08/01
Checked:

Element			Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	MnO	Cr_2O_3	V_2O_5
Unit			ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Method			M289	M289	M289	M289	M289	M289	M289	M289
70299M NON MAG	DH101	1-2m	248 47%	(346) 171 51%	(198) 171 14%	(200) 212 12%	(91) 83 9%	<10	1	<10
70300M NON MAG		3-4m	170 40%	(416) 225 46%	(189) 141 25%	(164) 140 15%	(74) 68 8%	<10	2	<10
70301M NON MAG		5-6m	125 34%	(240) 272 *	(346) 326 6%	(156) 153 2%	(52) 55 0%	<10	1	<10
70325M NON MAG	DH103	1-2m	106 3%	(428) 203 52%	(96) 94 2%	(228) 183 20%	(109) 92 16%	<10	1	<10
70326M NON MAG		3-4m	212 10%	(470) 144 69%	(111) 75 32%	(272) 180 34%	(146) 109 25%	<10	2	<10
70237M NON MAG		5-6m	132	(400) 102 75%	(132) 80 39%	(178) 102 43%	(96) 57 41%	<10	<1	<10
70328M NON MAG		7-8m	78	(54) 91 *	(80) 102 *	(240) 217 10%	(107) 102 5%	<10	1	<10
70329M NON MAG		9-10m	90 4%	(301) 121 60%	(79) 57	(141) 85 60%	(75) 47 37%	<10	<1	<10
70330M NON MAG		11-12m	68 23%	(572) 113 80%	(133) 71 47%	(240) 158 34%	(118) 83 30%	<10	<1	<10
70331M NON MAG	DH104	1-2m	85 43%	(1440) 389 73%	(216) 162 25%	(171) 55 68%	(93) 34 63%	<10	2	<10
70332M NON MAG		3-4m	79 40%	(610) 120 80%	(233) 192	(270) 85 69%	(70) 35 50%	<10	<1	<10
70333M NON MAG		5-6m	123 15%	(366) 60 83%	(121) 94	(220) 187 18%	(81) 75 7%	<10	1	<10
70334M NON MAG		7-8m	128	(463) 68 85%	(96) 68	(181) 133 26%	(72) 56 22%	<10	<1	<10
70335M NON MAG		9-10m	52 16%	(629) 103	(160) 79	(211) 119 44%	(49) 31 37%	<10	<1	<10
70336M NON MAG		11-12m	64 11%	(364) 52	(158) 113	(140) 102 27%	(49) 41 16%	<10	1	<10
70337M NON MAG		13-14m	58	(519) 74	(148) 79	(234) 142 39%	(59) 42 29%	<10	<1	<10
Av reduction			22%	72.2%	27.4%	32.6%	24.7%			

Av Fe_2O_3 144ppm

NOTE: · material is unscreened, unwashed.
· assay results for pre-mag. separation (in brackets)
· % reduction

DH101	40%	÷ 32%	15%	9.7%	5.7%
DH103	14.5%	÷ 56.2%	÷ 24.7%	33.5%	25.7%
DH104	21%	82.6%	31.1%	41.6%	32%

Limit of Detection	10	10	10	10	10	10	1	10

ALS 07/09/01

ST 33142 - 0

Silica Sand Magnetic Separations

For ALS / J. J McDonald & Sons Mining

Sample No.	Non - Mags Wt grms	Mags WT grms	% Mags
70299 m	156.0	10.0	6.0
70300 m	163.0	15.0	8.9
70301 m	153.0	24.0	13.6
70325 m	125.0	24.0	16.1
70326 m	163.0	75.0	31.5
70237 m	193.0	84.0	30.3
70328 m	205.0	28.0	12.0
70329 m	156.0	57.0	26.8
70330 m	168.0	101.0	37.5
70331 m	14.0	32.0	69.6
70332 m	117.0	152.0	56.5
70333 m	364.0	84.0	18.8
70334 m	231.0	132.0	36.4
70335 m	130.0	148.0	53.2
70336 m	218.0	60.0	21.6
70337 m	189.0	84.0	30.8

Note: WHIMS simulation performed on a Readngs Induced Roll Magnet

Settings = 130rpm, 4.0mm air gap splitter set +2, 6.0amps/15k gauss

BATCH No. ....

DATE RECD. ....

SAMPLE TYPE ....

CARRIER ....

CON NOTE No. ....

WEIGHT ....

DISPOSAL ....

APPENDIX 3

CALGON TESTS - CSIRO REPORT

REPORT TO JJ McDONALD & SONS FOR QUOTATION # 31749

Cleaning Silica Sands

1. INTRODUCTION

Two glass sands samples were provided to CSIRO Minerals by Mr Gerhard Krummei on behalf of JJ McDonald & Sons Mining Pty Ltd in November 2001. One was of "glass" grade, the other of "flour" grade. CSIRO Minerals was contracted to attrition samples of each sand under specified experimental conditions in order to remove impurities and hence improve the grade of the sands. Analysis of the samples taken during the tests was agreed to be the responsibility of the client. The experimental conditions used in the tests and the analysis of the samples taken are provided in this report.

2. EXPERIMENTAL

2.1. Glass sands samples

The two glass sands samples provided for this work were labelled Glass Grade Sample DH 110-S (-600 + 75 µm) and Flour Grade Sample DH 110-F (-250 + 25 µm). The samples were given the CSIRO designation numbers 2113A and 2113B respectively. There was approximately 1300 g of each sample.

2.2. Sample preparation

Each sample was thoroughly blended and three 400 g charges were riffled out from each for testing. A 50 g head sample for analysis was also riffled out. The remaining sample was bagged.

2.3. Reagents

The only reagent used in the testing was AR grade sodium hexameta phosphate (SHMP), commonly known as Calgon. It was added at the 0.5 or 2.0% w/v level as a dry powder to the attritioning cell at the start of each test.

Distilled water was used in all tests, including washing and decanting.

2.4. Attritioning equipment and procedures

The four attritioning tests undertaken were conducted in a 1 L glass Denver flotation cell, fitted with an attritioning head, operating at 1650 rpm. Using 400 g charges of glass sand and 800 ml distilled water a pulp density of 33.3% solids was obtained. All tests were conducted at room temperature, nominally 25ºC, and natural pH, which was 6.8 for sample 2133A and 5.8 for sample 2113B.

The attritioning procedure used was as follows. A 400 g charge of glass sand was added to the cell containing 800 ml distilled water. The agitator was turned on and the required dose of SHMP (dry powder) was added. The time of this addition was taken to be time zero. The pulp was attritioned for 1 h with sub-samples of the solids taken at 15, 30 and 60 minutes. At the end of the test the agitator was turned off, the pulp allowed to settle and a 10 ml liquor sample taken. The pulp was then washed into a 10 L bucket and 2 L of distilled water was added. The pulp was mixed thoroughly (ie, re-pulped), allowed to settle and the slimes fraction decanted off. This wash/decant procedure was repeated another two times (ie, three wash/decants in total). The final solids sample was washed into a tray, excess water decanted off and the sample dried in an oven at 60ºC overnight. The test conditions and dry weights of sub-samples and final products are given below in Table 1.

Table 1 – Attritioning test conditions and sample weights

Test no.	SHMP (% w/v)	Feed	Sample no.	Sample time (min)	Sample wt (g)	Wt loss (%)	Initial pH	Final pH
1	0.5	2113A	2113A/1/1	15	9.1			
			2113A/1/2	30	6.1			
			2113A/1/3	60	12.5			
			2113A/1/4	60	356.1	4.1	6.8	6.2
2	2.0	2113A	2113A/2/1	15	27.0			
			2113A/2/2	30	58.0			
			2113A/2/3	60	286.1	7.2	6.8	6.1
3	0.5	2113B	2113B/1/1	15	35.9			
			2113B/1/2	30	52.3			
			2113B/1/3	60	217.6	23.5	5.8	6.1
4	2.0	2113B	2113B/2/1	15	42.6			
			2113B/2/2	30	40.6			
			2113B/2/3	60	194.3	30.6	5.8	6.1

2.5. Sampling procedures

2.5.1. Solids

At the required times a small beaker was dipped into the attritioning cell to obtain a representative pulp sample. This sample was washed into a 10 L bucket and 2 L of distilled water was added. The pulp was mixed thoroughly (ie, re-pulped), allowed to settle and the slimes fraction decanted off. This wash/decant procedure was repeated another two times (ie, three wash/decants in total). The final solids sample was washed into a Millipore filter funnel and filtered using 1.2 micron filter paper. The solids were then transferred to a tray and dried in an oven at 60ºC overnight. Dry sub-samples were then weighed and bagged for analysis. Approximately 50 g of material was riffled from the final dry product samples for analysis.

2.5.2. Liquids

At the end of each test a 10 ml liquor sample was taken. The liquor was filtered though a 1.2 µm Millpore filter and bottled for analysis.

2.6. Product analysis

Solid samples were sent to Australian Laboratory Services (ALS) by Gerhard Krummei for analysis for Al_2O_3, Fe_2O_3, TiO_2, CaO, MgO, MnO, V_2O_5, and Cr_2O_3.

3. RESULTS

Analytical results for the solids as reported by ALS for all tests are presented in Table 2.

As notified by Gerhard Krummei, the assay value for sample 2113A/1/1 is a calculated value because of a mix up in the samples by ALS. From the trend in the assay values, it appears that the Fe_2O_3 and TiO_2 assay values for the glass sands head sample (2113A) are in error also.

The results indicate that the lower SHMP dose had little effect on the impurity levels in the glass grade sample, 2113A. However, the treatment with the higher dose of 2% w/v SHMP did give a significant decrease in the impurity levels, to 70 ppm Fe_2O_3 and 20 ppm TiO_2. Beyond an agitation time of 30 minutes there was no further decrease in the impurity levels.

With the flour grade sample, 2113B, both additions of SHMP gave a similar reduction in impurity levels and there was little effect of increasing agitation time beyond 15 minutes. However, the impurity final levels were higher than those achieved with the glass grade sample at the 2% w/v SHMP addition.

The result from these limited number of tests suggest that it is better to treat the coarser glass grade sample than the finer flour grade sample. In view of the limited number of tests, the results for the glass grade sample appear to be very promising, although it is not known what impurity levels are acceptable for the proposed applications.

It is anticipated that lower impurity levels could be achieved with further testing using different contact conditions (eg multiple contacts as in a washing circuit) and the addition of other chemicals, instead of or as well as SHMP.

Table 2 – **Analysis of solid products**

Sample	Al_2O_3 (ppm)	Fe_2O_3 (ppm)	TiO_2 (ppm)	CaO (ppm)	MgO (ppm)	MnO (ppm)	V_2O_5 (ppm)	Cr_2O_3 (ppm)
2113A head	400	170	60	240	120	<10	<10	<1
2113A/1/1*	150	850	830	190	100	20	<10	10
2113A/1/2	170	630	640	190	110	20	<10	6
2113A/1/3	150	440	420	190	110	10	<10	8
2113A/1/4	170	850	920	210	130	30	<10	9
2113A/2/1	210	100	30	230	120	<10	<10	2
2113A/2/2	170	70	20	190	100	<10	<10	3
2113A/2/3	140	70	20	190	100	<10	<10	4
2113B head	830	400	120	580	300	<10	<10	2
2113B/1/1	390	180	50	480	210	<10	<10	1
2113B/1/2	350	150	40	490	210	<10	<10	1
2113B/1/3	320	150	40	520	230	<10	<10	2
2113B/2/1	360	170	40	470	210	<10	<10	<1
2113B/2/2	360	170	50	550	240	<10	<10	2
2113B/2/3	290	140	30	500	210	<10	<10	2
56% 2113A + 44% 2113A/1/1	290	470	400	220	110	10	<10	4

Data for 2113A/1/1 is calculated as a mixture of 2113A/1/1 and 2113A/1/1

APPENDIX 4

ACID WASH TESTS - PRELIMINARY DATA

927032

ATTN : Gerhard
From : Chris Browne

Below are the initially reported results on solids samples submitted to ALS for ALS 35/75/B3 and ALS 20/250/B8. The head analysis described as "orig" is as you reported to me, and the head analysis described as ALS is that given by AL:S (Bris) on head samples submitted by myself.

		oC	AL2O3 ppm	Fe2O3 ppm	CaO ppm	MgO ppm	TiO2 ppm	MnO ppm	Cr2O3 ppm
B3	Head orig		111	80	350	174	25	0.3	0.5
B3	Head ALS		141	67	469	232	32	0	0
B3	5% H2SO4	15	134	53	422	214	30	0	0
B3	10% "	15	140	55	451	221	30	0	0
B3	5% "	30	129	50	426	215	25	0	0
B3	10% "	30	133	49	430	219	26	0	0
B3 Density Fraction>2.65			134	68	454	224	32	0	0
B8	Head orig		97	54	144	81	17	0.2	0.1
B8	Head ALS		112	58	172	93	22	0	0
B8	5%H2SO4	15	104	50	142	83	19	0	0
B8	10% "	15	106	49	143	84	22	0	0
B8	5% "	30	109	52	125	71	19	0	0
B8	10% "	30	98	46	133	79	20	0	0
B8 Density Fraction >2.65			391	56	160	89	21	0	0

finer fraction ALS 35/75/B3

Coarser fraction ALS 20/250/B8

The liquor samples submitted to ALS are shown on the attached sheet. There are some inconsistencies which I will comment on in my report.

The density fraction in each case is that which sank in bromoform, and represented the majority of the sample in each case.

I may have some analyses checked before sending my report.

J.J. McDONALD & SONS MINING PTY LTD
ACN 051 399 261 ABN 29 051 399 261

FACSIMILE TRANSMISSION

TO	:	Chris Browne, Osleach Pty. Ltd.	FAX: 07 5598 8590
FROM	:	Gerhard K. Krummei	FAX: 03 9820 2595
DATE	:	31st May 2002	
PAGES	:	Two	
SUBJECT	:	SILICA FLOUR - ACID LEACH TESTS	

This afternoon I mailed to you two samples of about 0.5 kg each of two types of silica flour product for acid washing tests as per our phone discussions over the last two weeks.

Both samples were cleaned of magnetic material through a lab-size WHIMS at a field strength of 15,000 gauss. This yielded only a tiny amount of magnetic impurities. A few flecks of black, possibly Fe-bearing organic material which does not seem to float, remain in the flour product.

Sample AIS 35/75/B3 is a fine silica flour product which, pre-WHIMS clean-up, assayed 80 ppm Fe_2O_3, 25ppm TiO_2 and 350ppm CaO.

Sample AIS 20/250/B8 is a somewhat coarser silica flour product which, pre-WHIMS clean-up, assayed 54 ppm Fe_2O_3, 17ppm TiO_2 and 144 ppm CaO.

The purpose of the acid washing tests, using sulphuric acid, is to determine primarily how much of the residual iron, and to a lesser extent CaO, can be removed by agitation/attrition washing by dilute H_2SO_4. at ambient temperatures. In line with a previous experiment on silica sand, it is suggested that 5% and 10% acid strengths be used at 15°C and 30°C with sampling at 30, 60, 120, 300 minutes intervals, with the final sample at 24 hrs.
It is desirable that the iron content of the commercial end product be as low as possible.

The head and last (24 Hr) sample of each run should be analysed for Al_2O_3, Fe_2O_3, TiO_2, CaO, MgO, MnO, Cr_2O_3 and V_2O_5.

The remaining samples of each run need only be analysed for Fe_2O_3, TiO_2, and CaO at this stage.

Arrangements will be made with ALS Chemex, Brisbane, to authorise you to submit the project samples for analysis at their laboratory on our behalf. A copy of my memo to ALS on the matter is attached for your reference.

A brief report on procedures, results and comments/conclusions would be required at the end of the project.

Please retain any head sample material for eventual return.

GERHARD K. KRUMMEI
for and on behalf of
J.J. McDonald & Sons Mining Pty. Ltd.

Suite 28, 487 St.Kilda Road, Melbourne. Vic. 3004. Australia
Telephone & Facsimile: 61-3-98202595

APPENDIX 5

ULTRASOUND TESTS - AGRICOLA REPORT

AGRICOLA CONSULTING SERVICES PTY LTD
A.C.N. 052 486 521

agricola consulting services

Tony Farmer
Consulting Metallurgist

147 Greville Street Chatswood
New South Wales 2067

Telephone: 02 9415 1858
Facsimile: 02 9411 6292
E-mail: anthony.d.farmer@csiro.au

10 September 2002

Mr. G K Krummei
J J McDonald & Sons Mining Pty Ltd
Suite 28, 487 St Kilda Road
Melbourne
Victoria 3004

Re: Application of ultrasound in cleaning silica flour.

Sample Description

Ultrasound was applied to two out of the four samples received:

- Sample US77, which was visually the most contaminated with what appeared to be iron oxides and iron rich clays and
- Sample EQ010 US, which was the whitest of the samples.

A representative sample of each material was taken as a head sample. Approximately 1kg of each was then wet washed through a 300µ screen and several other screens down to 38µ. The 300/38 micron fractions were combined and the three fractions dried and weighed. The particle size distributions reported below:

Table 1 Particle Size Distribution

Sample	Aperture-microns	Wt-g	Wt%
EQ010 U/S	>300	240	24.4%
	300/38	459	46.6%
	<38	286	29.0%
	Total	985.0	100.0%
U/S 77	>300	432	40.3%
	300/38	420	39.2%
	<38	220	20.5%
	Total	1072.0	100.0%

The highly contaminated sample, U/S 77 contained considerably more +300µ material, possibly due to smaller particles being agglomerated by cementation. The ratio of the two finer fractions was comparable for the two samples.

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Test work

About 100g of the dried, sized fractions were re-wetted and sonicated in an equal amount of water containing 0.5% sodium carbonate, for five minutes at full power. The 300/38μ material was then washed on a 38μ screen to remove any of the dislodged surface contamination.

The -38μ material was sonicated and then cleaned by decanting the very fine slimes, which would not readily settle. The material was then passed through a 1 Tesla laboratory wet high intensity magnet.

Separate samples of the original material (not dried) were washed through a 300μ and 38μ screens to produce the washed 300/38μ samples.

The following samples were sent to McDonald Mining for analysis:

EQ010 Head sample

EQ010 Unsonicated 300/38μ sample

EQ010 Sonicated 300/38μ sample

EQ010 Unsonicated -38μ sample

EQ010 Sonicated and magnetically separated -38μ sample

US77 Head sample

US77 Unsonicated 300/38μ sample

US77 Sonicated 300/38μ sample

US77 Unsonicated -38μ sample

US77 Sonicated and magnetically separated -38μ sample

The above samples were analysed by the Australian Laboratory Services. Results are shown in the table 2.

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Table 2 Summary of analysis results

Element	Sample No.	Fe2O3	Al2O3	TiO2	CaO	MgO	MnO	V2O5	Cr2O3
Unit		%	%	%	%	%	%	%	ppm
Method		M289-1	M289-1	M289-1	M289-1	M289-1	M289-1	M289-1	M289-1
Sample Description									
US77 - Total head sample	5501	0.889	0.597	0.058	0.024	0.010	0.001	0.002	12.0
US77 - 300/38µ washed	5502	0.335	0.212	0.012	0.032	0.009	-0.001	-0.001	5.0
US77 - 300/38µ washed & sonicated	5503	0.101	0.038	0.003	0.028	0.009	-0.001	-0.001	1.0
US77 - 38µ unsonicated	5509	0.718	0.519	0.036	0.050	0.016	-0.001	0.001	11.0
US77 - 38µ sonicated & mag.sep. 1 tesla	5510	0.249	0.202	0.017	0.047	0.018	-0.001	-0.001	5.0
EQ010 - Total head sample	5504	0.024	0.017	0.015	0.032	0.006	-0.001	-0.001	-1.0
EQ010 - 300/38µ washed	5505	0.021	0.016	0.005	0.030	0.007	-0.001	-0.001	-1.0
EQ010 - 300/38µ washed & sonicated	5506	0.019	0.014	0.006	0.031	0.008	-0.001	-0.001	-1.0
EQ010 - 38µ unsonicated	5507	0.041	0.023	0.020	0.036	0.009	-0.001	-0.001	1.0
EQ010 - 38µ sonicated & mag.sep. 1 tesla	5508	0.061	0.020	0.015	0.037	0.009	-0.001	-0.001	-1.0

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Comments

The iron reduction was more dramatic for the highly contaminated sample. The best result for this material was obtained for the washed and sonicated 300/38μ sample (5503). The reduction in the -38μ material after sonication could have been improved with better removal of high iron fines of lower magnetic susceptibility, which were not removed by the 1 Tesla magnet. The magnet removed very little of the iron containing impurities judging by the very low amount of magnetic mineral collected.

In the case of the low iron material there was some reduction in iron in the coarser fraction (samples 5505 and 5506). The unsonicated -38μ fraction (5507) indicates that more of the contamination reports to the fines, while the rise in iron after sonication and was probably due to contamination from the magnet despite the fact that the matrix was removed and cleaned between samples.

The results are encouraging for a first attempt. A great deal more work needs to be done in order to determine the optimum processing method. However a number of observations can be made:

- The iron contaminants are of low magnetic susceptibility and require much higher strength magnets.
- Much of the contamination is released as fine slimes and may best be removed using hydrocyclones cutting at 5-10 μ. (eg AKW cyclones)

It is our opinion that a system consisting of simple screening to remove the undesirable top size followed by sonication and cyclone separation would achieve a "standard" product of around 0.05% Fe_2O_3 or better. If a "premium" product were commercially justified, further sonication plus higher intensity (>2 Tesla) magnetic separation may achieve it.

We would be able to simulate all the separation processes in our laboratories except for the high intensity magnetic separation, which could be carried out at Eriez Magnetics on samples prepared by us.

Before doing this work it would be helpful to look at closely sized fractions of sonicated material in order to determine the most desirable top and bottom cuts (screen and hydrocyclone respectively). This can be achieved by screening a typical (or representative) material at say 300μ, sonicating it and again screening on eg a 75μ screen. The plus 75μ fraction would then be dried and screened on a √2 series of test screens while the minus 75μ fraction would be separated on a cyclosizer in fractions down to say 5μ. The other test would be to take some material in the size range determined by the first test and digest it with aqua regia. This would indicate the lowest level of iron that would result from the removal of all surface contamination.

It is estimated that the preliminary work would take about 2-3 days and would cost $4000.00 not including analysis. Bench scale simulation of a possible flow sheet would take about one week and cost $9500 and would yield a few kilograms of product.

agricola
consulting services

From these results we could undertake small scale pilot plant work to more closely define the flow sheet and produce a few hundred kilograms of material for market evaluation. The cost of this would depend on the extent of work required and would be best left after the preliminary and bench scale work was completed.

Tony Farmer

A D Farmer
Consultant.

927040

APPENDIX 6

MINERALOGICAL EXAMINATION - CMS REPORT

927041

Central Mineralogical Services

8 Bradshaw Avenue, Crafers, S.A. 5152
Telephone (08) 8370 9779 Fax (08) 8370 9788
International Telephone +618 8370 9779 Fax +618 8370 9788

CMS

22 March 2002

Dr G. Krummei
J J McDonald & Sons Mining Pty Ltd
Suite 28
487 St Kilda Road
MELBOURNE VIC 3004

REPORT NO. CMS 02/3/4

YOUR REFERENCE:	Letter 15 March 2002
DATE RECEIVED:	18 March 2002
SAMPLE NOS:	As per report
SUBMITTED BY:	G. Krummei
WORK REQUESTED:	Mineralogy

H.W. Fander

H.W. Fander, M. Sc.

REPORT CMS 02/3/4

SILICA SANDS PROJECT SAMPLES

Nine samples were received for mineralogical examination, to determine the non-silica contaminants.

All the samples were mineralogically examined as received, and three samples were subjected to panning procedures to concentrate the heavy minerals. Polished sections were prepared and examined of most products.

GENERAL COMMENTS

Quartz

Three types of quartz can be distinguished:

a) The major form is "milky" quartz, occurring as subangular, irregular grains; the milky colour is thought to be due chiefly to minute air bubbles within each grain, also possibly ultrafine TiO_2 and occasionally, fine carbonate inclusions.

b) The minor form is clear colourless quartz, generally as smaller, more rounded grains than the milky quartz.

c) About 5% or less is "smoky" quartz occurring as pale brown grains in ***2213/A1/4*** and other samples; the grains are subangular and in a similar size range to the milky quartz (i.e. up to 700µ).

Other Components

These include a variety of mineral and artificial phases, detailed in the individual descriptions. The presence of some phases can only be explained by assuming that contamination has occurred at some stage during processing.

SAMPLE DESCRIPTIONS

DH 110-S/5K

This contains 10-15% of limonite-impregnated, rounded aggregates of fine quartz-sericite; the amount of limonite (=earthy goethite) impregnation is variable, thus the magnetic response also varies over a range of susceptibilities. The aggregates may represent a ferruginised siltstone horizon; they are relatively soft and could be attritioned and removed by washing. The aggregates are up to 600µ in size.

There are very rare grains of zircon, brookite (TiO_2), tourmaline, hematite, pyrite and carbonaceous matter and brass flakes.

SAMPLE DESCRIPTIONS

DH110-S/10K

This contains about 35% of limonite-stained quartz-sericite aggregates (30-750µ). There are **rust** flakes up to 600µ across, comprising 1-2% of the sample, and a trace of ferrous slivers, superficially oxidised, originating from equipment.

There are traces of hematite and martite (altered magnetite), and isolated brookite grains. Very occasional quartz grains contain small pyrite inclusions.

DH110-E/10K

Limonite-stained quartz-sericite aggregates comprise 35-40% of this sample. Ferrous flakes and slivers amount to 1-2% and there is a trace of rust flakes.

Trace amounts of chalcopyrite, chalcocite-digenite, bornite and pyrite occur as small (<100µ) grains, presumably representing contamination from equipment.

2213/A1/4

This contains black, submetallic, rounded grains and isolated particles of black carbonaceous matter.

The sample was hand-panned in a 15cm Petri dish to concentrate the black grains; the concentrate was briquetted and polished, and the grains were identified as **ilmenite**, comprising a small trace of the sample. There are also isolated grains of pyrite. The ilmenite grains range from 30µ to 300µ in size.

2213/A2/2

Apart from isolated grains of black carbonaceous matter no other dark minerals were detected, even after hand-panning. A trace of smoky quartz occurs.

1223/B1/3

A trace of black carbonaceous matter (including fibrous material) is the only dark constituent. A trace of smoky quartz is present.

1223/B2/3

As for B1, the only dark component is a trace of black carbonaceous matter.

Quartz grains are up to 240µin size, and most are in the 40µ - 100µ range.

A1S20/250/B8

A heavy-liquid separation was unsuccessful; a 100g sample was Superpanned and the concentrate was examined in polished section.

The sample contains traces of pyrite, chalcopyrite and bornite, and rare grains of goethite, rusty ferrous metal, zircon, magnetite and ilmenite.

SAMPLE DESCRIPTIONS

A1S35/75/B3

This contains a trace of black carbonaceous matter. A Superpanner concentrate was produced which contained pyrite, chalcopyrite and bornite grains in trace amounts (i.e. in reference to the original sample).

The sulphides in B8 and B3 are believed to be contaminants. Since *DH120-E/10K* contains the same sulphides (and was not further processed at Central Mineralogical Services), clearly the contamination occurred elsewhere.

PHOTOMICROGRAPHS

1. DH110-S/10K x 25
Limonitised quartz-sericite aggregates (various shades of brown); rusty Fe sliver (ringed); milky quartz.

2. DH110-S/10K x135
Clumped rust particles and a sliver of Fe (bright).

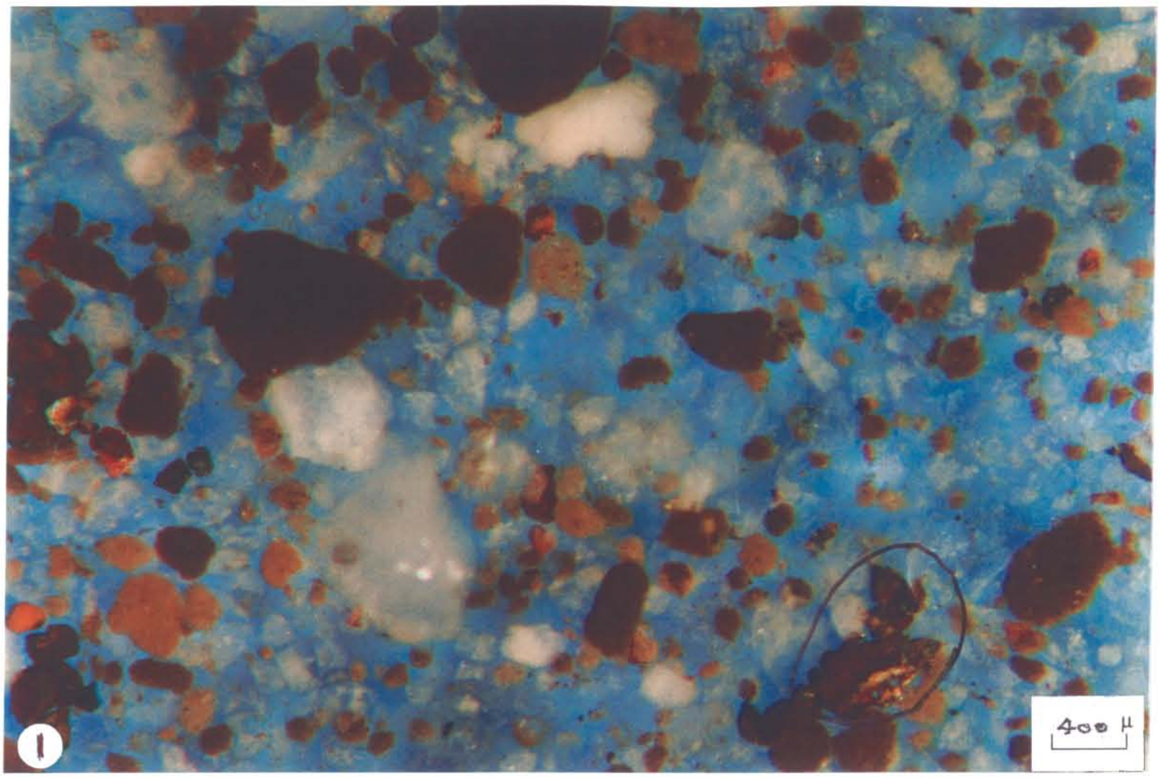
3. DH110-E/10K x270
Small ferrous particles. Part of a large ferruginised quartz-sericite aggregate.

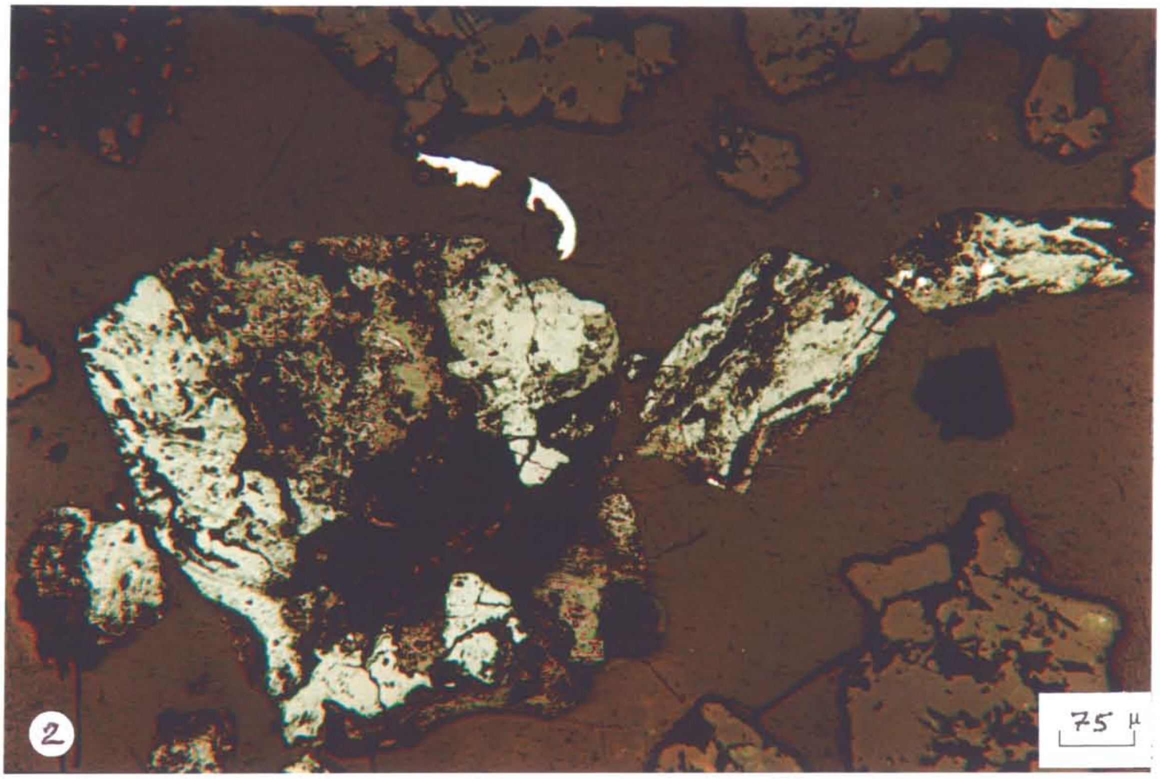
4. DH110-E/10K x270
Bornite/digenite grain and ferrous particle (bright).

5. 2213/A1/4 x270
Rounded ilmenite grains.

6. A1S 20/250/B8 x270
Chalcopyrite (cp), pyrite (py), bornite (bn) and bornite/magnetite composite.

NB Note the shapes of the quartz grains in all photos.





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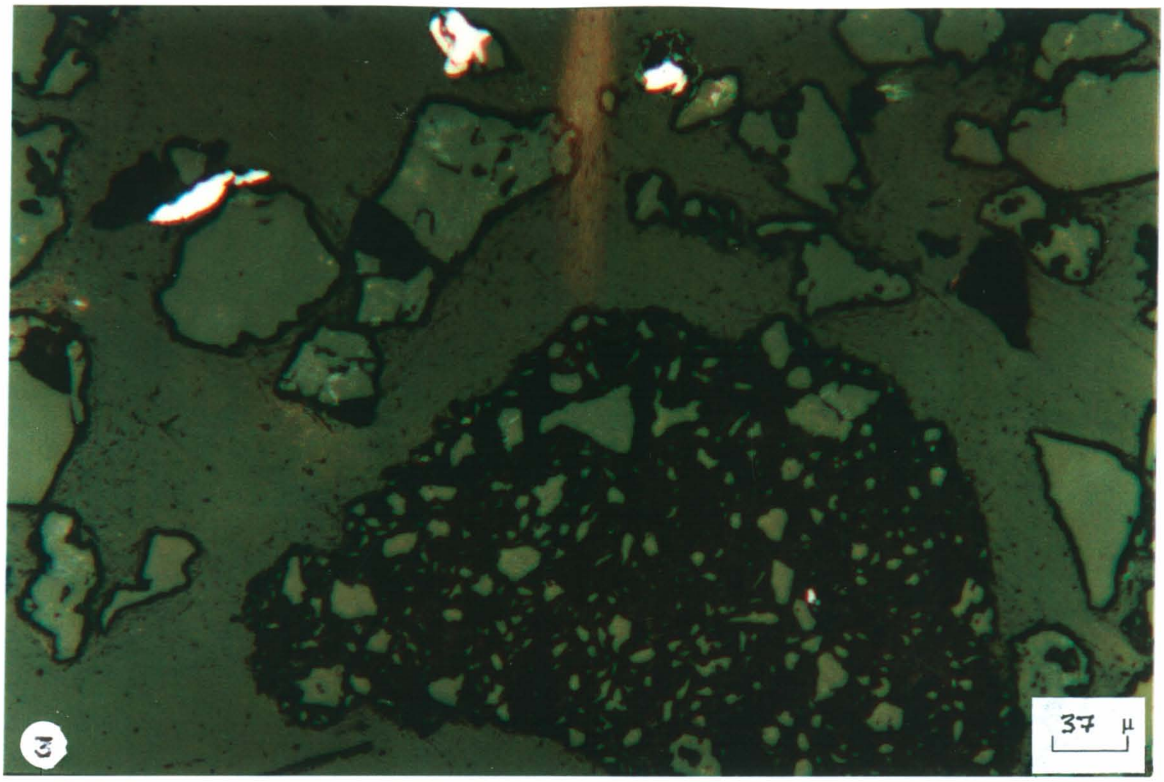

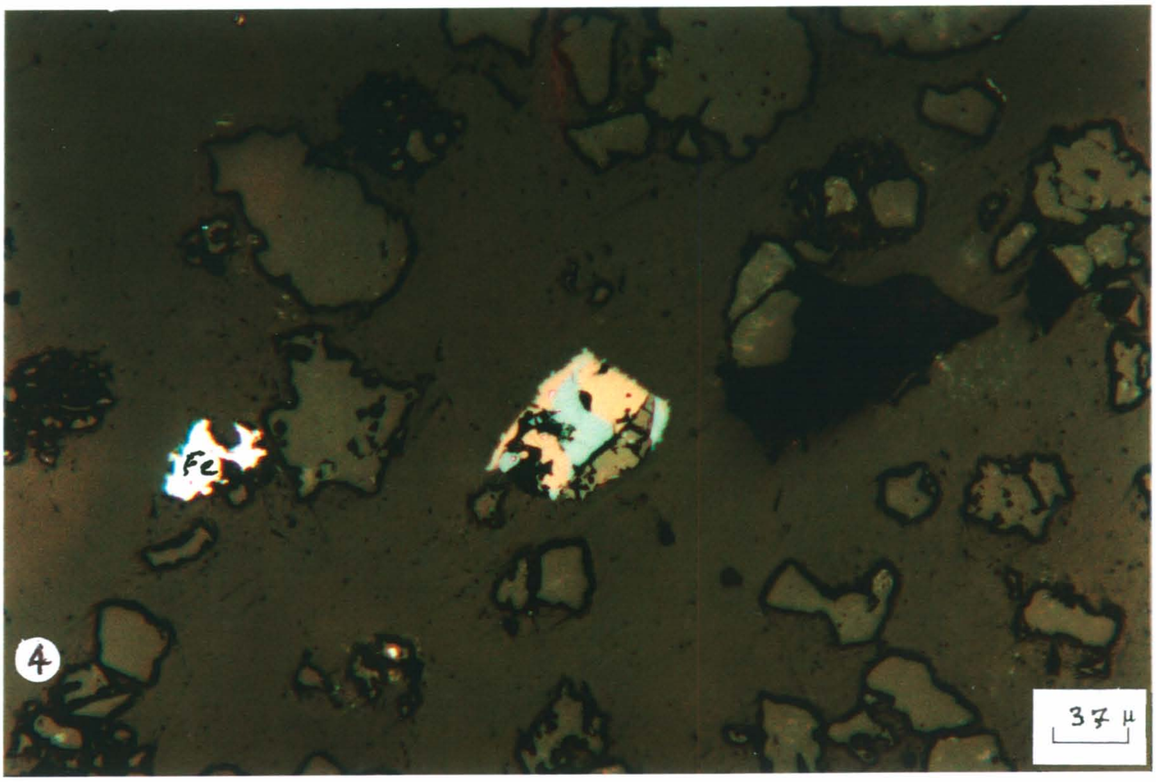

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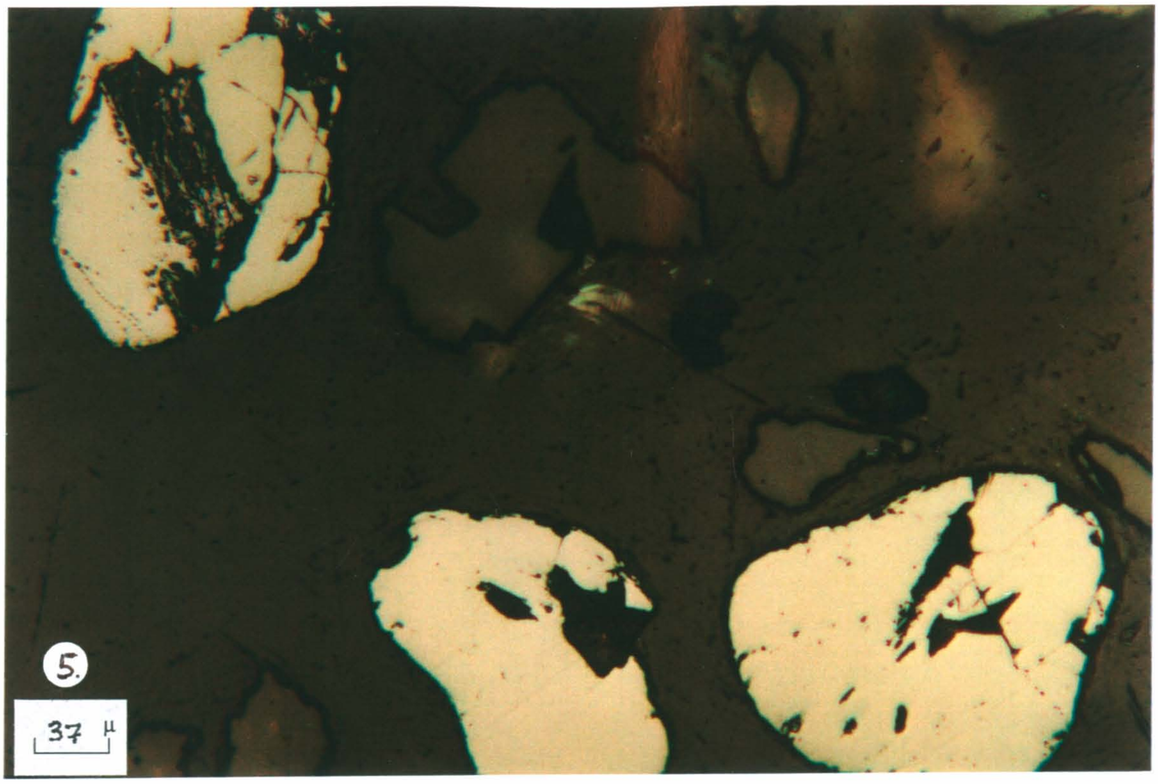
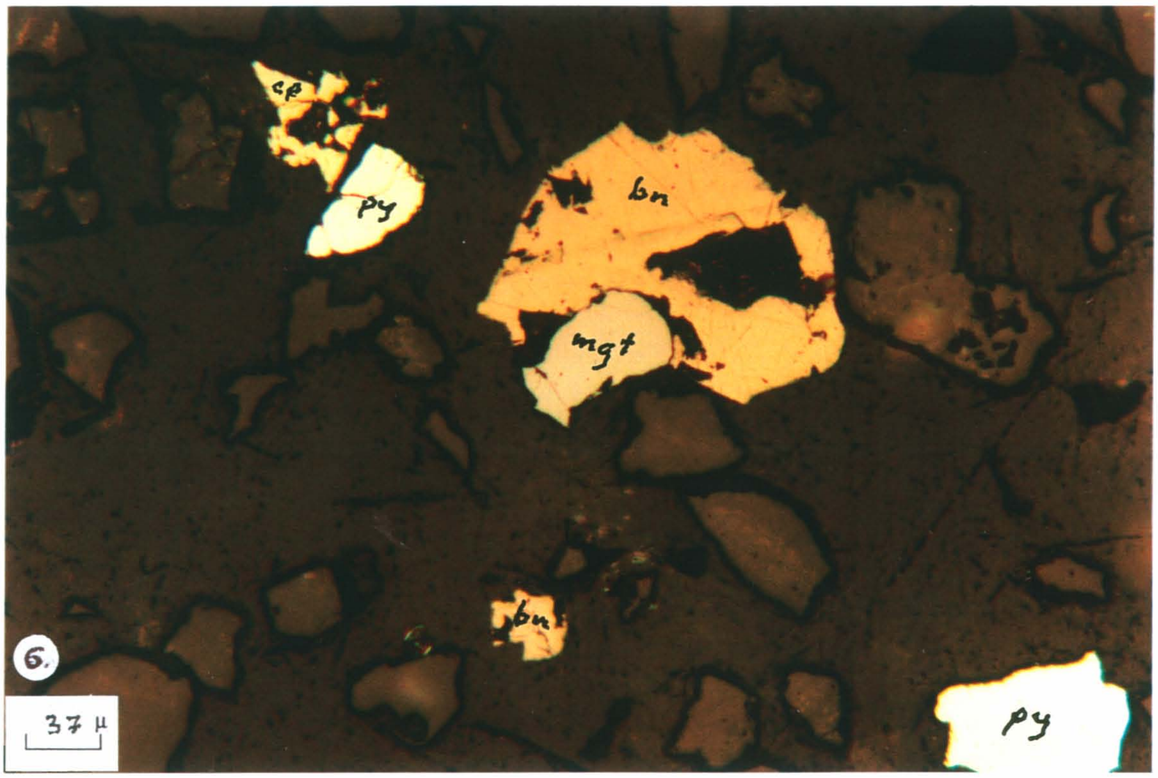




5 cm

927048

J.J. McDONALD & SONS MINING PTY LTD

ACN 051 399 261 ABN 29 051 399 261

15th March 2002

Dr. W. Fander
Central Mineralogical Services
8 Bradshaw Avenue
CRAFERS SA 5152

Dear Dr. Fander,

RE: MINERALOGICAL EXAMINATION - SILICA SANDS AND FLOUR PRODUCTS

Following my telephone call earlier this week I enclose herewith, on behalf of my client, J.J. McDonald & Sons Mining Pty. Ltd. a total of 9 samples for mineralogical examination along the lines described and requested below.

The material comes from the same general area as that dealt with in your report CMS 99/7/9 to which you may wish to refer for additional information.

THE SAMPLES:

The first seven samples are various products form the same "head sample".

DH 110S/5K and DH 110S/10K are WHIMS-derived, coarser fractions of the "head sample" obtained at 5K and 10K gauss field strenghths respectively.

DH 110E/10K is the magnetic fraction of the silica flour size band of the "head sample" obtained by WHIMS at a 10K gauss setting.

We need to know the identity of the magnetic particles and obtain some measure of the effectiveness of the use of WHIMS in this application.

Samples 2213/A1/4 and 2213/A2/2 are Calgon-leached products of the coarse (sand) fraction cleaned by WHIMS prior to leaching. You will note that these samples still contain variously sized, (?non-magnetic) specs of black material. There are also occasional, darker grains of ?silicate material.

We need to identify these (?mostly) metallic and silicate contaminants. The amount (approximate only) of these particles as a proportion of the whole would also be useful information, if it does not take up too much time. (?spot grain count). Some of the black specs look like metallo-carbon and may be of organic origin.

Samples 1223/B1/3 and 1223/B2/3 are Calgon-leached products of the flour-size fraction, also cleaned by WHIMS prior to leaching. Again, there are tiny specs of black metallic and darker silicate material.

Again, we need to identify these contaminants in this fine fraction and obtain a rough estimate of the quantity of these.

Samples AIS 20/250/B8 and AIS 35/75/B3 are the result of mechanically cleaned silica sand and silica flour fractions respectively from a bulk sample at a different location form the above. They have not passed through WHIMS, so that magnetic material is part of the "black spec" assemblage.

Again, we need to know the identity of the black specs, with a semi-quantitative estimate as part of the whole sample (?spot grain count).

Suite 28, 487 St.Kilda Road, Melbourne. Vic. 3004. Australia
Telephone & Facsimile: 61-3-98202595

In addition, could you perform a heavy media separation, at about the silica SG threshold, on sample AIS 20/250/B8 and report on the identity and approximate amounts of the "heavies". I leave it to your discretion whether to use part or all of the sample for this purpose.

OBJECTIVE:

The overall purpose of this assignment is to:

* identify the black specs of magnetic and non-magnetic material in the samples provided, and guage the efficiency of the magnetic separation process

* identify, and roughly quantify, the "heavy" silicate fraction in sample AIS 20/250/B8.

* photomicrographs of any salient sample features would be welcome

* provide information to assist towards design of a suitable beneficiation process to give an impurity-free silica sand and flour product

I require three copies of your final report.

Please return all sample residues and any slides to me at the completion of this assignment.

Your invoice should be made out to:

J.J. McDonald & Sons Mining Pty. Ltd.

and mailed to me so that it can be endorsed and passed on for payment.

I shall be pleased to answer any queries that may arise.

Yours sincerely,

GERHARD K. KRUMMEI

for and on behalf of
J.J. McDonald & Sons Mining Pty. Ltd.

APPENDIX 7

PROCESSING OPTIONS FOR SILICA FLOUR PRODUCTION

927051

PROCESSING OPTIONS
FOR
SILICA FLOUR PRODUCTION

PINE HILL SILICA SAND DEPOSIT

MAYDENA, TASMANIA

A PRELIMINARY STUDY

WILLIAM A TAYLOR

METALLURGIST

APRIL 2002

ABSTRACT

J.J. McDonald and Sons Mining Pty Ltd have established the existence of a resource of silica sand at Pine Hill, near Maydena in Tasmania. Consideration of the material characteristics and market research has indicated that the most viable product should be silica flour of high purity.

A review is presented of current practice and equipment used in the production of silica sand products. This section also addresses some issues specific to the Pine Hill site. Application of the available equipment to the Pine Hill deposit is developed with the aid of flowsheets detailing three possible treatment strategies.

Capital and operating cost estimates have been compiled based on the most conservative plant design and conclusions are drawn that a viable plant could be built and operated providing that the estimated product market volume and price were achieved. Capital cost of below $2,000,000 is a realistic estimate with production cost to the mine gate of below $50.00 per tonne provided the product specification is close to that assumed.

Initially the plant would not incorporate a mill so to maintain adequate product yield high-grade areas of the orebody would be targeted. Once cash flow is established and operating experience gained the addition of a mill is not expected to be a difficult operation. Oversize material rejected during earlier operations could then be reclaimed and used to produce high-grade product.

Some suggestions are made for future investigations into commercial and operating aspects for which sufficient data has not yet been accumulated. Of major importance is the improvement of knowledge on upgrading of material currently considered as low grade due to iron staining and contamination. Advances in this area will lead directly to improvement in reserves and possibly lower operating costs.

APPENDIXES

1 Introduction

Following a request from Mr. Gerhard K. Krummei of JJ McDonald and Sons Mining pty ltd I traveled to Tasmania to inspect their prospective silica sand mine at Pine Hill, near Maydena. The object of this visit was to gain a first hand knowledge of the deposit and the surrounding area to assist in compiling the following report.

This report is a preliminary scoping study to investigate the viability of a mining operation on the Pine Hill deposit. It tends to concentrate on the plant design and operation rather than details of mining and infrastructure, except in the aspects that will directly affect production.

It is believed that the most likely major product will be silica flour of high purity and a sizing in the –250 to +30 micron range. This product is to be dry and packaged in one tonne bulk bags and production at a rate of 25,000 tonnes per year is considered in detail. The product size range represents a minor portion of the total deposit size distribution and consideration has been given to improving the silica flour yield by using some method of comminution such as grinding in a tumbling mill. Due to the high capital cost the initial operations may not incorporate a mill, but could target the areas of the ore body that have the highest proportion of fine material to establish cash flow and finance later expansion. Reject material suitable for later reprocessing and upgrading could be stockpiled. Sales of other products are possible and various subsidiary streams may be generated for stockpile or immediate sale.

Spreadsheets have been produced which detail several processing routes with process flows and tentative estimates of capital and operational cost. At this stage they can be taken as a guide only and many areas could not be examined in detail in the time available. They are believed to be representative of feasible processes and equipment requirements but there are many unknown factors and considerable changes must be expected during production of a final design.

The report begins with an overview of the unit processes and equipment that could be used to produce a suitable product. Following this is a discussion of three flowsheet proposals; the actual flowsheets along with tentative estimates of capital and operating costs are attached as appendices. Finally conclusions are presented along with recommendations for further research and development work.

2 Production of Silica Flour

2.1 Mining and Rehabilitation

Although it may seem out of place I will consider rehabilitation first. Current practice is to consider the means and cost of rehabilitation from the very beginning of planning and throughout the mining operation. This helps to ensure that sufficient provision is made for the ultimate rehabilitation cost and reduces the occurrence of often extremely unpleasant surprises. Prestripping and stockpiling of overburden will require careful planning to ensure that rehabilitation is not compromised. In other areas such as

Western Australia this is a high cost operation due to the necessity to use the topsoil within about 18 months of stripping to ensure viability of the seed stock. However conditions for regrowth appear to be favorable in the mine area and the ready availability of suitable seed mixtures may reduce the need for careful husbandry of the topsoil. Local forestry expertise could also be of great benefit. Of course the relevant authorities must be consulted and the rehabilitation criteria and methods agreed before the operations commence.

Due to the relatively small plant throughput the mining will be on a campaign basis. Preliminary calculations indicate that an excessive stockpile area would be required for annual mining campaigns so bi-monthly or tri-monthly operations are most likely. This will also be better from a cash flow perspective.

Acquisition and operation of mining equipment by the owners would not be economic so a contractor would be engaged to carry out the prestripping and mining operations. The contractor may also supply equipment on a more permanent basis for transport of material from mine stockpiles to plant stockpiles between mining campaigns. It is possible that the mining contractor could supply the loader required for plant feeding.

Since there is potential for the ore to dry during mining and screening operations dust control could become a major issue. Silica dust in fine sizes is a very dangerous material and strict regulations are in force as to maximum airborne concentrations. Simple measures such as water sprays may be sufficient but this will need to be combined with careful design of equipment to minimise dust generation and ensure it is contained. Part of the mining contract will be for the contractor to comply with all regulations and company requirements for dust control.

Choice of initial mining area will be strongly influenced by plant design and product requirements. The need to maximise product yield, the presence or absence of a milling stage in the plant and the response to product purity upgrading of ores from various areas will affect mining decisions. Since these details will not be known until planning is far advanced very few conclusions can be drawn at this time.

2.2 ROM Primary Screening

There is an appreciable but variable amount of oversize material present in the ore and this appears to mainly consist of nearly pure silica in the raw state. Selective mining using excavator or front-end loader (FEL) can separate the very large boulders but the smaller material must be screened off to avoid problems in the plant. Samples of the oversize have in the past been found suitable as feed for silicon metal production and other pyrometallurgical applications so there may be a case for building a stockpile for future sale. Alternative markets are for road building and other civil engineering uses but these are low value products and do not justify much capital expenditure on plant design.

Primary screening is best carried out as at least a two-stage process. Initially the large rocks that were not removed during mining must be separated on a heavy-duty screen or Grizzly. Then the material of greater than 50mm should be screened off and stacked. This process will eliminate the need for a Grizzly at the plant feed hopper and reduce the chances of damage to plant feeding and trash screening equipment.

Suitable equipment for the primary screening would be a portable road metal screening plant and these units are often available for short-term hire or could be supplied by the mining contractor. Usually they either incorporate a crusher or are intended to operate in a crushing circuit, but it is quite simple to bypass the crushing section. If a market is found for the oversize material in a particular size range the crushing step might become a necessity.

An impact type crusher could substantially improve the proportion of fines in the plant feed but trials would be necessary and dust generation is certain to be increased. In any case the screening and crushing operations will be the areas where the maximum dust control effort will be focussed.

2.3 ROM Stockpiling

Whatever the mining method and schedule there will be a need to stockpile mined ore. Whether the stockpiles are at the mine site or the plant site will to some extent depend on the frequency of mining and the area available at the mine site and plant. It is most likely that a combination of both will be used.

A substantial part of the mined and screened material from each campaign would probably be stockpiled at the mine site with the remainder being transported to the plant stockpiles during the campaign. Stockpiles at both plant and mine would be segregated according to plant feed quality criteria. Between mining campaigns there may need to be a more or less continuous transport of material from the mine site to the plant stockpiles.

Plant stockpiles should be of the "finger" type, segregated to give best chance for blending of feed. In siting of the stockpiles all possible advantage should be taken of the local topography to avoid the building of ramps or cuttings and to ensure easy access of the plant feed loader.

Consideration must be given to possible dust generation from stockpiles as this could cause environmental and health and safety problems as well as being a loss of valuable material. Most methods of stockpile dust control are expensive and of limited utility. The best options are to build stockpiles in sheltered areas and to minimise their size as much as possible.

2.4 Plant Feeding

Adequate feeding arrangements are crucial to efficient plant operation but this is sometimes overlooked in plant design, particularly when second-hand equipment is being obtained or adapted.

Feeding of the plant will almost certainly be via a Front End Loader (FEL) and feed bin. Feed rate is expected to be around 25 t/h and this can be achieved using a small to medium articulated wheel loader. A machine of the type known as a tool carrier is the most useful as these have the ability to be used as light cranes and forklifts by addition of suitable attachments. Caterpillar type IT28 or IT18 would fit the bill.

The feed hopper and conveying system up to the trash screen will here be considered as one unit, and this item has the following requirements:

- Provision of sufficient capacity to ensure minimum interruptions to plant operations and smooth out minor fluctuations in feed grade. Usually a capacity of about ½ to ¾ hour at plant design feed rate is adequate, but bigger is better if a range of suitable second-hand bins is being considered.

- Control of the plant feed rate. A variable speed feeder is necessary and this must be linked to an accurate feed rate-measuring device, usually a belt weightometer under the actual feed belt.
- Feed totalisation for metallurgical and statutory accounting. The weightometer will have a totaliser function and this can be used in conjunction with stockpile surveys to account for plant performance and calculate royalties.

The feed hopper should be a permanent steel structure arranged if possible to take advantage of the topography so that a ramp is either not required or is as small as possible. Stockpiles must be within a small radius to minimise tramming by the FEL. An alternative is to build the feed stockpile at ground level or on a raised pad or bank. Feed is taken from under the stockpile via a feeder and belt housed in a tunnel. This eliminates the steel hopper structure and can be the simplest and cheapest option depending on the topography. However it is more often used at higher feed rates than expected for this plant.

The feed material is fine and has a tendency to pack solid and hang up when wet and this is expected to cause feeding problems. Careful bin design and the use of anti-stick materials could reduce or eliminate the tendency to hang-up but this will be expensive and not guaranteed to work. Also if second-hand equipment is used the bin design is likely to be less than optimum and in any case some form of bin activator, for instance a compressed-air cannon could be necessary. This is where the reclaim tunnel system mentioned above may show some advantages.

A separate feeder such as an apron or vibratory unit is a source of problems and expense and will probably not be necessary as this task can be carried out by the conveyor to the trash screen head hopper.

Feed rate measurement and control is best achieved using a belt weightometer on the feed belt and a variable frequency drive on the feed conveyor motor. There have been accuracy problems with belt weightometers on excessively short belts but the newer units may be less prone to it. All weightometers require regular calibration and the design must ensure this is a simple process.

2.5 Trash Screening

Trash screening is essential to remove large oversize and trash that could damage the sizing screens or block valves in a hydraulic classifier. Aperture sizes are not critical otherwise and could be up to 12mm for this application. Too small an aperture will lead to low throughput and blinding problems however.

The only type of screen machine considered for this application is the low to medium frequency horizontal vibrating screen using polyurethane screen panels or a combination of polyurethane and wire screens depending on the open area required. The screen will not be very large, about 2.4m by 1.2m would be suitable. Second - hand equipment is commonly available and relatively cheap but must be carefully inspected for cracks and corrosion. Availability of replacement screen panels is also important; they should be locally produced and ex-stock.

The trash screen must be located so that the oversize material falls into a convenient hopper or bunded area for disposal by FEL. Drainage of the discharged material must not be neglected. An alternative oversize disposal method could be via a hopper and pump but this will depend on the potential uses of other oversize materials and the availability of water for tailing transport. This issue will be discussed under the heading of tailings disposal.

Feed to the trash screen comes from the plant feed conveyor through a head feed box where water is added to achieve a slurry of about 40% solids. The head feed box is not normally supplied by the screen manufacturer and should probably be considered as part of the feeder. It must ensure that the feed is well mixed with the added water and then presented to the screen surface without impact, which causes excessive wear to the screen decks.

Sprays are usually fitted to this type of screen and their purpose is to wash valuable material from the trash or oversize before it is discharged. Due to the tendency for blockages the water used by the sprays is usually the cleanest available.

2.6 Sizing Methods

Only one size range is being considered at this stage so the sizing steps consist of removing the oversize (+250 micron) and undersize (-30micron). These operations tend to use quite different units.

Screening would be considered for the removal of the oversize material (+250 micron). Screens are the most accurate classifying units but also tend to be the most expensive in terms of capital cost. In the finer sizes screens also have the lowest throughput per unit of capital cost. Cyclones however do not give a sufficiently clean cut for the larger size range, but are the most effective and economical device for sizing in the sub 100micron range. Hydraulic classifiers compete with both screens and cyclones but are not as accurate as screens in the larger size range are not as cost effective as cyclones in the smaller size range. Following are some further details on possible sizing units.

2.6.1 Screens.

The only proven device for screening in the size range being considered is the Derrick high frequency vibrating screen using polyurethane decks. Derrick have perfected a fine polyurethane screening surface that gives exceptional sizing performance approaching that of wire screens with much better life. This all comes at a price, a total of approximately $100,000 for a unit that will process about 22 tonnes per hour of trash screen underflow. Screen life for polyurethane should be about one year with total replacement costing about $6,000, replacement is a simple job taking about one hour maximum. Wire screens could last less than a week (possibly only one or two days) and cost $500-$700 to replace. Derrick Corp has been in business for a long time and parts availability is good. It is likely that a suitable second-hand unit would be available somewhere in the world if required but great care should be taken to obtain the correct unit.

A potential disadvantage of the polyurethane screening surfaces is they allow a small proportion of oversize material. In the 250 micron case there could be particles up to 300 micron and this may be unacceptable to some customers. Dry screening at the final product stage could carry out scalping of the oversize and these screens need not be large, as the proportion of near-size material would be small. A type of wet final scalping screen is the semi-submerged trommel used extensively in Japan and at Kemerton Silica Sand, but these machines are very expensive to build and operate.

Derrick offers a free evaluation service in which they will carry out trials of various units using actual feed samples. Cost of transport of sample to the USA is of course born by the customer. This service should be utilised before purchase of a new or second-hand machine to ensure that it will be suitable.

A similar unit to the Derrick is being offered by FSI Corp., represented in Australia by Krebs Engineers. The price is not substantially lower and they are an unknown quantity in terms of reliability and longevity, both of the company and its product.

2.6.2 Hydraulic Classifiers.

Hydraulic classifiers are a major competitor to screens. They have been used in sand plants of all types for many years and in Europe they are the principal classification unit for glass sand production. Essentially they use an upward flow of water to separate the slowly settling fine material from the larger sizes. One type consists of a vertical column of either circular or square cross section, open at the top with an inverted conical base having an automatically controlled valve at its apex. Cross sectional area determines capacity with a 1m^2 unit able to process over 80t/h. Height does not vary much and is about 3m. A controlled addition of water is made through perforated pipes inserted across the column, just above the conical base. Feed is introduced, usually as high-density slurry from a cyclone, via a central tube extending down from the top by about 750mm. The rising current of water carries the smaller sizes over the edge at the top where they are collected in a launder; the oversize is discharged from the valve at the bottom. The bottom discharge is controlled to maintain a constant high slurry density in the column; this leads to hindered settling and better classification. Cut size is controlled over a wide range by varying the upcurrent water rate and or the slurry density. There are many variants available, some with flat bases or other features, but most do a similar job.

Hydraulic classifiers can operate down to 30 micron and up to over 1mm but water consumption increases with cut size and can become excessive. Accuracy of cut is less than that for screens and multiple units may be necessary to get an acceptable product if size specifications are tight. A controlled flow of water is required for the upcurrent supply and this should be free of material that could block the apertures in the distribution pipes. A water circuit dedicated to the hydrosizer is almost essential but this can use recycled water that has been filtered to remove trash.

Suitable units are made by several manufacturers the most popular being Linatex and Floatex (now owned by Outokumpu), Eriez have recently entered the market with a very good unit and they have been most willing to supply a trial machine.

Cost for about 20t/h would be in the region of $50,000 installed including ancillaries. They are simple units and could also be manufactured by any competent steel fabrication shop and I built two of them about 8 years ago with excellent results. There are no enforceable patents on the basic process but some of the manufacturers may try to bully an operator out of making his own and in any case own manufacture may not be desirable.

2.6.3 Hydrocyclones.

Hydrocyclones are one of the most cost effective classification units, particularly in the finer size ranges. They will be specified for separation of the fine size fraction and dewatering duties in all the plant flowsheets considered here. Along with the undersize silica and slimes the cyclones will also remove organic materials.

Cyclones are produced by several manufacturers but in this report and flowsheets the units used will be as supplied by Krebs Engineers. These are constructed of polyurethane and can be supplied with critical parts in still more wear resistant materials such as ceramics or carbides.

There are several possible positions in the circuit for the desliming and removal of the fine size fraction and the treatment of each must be considered in the light of the limitations and sensitivities of the other process units. The use of the cyclones will be discussed in detail in the description of the several flowsheets to be considered.

2.6.4 Milling

The variable size distribution of the ore and the need to maximise product yield leads to the consideration of reduction of the oversize material to product size. There are several methods of achieving this, but the most available and proven is some form tumbling mill. Preliminary grinding tests have been carried out and although the data is not precise the indications are that the ore work index is fairly low.

Some sand processors in Japan have used rod mills with good grinding results, but problems of excessive iron pickup on sand grains were reported. Apparently the iron from the mill rods tends to smear onto the sand grains as very thin films that are difficult to remove by any conventional methods and not amenable to magnetic separation. Another problem is buildup of high magnetics on WHIMS matrix and this can lead to blockage and actual machine damage. Free grinding iron can however be removed effectively by low intensity wet magnetic separation so it is not as great a problem as the thin films. Due to these problems the Japanese will probably be prejudiced against milling using steel media.

Should product purity requirements or customer preferences dictate that non-metallic grinding media are used, for instance flint pebbles there is little data available to enable mill size predictions to be made. Other silica flour manufacturers use this type of mill and their experience may be the best guide provided they are willing to co-operate. Generally it can be said that pebble mills are much larger and less efficient than conventional ball or rod mills for the same capacity and grind size.

2.7 Methods for Separation of Impurities

The major impurity in the Pine Hill deposit is iron and this occurs as oxides in surface coatings and deposited in cracks and voids, aggregates of limonite with quartz sericite and also combined as iron oxide with titanium dioxide to form ilmenite. There are also some carbonaceous particles thought to contain iron.

Impurity separation and removal methods depend on the impurity characteristics. Chemical or mechanical action or a combination of both can remove surface coatings as soluble compounds or slimes. Friable particles such as the limonite-quartz-sericite and carbonaceous impurities can be broken up by mechanical action and removed as slimes.

Spirals can separate high specific gravity impurities, and magnetic impurities are extracted by wet or dry magnetic separation methods. Since the magnetic impurities are also of high specific gravity there is considerable overlap between spirals and magnetic separators.

In the following sections the possible processes will be considered in more detail.

2.7.1 Chemical Treatment with Acid.

Acid treatment may be the only feasible method of cleaning the surface coatings from the sand grains but it has many problems and all alternatives should be considered. Although it may be allowed under current regulations this is not guaranteed to continue and the potential for incidents involving chemicals can generate opposition and adverse publicity.

2.7.1.1 Acid Treatment

Some tests have been carried out on the treatment of Pine Hill sand with sulphuric acid in order to remove surface coatings. Results have been encouraging and all the proposed flowsheets in this report incorporate acid treatment steps.

The principal features of acid treatment are first, removal of as much of the impurities and reject size fractions as practical using conventional treatment, followed by addition of acid and reaction for a period of time, then washing of the sand to remove the acid and dissolved impurities. Acid treatment has been combined with attritioning in the flowsheets presented here as this is considered to provide greater flexibility of treatment options.

Sulphuric acid has been considered due to its local availability and low cost. There are some problems with sulphuric however in that it is not the most effective acid for dissolving iron compounds. Other acids such as hydrochloric although more effective are considerably more expensive in any location and would probably have to be transported from the mainland, adding further to the cost. More detailed test work needs to be done on the acid treatment method and I would expect this to be part of a feasibility study.

Handling and transport of acid can be very expensive, even for sulphuric, which is most economically transported in concentrated form with essentially zero water content, this makes storage simpler as unlined mild steel tanks can be used. There are strict regulations on containment of acid spillage during transfer and storage. Bunding around storage tanks must be impermeable and capable of containing the entire contents of the storage tanks. Acid is delivered to the process by special dosing pumps, which must be interlocked and controlled to ensure minimum risk to personnel, the environment and process equipment. All plant operations must take the nature of the process fluids into account and acid vapor, splash, and spillage will affect most areas of the plant. All of this contributes to acid treatment often costing far more in practice than at first thought.

2.7.1.1.1 Waste from Acid Treatment

An essential subsidiary step to acid treatment is the neutralisation of the waste before disposal and this will require the addition of an alkali, probably lime, and sufficient time for reaction. A special vessel may be necessary for this operation, or it could be carried out in a thickener, this will be discussed under tailing disposal in this section of the report, and in the individual flowsheet discussions. Some thought has been given to establishment of a quarry to mine local limestone for neutralisation purposes. I do not recommend this for the following reasons:

- The lime must be fine in size and high in purity to achieve neutralisation in a reasonably short time, thus minimising the size of vessels required. Production of this quality of lime is a large and expensive exercise and not justified for the projected consumption.
- Capital cost of establishing a lime quarry would be high and there will be considerable ongoing costs associated with regulation compliance and the responsibility for rehabilitation. The areas being considered are either sensitive environmentally or poor quality and much further away.

Purchase of the quantity required of high quality lime is not expected be a major operating expense.

2.7.2 Mechanical Treatment, Attritioning.

Attritioning is almost universally employed by mineral sand mines for cleaning of non-conductor materials before electrostatic separation. The process consists of agitation of high-density slurry under high shear conditions so that the impact and abrasion of grains against each other removes the deleterious surface coatings. Friable composite impurity particles are broken down into slimes but attritioning has little or no effect on homogeneous mineral particles of the major impurities.

Slurry solids content up to 80% is often employed but there is considerable evidence that the effect of high slurry density is mainly to increase residence time and attritioning action is optimised at considerably lower slurry concentrations. Slurry concentrations above 75% are also difficult to achieve reliably using standard cyclones.

Most operations use some form of "attritioning aid" compounded from a mixture of acids and dispersant. The dispersant is by far the most important constituent and in many cases the acid can be dispensed with. The most effective dispersant has been shown to be soda ash.

Research work on attritioning has shown that it is best carried out in stages with intermediate washing steps. Surface coatings can reform if the mineral is allowed to stay in contact with the contaminated water for an excessive time so a stage time of about 15 minutes is often used. Attritioner discharge is diluted in a hopper to about 30% solids and slimes are then removed by a cyclone, which then feeds the following stage. Power inputs around 4kwh/t and more are often used and the slurry temperature at discharge can be quite high, indeed the temperature rise is sometimes used for control of power input.

In the plant flowsheets that follow the attritioning stage has been combined with acid washing. This arrangement gives maximum freedom to experiment with treatment options during production and since acid washing would require some form of agitated vessel in any case it is logical to combine the two.

Warman Ltd and others manufacture Attritioning units. The Warman attritioners are made in units of two cells with 37kw electric motor and gearbox drives on each cell. Gearbox failures were common on the units installed at Kemerton and I would not recommend that the standard Warman drive be used. Some years ago I did considerable work on redesign of the drive system using belts and obtained prices for local manufacture. Overall cost was considerably lower than Warman and maintenance costs predicted to be about 10%.

2.7.3 Spirals

Once the surface coatings and friable particles have been removed the remaining impurities will be either in inaccessible voids and cracks in the grains, or in the form of discrete grains of compounds of iron and other elements. The discrete grains will almost certainly have a significantly higher SG than silica so gravity methods such as spirals can be used to separate them.

The fine size range of the feed material may tend to mitigate against spirals, and in the past it was considered that spirals were of little use when particle sizes were below about 80 micron. However Mineral Technologies Ltd have recently developed a spiral capable of high efficiency at particle sizes less than 100 micron, in some cases to below 30 micron and these units could be considered as an alternative or adjunct to magnetic separation.

Gravity separation relies on fairly small force differences unless some form of gravity enhancement (usually centrifugal) is applied as in cyclones and some mechanical separators. Spiral separators therefore will not produce a clean heavies concentrate in one pass. The "mass take" is the proportion of head feed that is passed to concentrate and along with the proportion of heavy minerals (HM) is a measure of efficiency. The new spiral types remove 60% of the HM at a mass take of 15%. Although this is a very good recovery of HM the stage loss of product to the reject is too great and a multiple pass circuit with recirculation is necessary.

Multiple pass spiral circuits have more pumps and distributors and of course more spirals but a well-designed plant should remove more than 90% of all the heavy minerals. The cost should compare favorably with WHIMS; both in capital and operating but WHIMS may still be necessary if the highest purity product is required.

2.7.4 Magnetic Separation

Magnetic separation is often used to upgrade silica sand products by removal of the magnetic heavy mineral contaminants. There are several methods that could be used for dry magnetic separation but they may not be suitable for the product size range. Therefore wet magnetic methods must be used and for separation of fine magnetic particles from slurry the Wet High Intensity Magnetic Separator (WHIMS) is the only choice. The WHIMS separates magnetic particles by utilising very high magnetic flux gradients induced into a specially designed matrix. The matrix is contained inside cells on the circumference of a wheel, arranged so they pass through the pole gaps of a large electromagnet. Slurry is fed through the matrix while it is within the pole gaps, the nonmagnetic particles pass through but the magnetics are held until the cell is past the pole, when they are washed out and discharged. A single pass only should be sufficient and a very small reject stream is produced with high recovery of HM.

The machines produced by Readings (now owned by Roche Mining) have been well proven in service on similar duties to the proposed silica sand treatment circuit. Eriez magnetics machines have suffered from a high rate of matrix wear but recent developments have led to improvements that may render them more competitive.

Although they are certainly very effective WHIMS have several disadvantages not the least of which is their high cost and relatively low throughput. Maintenance can also be a significant expense if the material treated is very abrasive or corrosive but this has been more of a problem with the machines produced by Eriez Magnetics. Power consumption is also fairly high but not prohibitive compared with other processing steps.

Since the sand is to be dried prior to shipment the dry methods of magnetic separation could also be considered. Modern permanent magnet materials such as neodymium-boron-iron can produce extremely high magnetic field gradients with near zero power consumption and have virtually taken over in the mineral sands industry. There are two configurations that can be considered: permanent magnet drum and permanent magnet belt.

Permanent magnet drum type dry separators are lower intensity than the belt machines but have a higher throughput and lower maintenance cost, static electric problems are non-existent. Belt magnetic separators can have very high magnetic field gradients and are more effective than WHIMS in some cases. However if the feed material is very fine and dry there can be problems with carry over of product into the magnetic reject due to electrostatic effects. This trouble has been minimised in mineral sand plants by the use of conductive belts and control of mineral temperature and moisture content.

All types of dry magnetic separators are restricted in throughput for fine particle separation by the necessity of maintaining a single particle thickness layer on the separator belt or drum, and this will probably be the major reason for not using them.

2.8 Product Handling

Product handling in this case encompasses the following steps:

- Drying and packaging into bulk bags.
- Storage of packaged material if necessary.
- Loading of packaged material on to vehicles for transport to the export port.

Each of these stages is considered in more detail in the following sections.

2.8.1 Drying

The plant product will require drying to low moisture content before bagging and some form of fuel heated device will be necessary. Drying and bagging will need to be carried out in an enclosed clean area, which can also incorporate the storage area for batches awaiting shipment.

It is envisaged that the drying and bagging operation will be virtually continuous while the plant is running. This will minimise the necessity to store wet, easily compacted material. In the event that significant intermediate storage is necessary any type of bin could cause problems and open stockpiles may be the only practical option.

Due to the fine particle size of the material the drying step will not be a simple operation and although there are many designs available only two types will be considered here the fluidised bed and the rotary.

Fluidised bed drying (FBD) has gained great popularity in many mineral sands operations due to relatively low capital cost and promises of low operating cost. In a FBD hot gas is passed upwards through a layer of the material to be dried, fluidising and heating it. The arrangement is very simple with few moving parts but in practice FBD has many problems. They must be designed specifically for the material to be treated and operation is often difficult to control, especially when conditions or material characteristics are varied. Also for extremely fine materials such as silica flour the dust recovery may be impossible to achieve at reasonable cost.

Rotary dryers are produced in many configurations between which the most important distinction in this case is whether or not the heating gas flow is in direct contact with the process material. Indirect dryers operate by heating the outside of a near horizontal rotating metal barrel through which the process material passes by gravity and tumbling action. Heat transfer efficiency is not as good as direct heating but can be improved by careful design. A gentle flow of flushing gas is maintained through the barrel to remove vapours driven off by the heat, and dust generation is very low. Direct dryers use a similar arrangement of rotating barrel but combustion gases pass through the barrel either counter or concurrent to the process material. Heat transfer can be very efficient but dust generation is much greater due to the high velocity and turbulence of the combustion gases.

Whichever type of dryer is chosen the process material will need to be dewatered before it is fed to the dryer. Moisture content should be as low as possible with a maximum of about 6% and this cannot be achieved by cyclones alone. For this purpose a vacuum assisted filter is necessary and the most effective units of this type use a belt, similar to a conveyor with a vacuum box underneath the top run. The filter should be fed via a cyclone with perhaps an intermediate surge bin to ensure steady feed. Principal manufacturer of this type of machine is Delkor Ltd of South Africa and they cost $80,000+. Other filter types such as ceramic disc or presses are all far more expensive and too low in throughput for the task

2.8.2 Bagging, Storage and Transport

It is intended to store and transport the product in one tonne bulk bags so filling and handling needs to be considered. Since the drying operation will be continuous and will require supervision the same operator might be able to run the bagging stage. In this case it is expected that the degree of automation required will be high. It may be more cost effective to have two full-time operators in this area with a simpler bagging machine. A suitable scale will be needed to ensure the correct bag weight is maintained and this could be linked to automatically shut off feed to the bag being filled. A simple roller can be used to move the bags on pallets away from the filling station and a small, possibly electric forklift or "walker stacker" could then move them to the storage area close by under the same roof.

As with all steps involving fine dry silica dust control is essential. The dust control equipment installed for the dryer could be enlarged or redesigned to cope but this is often not possible and a dedicated dust collector may be necessary for the bagging operation.

Storage of large tonnage of bulk bags is not a trivial matter as they cannot be safely stacked more than two high unless each bag is on a pallet or a shelf, an expensive option. The provision of adequate maneuvering space between rows means the storage per unit of floor area is low. Handling is also slow if pallets are not used, as someone has to guide the forklift tines through the bag loops. This has serious implications when transport options are being considered. Innovative design thinking could eliminate most of these problems and the bulk bag suppliers could have some ideas.

Transport to the port of Hobart could be by rail provided the track and rolling stock can be brought up to a suitable standard. There are some potential problems with this as the railhead is some distance from the mine. Double handling of product for transport from mine to railhead is inevitable and will be expensive and logistically difficult as it would require a forklift at both the mine and railhead. Campaign trucking to the railhead will probably require a number of vehicles and the capacity to store a large amount of product at the mine with the attendant problems as mentioned in the previous paragraph. Daily production will be about 500 tonnes or up to four truckloads per day but this may not be enough to warrant a cost-effective continuous operation for a subcontract operator and vehicle.

I consider that a containerised system with containers being loaded with bags as they are produced at the mine then taken by road to the port, either continuously or in campaigns could be a cheaper and more flexible option. Containers awaiting shipment could be stored at the port and there would then be only one load-unload cycle per container during land transport.

A separate report addressing transport options will be necessary, as transport will be a very significant cost this should be part of a feasibility study.

2.8.3 Dust Control

Dust control is an extremely important aspect of any operations involving fine dry silica. All types of dryers will generate entrain fine particles in their heating or heat transfer gas streams and dust collectors are often part of the dryer package supplied by various manufacturers. Packaging machines can minimimise dust emission by careful design but it cannot be eliminated and they will also require some means of dust extraction.

There are many types of collectors classified by the method of dust removal but the two types considered here are filters and wet scrubbers.

Filter types use membranes usually made from cloth and often in the form of bags, hence the colloquial term "baghouse". They are the most expensive in capital cost and depending on the duty can have a high operating cost. High temperatures are an especially difficult case. Baghouses are necessary whenever the collected material must be kept dry but this may not be necessary for the silica flour process. In our case the collected material can be returned to the process and a wet scrubber could be used.

Wet scrubbers as the name suggests collect the dust particles on fine water droplets, which are then collected and disposed of as slurry. This can be pumped back to a suitable stage of the treatment process. However should a market be found for the fine dust material it would need to be dried, which could negate some of the wet scrubber advantages.

2.9 Pumps and Pipework

Pumping of slurry and water is an essential process in most minerals processing plants. Fortunately modern developments in slurry pumping have eliminated most of the early problems and vastly lowered the cost.

2.9.1 Slurry Pumps

All the slurry pumps are specified as Warman centrifugal type AH with electric motors. These units have been proven in countless installations throughout the world and there are few suitable substitutes. Impellers and liners are specified in polyurethane, which has demonstrated exceptional wear life in many similar mineral sands and silica sand operations. Wear of impellers and liners is difficult to predict but I believe that the Pine Hill material will not be especially severe due to the fine grain size. Spare parts for Warman pumps are available from stock in Tasmania and the types of pumps and wear parts would be kept to a minimum in the plant design to ensure lowest requirement for on site inventory.

All slurry pumps have been specified with expeller seals as these are considered to be suitable for the duty and in my experience are reliable and cheap to operate. Gland seals require a constant clean water supply and this is expensive and troublesome, however for high suction and discharge pressures they may be the only option.

Second-hand pumps are often available both from Warman and machinery dealers. Most parts are replaceable by unskilled labor and impellers and liners are disposable. There is little risk in purchasing second hand Warman slurry pumps provided they are of the AH series, earlier designs, while still supported are much less durable, efficient and versatile.

2.9.2 Sump Pumps

Sump pumps are required to return spillage and cleanup waste to the process. Again Warman pumps have been specified for the same reasons detailed above in reference to slurry pumps. The sump pumps are all of the vertical spindle type and are quite efficient at fairly low heads. In some cases they can do double duty as process pumps, reducing capital cost and this has been considered wherever possible in the flowsheets.

2.9.3 Water Pumps

Since water is probably to be supplied from a bore a submersible pump will be required and this can only be completely specified when the bore details are known. Process water pumping duties will be handled by a centrifugal water pump, probably KSB Ajax, steer clear of Southern Cross if possible. This pump would be direct coupled to the electric motor and located near the process water dam or pond.

2.9.4 Pipework

Slurry and water pipework will be heavy wall polyethylene as per current practice in mineral sands and silica sand operations. Poly pipe is light in weight and so is easy to mount and handle, welding is simple and strong with low cost equipment and wear resistance is good. In areas where extra wear resistance is required such as pump discharge pieces and sharp bends special polyurethane parts are usually used.

2.10 Water Supply

Although in places like Tasmania there appears to be an abundance of water its use, particularly in industrial and mining operations is always a sensitive issue and reasonable efforts must be made to ensure all water is used in a demonstrably responsible manner. Not only the supply of water to the plant but the disposal of contaminated waste water must be considered, it usually makes economic and political sense to recover and recirculate as much water as possible, and to raise the concentration the tailing stream. Thicker tailings are easier to dispose of and there is less possibility of the discharge of contaminated water from the site. In any case contaminated drainage from site will probably not be allowed by the operating license for the mine.

Water requirements will be in the region of one cubic meter per tonne of feed for a plant without a tailing thickener, or about half this figure for a thickener equipped plant. Thickeners are a fairly expensive item if obtained new, but the slimes in the Pine Hill deposit appear to be fast settling and a relatively small unit could be required. When considering the elimination of a thickener the cost and area required for adequate slimes settling ponds must be considered. Management of slimes settling ponds can often be very difficult and time consuming, particularly if head feed characteristics change.

There are three potential sources of water in the mine site area, pumping from a river, a storage dam built on site or nearby, or a bore. The local rivers do not appear to have sufficient flow during the summer months to support the operation without a large on-site storage. Remote pumping units would need to be diesel powered and be fitted with telemetry systems to reduce the supervisory burden and this is expensive. The pumps and pipelines would also be difficult to secure, making them a target for vandals.

Dam building is a very expensive operation with also no guarantee of continuity of supply during the drier months. This leaves a bore on site as the most practical and reliable option this of course providing that the hydrogeology of the location is suitable. I would expect a relatively shallow aquifer to exist, associated with the limestone formations and underground streams, but this is to be avoided if possible due to the sensitive nature of these features. A hydrogeologist or local drilling contractor should be consulted to find further details of the deeper aquifers in the area.

All the flowsheets incorporate a process water storage pond or tank with sufficient holding capacity for about a day of plant operation. Assuming the sinking of a successful bore water will be pumped from it to the storage as required using a readily obtainable submersible electric pump. Should a thickener be installed its clean overflow would also be discharged into the process water storage. In the event that a thickener is not installed then decant water from the tailing pond and settling ponds would be discharged to the process pond.

Water for the process is pumped from the process pond by electric centrifugal pump via a ring-main system to supply the various requirements. If very clean water is required by any process stage then an additional separate storage can be provided that does not receive any recirculated water. Potable water can be supplied direct from the bore if it is suitable for drinking otherwise a rainwater tank and small treatment plant would be sufficient for the small site requirements.

2.11 Electricity Supply

Total plant electricity requirements are estimated to be less than 250 kW without a mill in the circuit. Milling could add up to 150 kW depending on the size of mill and feed rate. Extra plant capacity due to expansion may account for a further 250 kW so the power supply must be capable of about 750 kW although this consumption need not be provided for in the first stage of plant operation.

The local electric supply should be adequate with some extension and upgrading of transmission lines. The multiple conductor high voltage service terminates West of Maydena and continues to the gatehouse in what appears to be a single wire. Provision of power to the mine would require the running of extra conductors and the existing poles may not be suitable. Local contractors in the power reticulation sector would be able to provide greater detail on the estimated costs of this work. At the current stage there has been no further investigation of this aspect.

2.12 Tailings Disposal

Tailings disposal is another very sensitive subject, and it is difficult at this stage with little data to consider more than some very general points. Many operations do not give sufficient attention to the tailings disposal method before mining commences and this can lead to extensive delays and expensive restoration work at a later stage.

Although data is limited it appears that the Pine Hill material contains fairly small proportion of slimes and the fine silica should be fairly quick to settle. This indicates that there may be few problems in tailings disposal. However testwork should be carried out on the settling characteristics of the tailings very early in a feasibility study to determine the best disposal method and aid in design of tailing ponds. This work will also indicate whether recovery of clean water from the tailings is a viable proposition and the necessary size and arrangement of tailing and decant ponds. It may be found that a thickener is necessary to conserve water and minimise the pond areas.

Whether or not a thickener is installed the tailings must be pumped from the plant to a tailing pond where the solids must settle eventually to a consistency in which they can be reclaimed or planted over. Tailing pond management can be quite difficult; the tailings as they arrive are in a semi-fluid state and usually take considerable time to settle to a solid bed. Full utilisation of the available pond area requires that the tailings discharge point is regularly moved but this can be almost impossible when the tailings are unable to support machinery. Unthickened tailings could possibly be cycloned to aid in stacking but this is a difficult operation requiring close supervision and may not be viable. Ponds will probably be of bunded construction but construction materials are uncertain at this stage. Oversize reject could be used but should sealing of dam walls be necessary it will require a higher clay content or the use of impermeable liners. The oversize could be used as a filtration bed to produce clean water for discharge.

As in the case of transport all aspects of tailings disposal must be considered in a feasibility study. Specific engineering expertise is necessary for most tailing pond design and this is best provided by one of the established mining engineering consults.

2.13 Supervision and Control

2.13.1 Sampling and Assaying

For a product with high quality specifications the requirements and or preferences of the customer will often dictate the sampling and quality control regime. There will certainly be a need for sampling and both chemical and physical property monitoring but the frequency and precision could vary. The process itself can probably be monitored and controlled over quite long periods without the need for prompt assaying.

For the purpose of this study I am assuming that the head feed would be sampled using an automatic slurry sampler to produce a daily composite. This could be tested for size distribution using sieves in a simple on-site laboratory. Once the commissioning and initial development is complete assaying of the head feed on a daily basis should not be necessary but a weekly composite could be checked to help find trends. Examination could also be carried out using a stereo microscope to check for degree of surface contamination and inclusions, and amount of heavy mineral contamination. Product examination by microscope could also be a valuable technique.

The product would be sampled using an automatic cutter at the bagging station. Individual samples for each bag could be taken but I think it unlikely that assaying of each sample would be done. Rather a daily composite would be made from splits of the bag samples and assayed. Splits from each bag could also be retained in case of dispute. The customer however may demand a more rigorous regime and this would need to be reflected in the price.

All assaying would be by XRF using fused beads to provide the high sensitivity and precision required at low impurity levels. On-site assaying is probably out of the question due to the very high capital cost and necessity for expert supervision. The simple "bench-top" XRF units being sold by some manufacturers do not have sufficient sensitivity for this application.

South Eastern Tasmania is apparently lacking a service capable of carrying out a suitable standard of assay work. It may be necessary to come to an arrangement with another mining company, not necessarily in the silica sand business, to get assays in a timely fashion. Most of the candidates however are some considerable distance from Maydena so transport of samples may become a problem.

2.13.2 Process Control

During the last ten years there has been a revolution in the way even quite small plants are operated. Programmable Logic Controllers (PLC's) are now almost universal and are modestly priced. This has greatly lowered the cost of designing and installing process control and given the plant operator more flexibility. Plant startup and shutdown sequencing can be made almost automatic and operation and monitoring is relatively simple via a personal computer terminal using readily available low cost software. All of this acts to free personnel to carry out other duties.

2.13.3 Manning

Manning levels are to be kept to the minimum consistent with safe and reliable plant operation. Operators should be trained in all aspects of plant operation and regularly swap jobs for instance, driving the loader for half a day followed by plant duties for the remainder. One operator will be occupied within the plant area but this would not occupy him full time. The mining contractor would supply mining personnel and this may extend to supply of a loader and operator for plant feeding. This person may also be able to drive a truck bringing material from the mine site to the plant stockpiles or feeder in cooperation with the plant operator who drives the loader while the other is away. Drying and bagging operations will probably require the full attention of two operators, and they may need to be permanently in this role, though it should be possible for one of them to rotate jobs with the others on say a weekly basis.

Operators should have maintenance experience so they can handle mechanical breakdowns and assist during scheduled maintenance shutdowns. They do not need trade qualifications and to some extent it is undesirable that they have them. Scheduled and major breakdown maintenance in the mechanical and electrical fields would be sub-contracted to local or regional small business. A small maintenance workshop and stores area for use by operators and subcontractors could be provided under the bagging and storage roof.

Total permanent workforce for plant operation would be the loader driver and three operators plus one supervisor who should be a hands-on type who can take over any role when required.

2.14 Plant Structure and Layout

Plant layout can only be decided in detail at a much later stage but certain general points can be discussed here.

The wet sections of the plant would be built over a concrete floor with a shallow raised concrete containment bund around it. All of the slurry pumps and hoppers would be installed on this floor and two sump pumps would be set into it.

The plant structure would be conventional steel construction with up to three levels of various areas above the concrete floor. On level one the trash and primary sizing screens, attritioners, and WHIMS would be installed. On this level there also could be some spirals if they are required. Level two would have the majority of the spiral circuit and its area would be somewhat less than for level one. The third level would contain most of the cyclones and header tanks for process and recirculation water; it can be quite small in area, not much more than a large platform with access by ladder. If the terrain permits the process header tank could be located on a higher ground level, saving on steelwork. Total enclosure of the wet plant section would be confined to the spirals to protect them from wind and weather all other units can be left in the open.

A large shed with concrete floor would be located close to the wet plant. This would contain the drying and packaging equipment and product storage area. It should be as much as possible a standard industrial building to keep the cost low. The plant control room, air compressors, and possibly some of the electrical switchgear could be installed in the dryer building or an annex to it with savings on construction cost.

Initially it was thought that the plant could be a modular skid mounted design but further investigation indicated that this is only practical at a smaller scale and with penalties in design flexibility so it has not been considered here. Instead the design would be conventional with structural steelwork prefabricated so construction then becomes a simple bolt-together operation. Site fitting and welding is avoided as much as possible. This type of construction organisation is today almost universal and there will be at least one steel fabrication shop capable of turning out suitable work. Detail design becomes extremely important however and mistakes are very costly and time consuming to rectify. A competent structural and plant design engineer is required and he must be well briefed and supervised.

As the pipework is predominantly polyethylene it can be largely fabricated on site using common equipment. However the temptation not to do detail design of pipework must be resisted, many projects have had huge time and cost overruns caused by lack of planning in this area.

Most of the electrical control equipment can be provided in pre-built modules that can be installed and connected very rapidly. The motor control centre should be close to the plant control room and could be under the drying shed roof. Again good detail design of the installation will pay dividends in cost control and speed of installation.

2.15 Plant Construction

This report cannot go into fine detail of the plant construction schedule but some general points can be discussed. It is difficult to be precise about plant design and construction time but if new equipment is used a period of at least 12 months should be allowed from the time the decision to proceed is made and commissioning of the plant.

The main influence on construction scheduling will be the lead times for equipment manufactured overseas. These often vary depending on demand for particular products, but this is difficult to predict. At one stage Derrick Screens had a lead-time of 12 months and even large locally produced machines such as WHIMS could take six months to arrive. Therefore it is unfortunately necessary to finalise the major equipment list very early in the planning process to ensure minimum construction delays. This also places great importance on proving equipment suitability by pilot plant testing of units as near as possible in performance to those selected for the operating plant.

The use of second-hand equipment may reduce some of the lead time problems but introduces many of its own. Unless an entire plant is purchased, which is unlikely in this case, the used equipment must be accumulated over a considerable time. This almost inevitably requires a large amount of travelling to view often unsuitable items. Even the suitable machines must be refurbished or at least stripped and examined before they can be used. Many compromises must be made and plant design may not be finalised until the plant is completed or for some time afterwards. Promised cost savings rarely eventuate and plant performance may be compromised for a long period while equipment problems are resolved.

3 Proposed Plant Flowsheets

In this section three possible plant flowsheets are presented and discussed. They range from a high cost but low risk scenario using screens and WHIMS through to the potentially lower cost but somewhat more daring options of hydraulic classifiers and spirals. Due to its better-known characteristics the first spreadsheet is better defined than the other two and they should therefore be considered as ideas and a set of directions for further research.

3.1 Option A., Screening and Wet Magnetic Separation.

3.1.1 Overview: Option A.

This flowsheet uses entirely conventional technology in a simple straight through process without any circulating loads. Major points are the use of wet screening for primary sizing in the plant, and WHIMS for removal of heavy mineral contaminants. A detailed flowsheet with capital and operating cost estimates is attached in Appendix A. Following is a brief description of the major stages in the process.

3.1.2 Process Details: Option A.

3.1.2.1 Feeding

Feed arrangements are as discussed in the overview of production equipment above and consist of a feed bin supplied from stockpiles by a front-end loader, a feed conveyor with speed controller and belt weightometer, and a feed box discharging onto a trash screen. Water is added to the ROM material as it passes through the feed box and sprays on the screen add further water and help flush the undersize through to the hopper below. Slurry concentration is adjusted in the hopper to about 40% solids by further water addition before it is pumped to the plant primary screen.

3.1.2.2 Plant Primary Screen

Primary screening is required to remove the material larger than the top size of the product specification. It can be carried out either before or after desliming but in this case is applied first so that the desliming cyclone can be used to raise the slurry concentration before the attritioning stage. Oversize from this screen is low in moisture content and could be discharged into a bunker from where a front-end loader would tram it to waste or stockpile.

For the primary screening a Derrick model F48-120R-4SM screening machine with 230-micron polyurethane screen panels has been specified. Other screen sizes are available and 250-micron could be fitted giving an increase in throughput and product yield. These machines have been used in all the successful fine screening processes I have seen over the last ten years and although they are high in cost the operating costs are usually quite low. The polyurethane screens are the principal reason for Derrick success. They were until recently a unique design with very high open area combined with exceptional wear resistance. Derrick screens have one major disadvantage in that they are very expensive; a unit capable of 22t/h would have an installed cost of $100,000 and would need to be duplicated if extra production was required. Now some other manufacturers are claiming to duplicate Derrick performance but their results should be treated with caution, as any problems with primary screening will affect all other operations.

Suitable second hand units may be available but they are highly sought after and would also need to be carefully inspected by a knowledgeable person to detect any faults before purchase. A common problem is the exciter motor, which is prone to expensive failure but this is easily fixed by fitting a substitute motor from Eriez at 10% the cost of a Derrick rebuild, (they also last much longer).

Before plant design can be finalised a sample of screen feed material must be tested by Derrick to ensure that the correct unit and screen types are specified. This is a free service except for the cost of transport of samples to the USA.

Structural requirements for Derrick screen mounting are minimal and vibration does not need to be taken into account as the frequency is quite high and isolation is good. Power requirement is less than 1.5kw. Maintenance cost excluding screen replacement is very low there being essentially only two moving parts.

3.1.2.3 Cyclone 1, Attritioner Feed Deslime.

The deslime cyclone is fed with slurry from the trash screen underflow and it both removes the undersize mineral and slimes and raises the slurry concentration to the level required for efficient attritioning. It will also reject the majority of light materials such as organics into its overflow stream.

In this circuit design the overflow from cyclone 1 is the exit point for fine rejects and contaminated water. Lime for acid neutralisation would be added to this stream, probably as a slurry and the mixture allowed time to react in a neutralising tank or thickener, (or both) before being conveyed to the tailing storage facility.

Cyclone underflow at about 72% solids discharges directly into the feed well of the attritioning cells, higher slurry concentrations can be achieved but at risk of excessive loss of product to cyclone overflow.

Specified for this duty is a single unit Krebs U10 gMAX in polyurethane. There are several other manufacturers but Krebs have very high performance and competitive price. All of the parts subject to wear are individually replaceable and reasonable in price. Availability is good but is ex-Brisbane as there is no agent in Tasmania at present.

There is little chance of obtaining a second-hand unit that will be suitable, the duty is quite critical and cyclone efficiency has a great impact on overall product yield. The cost of a new unit is not high so the savings also would be minimal.

3.1.2.4 Attritioning Cells

Deslime cyclone underflow feeds a bank of two Warman attritioning cells. These are each of 1m3 volume and give a total residence time of about 16 minutes. Addition of acid or other surface cleaning aids should be made to the attritioning cell feed so the attritioning action and temperature increase will accelerate cleaning. The motors specified by Warman are 37kw and if they are operated at 75% power will input about 5.7kwh/t. Such high power input may not be necessary and tests should indicate a suitable value.

Attritioning is applied here before magnetic separation so there is the best chance that magnetic materials adhering to sand grains will be liberated by the intense scrubbing action. Also friable iron minerals and organic particles with bound iron, which have low magnetic susceptibility will tend to be broken up and removed.

Warman are the only manufacturer of attritioning cells I am presently aware of, but several of the mineral sands mines have built their own machines with varying degrees of success. Basically the design and construction of the Warman attritioners is good with polyurethane wear surfaces and simple replacement of rapid-wearing parts. There have been problems with the drive gearboxes in some installations but these may have been solved in more recently manufactured machines.

Cost of the Warman units is very high at over $100,000 per set of two cells. Wear part replacements are also extremely high priced and this has encouraged other companies to offer substitutes. The gearboxes alone were $15,000 each and rebuilds cost over $6,000, and at Kemerton were at yearly intervals.

Second-hand units from various manufacturers could be available but many of them could be of poor design and in bad condition. My opinion is that it would be cost effective both in capital and operating cost to manufacture new units using low-speed electric motors and toothed belt drives rather than gearboxes. Preliminary design calculations and costing indicates they could be built for about $50,000 or less per set of two cells.

3.1.2.5 Cyclone No. 2, Attritioner Discharge Deslime.

It is essential that the attritioner discharge be immediately washed dewatered to minimise contact between colloidal and dissolved impurities and the newly clean mineral surfaces. Should this be neglected then surface coatings can reform very quickly and will not be removed in subsequent treatment.

Discharge from the attritioners is diluted to about 30% solids by addition of clean process water, then fed to the cyclone. Overflow from the cyclone can be recirculated to the feed and screening stages or alternately a proportion or all of it can be rejected to tailing depending on the degree of contamination. In the case considered the overflow is completely recycled, see the section on Water and Waste Circuit for a discussion of this issue.

Again a Krebs cyclone is specified, a U6 – gMAX, a smaller unit than Cyclone No. 1 and set to cut at a finer size to ensure minimum entrainment of product material in the overflow.

Underflow discharge from the cyclone at about 75% solids gravitates to the feed distributor of the WHIMS, clean water is added along the way to adjust the feed slurry concentration to suit the WHIMS.

3.1.2.6 Wet High Intensity Magnetic Separator, (WHIMS).

Low iron product specifications will require a magnetic separation stage to remove magnetic impurities such as ilmenite and other iron compounds. A WHIMS has been chosen for this circuit because of its excellent performance on fine minerals and some doubts about the practicality of dry magnetic separation.

A suitable WHIMS is the Reading 8 poles narrow gap which has been specified for this duty. Since the main use of these units has been for separation of large amounts of magnetics from small amounts of non-magnetics, which is the reverse of our duty, there may be some need for modifications. For this reason second hand units should be carefully examined and the manufacturers consulted as to their suitability.

WHIMS magnetics are rejected to tailings, depending on the water supply situation it may be worthwhile recovering the water contained in this stream with a small cyclone but this is not considered in this circuit. The non-magnetics are discharged into a hopper where clean water is added and the slurry is pumped to Cyclone No. 3.

3.1.2.7 Cyclone No. 3 Product Filter Feed

Before feeding to the product filter the WHIMS discharge must be dewatered as much as possible and this is accomplished by Cyclone No. 3. This stage can also be considered as a further washing step, removing the residual slimes and chemical residues. Water in the cyclone overflow will be relatively clean and is completely recycled untreated to the front end of the circuit via a distribution box.

Equipment specification is the same as Cyclone No. 2 and will run at similar pressure and flowrate since there is very little change in mass flow after the deslime stage.

Underflow from the cyclone could be discharged via a suitable feed box directly onto the belt filter. This arrangement may cause problems should there be an interruption to belt filter or dryer operation and in this flowsheet there is provision for a surge bin. Careful design will be necessary for this bin as the material will tend to compact very readily, the bin may need a screw conveyor discharge and measures to prevent material hanging up and adhering to the bin walls. Alternatively open stockpiles could be used but this may be impractical due to the time and equipment needed for feeding to the dryer.

3.1.2.8 Belt Vacuum Filter

The belt vacuum filter is necessary to reduce the product moisture content to a level suitable for feed to the final drying stage. Most suitable dryers can handle maximum 6% moisture in the feed without severe loss of throughput and other operational problems.

Delkor makes the most reliable and common type of belt filter and although they are expensive to purchase their throughput is high and operating costs are relatively low. A water ring type pump provides vacuum and clean water is recovered for use elsewhere.

The dried product from belt filter discharges directly into the feed box of the product dryer and the clean water underflow is recycled to the front end of the process.

3.1.2.9 Product Dryer

A rotary dryer fired by diesel fuel performs product drying. Heating is indirect to minimise dust generation and the process is fully enclosed and has its own dust extraction system of the wet scrubber type. Operation of the dryer will be almost fully automatic but will still require supervision. One of the operators carrying out bagging and storage duties could also look after the dryer.

Material is discharged from the dryer at a temperature of approximately 100 C into a bucket elevator. It cools substantially during the trip through the elevator and is then discharged into a bin from whence it is fed to the bagging station. A cooler may be required if a dryer with a higher discharge temperature is used.

3.1.2.10 Bagging and Transport

At the production rate envisaged the bagging operation will require a high degree of automation if one person is to run it and also look after the drying and storage functions. This means that weighing and feed shut-off must be linked and there may also need to be some mechanisation of bag movement from the bagging station. Cost of the automation must be weighed against that of extra personnel. I have not attempted to design or source any bagging equipment at this stage.

As mentioned previously I believe that the transport to the port should be in containers by road. Empty containers can be left at the mine site and filled by the bagging operator directly from the bagging machine. This minimises handling and also reduces the area required for product storage at the mine site. Full containers can be stockpiled at the port to make up a shipment.

Transport using the local narrow gauge rail system is also being considered but the extra handling required must be taken into account. The bagged product needs to be transported to the railhead and this will require either one truck with operator continuously employed or a considerable number of trucks in a campaign at least weekly.

3.1.2.11 Water Supply and Tailing Disposal

For the process being considered using acid washing there is a requirement for neutralisation of the waste discharge. In this circuit the only exit point for potentially acidified tailing material is via the overflow of Cyclone No. 1 and this is in very dilute form. To achieve rapid and complete acid neutralisation the alkali should be in the form of high-purity finely divided lime as a slurry fed directly into the cyclone overflow. The use of natural lime without substantial upgrading will give neither a sufficiently rapid or complete reaction without the installation of impracticably large holding vessels. In any case some residence time for reaction to proceed will be needed in either a holding tank or a thickener if one is fitted.

A side benefit of lime use is that any excess will aid flocculation of the slimes either in the tailings pond or thickener, possibly reducing the quantity of other flocculating agents required.

Water supply and tailing disposal are interdependent in that as much water as possible should recovered from the tailing and be recycled. Calculated data is shown in the spreadsheet model indicating the water savings obtained by the use of a thickener.

3.1.3 Conclusions: Option A.

- Option A uses the most proven technology and therefore presents the lowest risk option. There is little doubt that this circuit would perform close to predictions but the price for this is high capital cost and a certain lack of flexibility in size range.
- Screen cloth sizes are restricted in range so fine tuning of product sizing and yield can be a difficult process. The cost of polyurethane screens also tends to make sizing changes expensive.
- Magnetic separation of impurities by WHIMS requires the purchase of a very expensive machine with limited throughput and no option for expansion other than purchase of another similar machine. It may be possible to substitute spirals for this duty and this is discussed below.

3.2 Option B., Primary Sizing Using Hydraulic Classifier.

3.2.1 Overview: Option B.

The high capital cost of screening machines suitable for the primary screening duty leads to a search for an alternative and hopefully cheaper option. This circuit attempts to model the substitution of a Hydraulic Classifier for the Derrick screen in Option A.

3.2.2 Process Details: Option B.

Since most details of this circuit except for the classifier are similar to option A. only the aspects affected by this unit will be discussed.

3.2.2.1 Hydraulic Classifier

In this flowsheet the hydraulic classifier has been almost directly substituted for the Derrick screen in Option A. Hydrosizers require high density feed so cyclone No. 1 has been moved from the attritioner feed to feed the hydrosizer. Since the hydrosizer overflow containing the product size material is low in density an additional cyclone has been added to the circuit to dewater the attritioner feed. These circuit changes could be avoided if the hydrosizer was fed directly from the feed belt, but this is probably not feasible, as there could be no trash screen.

The oversize material is discharged in the hydrosizer underflow and since this will have a variable amount of water associated with it is passed through dewatering cone, (a simple dewatering device) before discharge to the oversize bunker.

For the use of one hydrosizer there is little significant change to the water balance of the circuit. A more complex arrangement using two or more classifiers would not necessarily use much more water provided a thickener was incorporated in the plant design.

3.2.3 Conclusions: Option B.

- Hydraulic sizing has the potential to reduce the capital cost of a plant of the size being considered by about $50,000. They give great flexibility to the operator in simple adjustment and control of product sizing. Hydrosizers are simple to build and give very high throughputs so a larger plant would show much greater cost savings.
- Operating costs could be substantially lower than for screening if there is a screen wear problem. However polyurethane screens have shown very low operating costs provided they are not accidentally damaged or not many changes of size specification are required.

- At time of writing no simulation results had been for the application of a hydrosizer so the flows shown in the spreadsheet should be treated with great caution. There is some doubt that only one hydrosizer would be sufficient to give a clean size cut and at least one additional machine may be necessary in a somewhat more complex circuit than shown here. This would of course negate the capital cost saving.
- The hydraulic classifier option requires further study and may prove to be the simplest and cheapest option if the product specification is suitable.

3.3 Option C., Spirals Used as Substitute for WHIMS

3.3.1 Overview: Option C.

Recent developments in spiral technology have pushed the size boundary below 100 micron to nearly 30 micron. It could now be feasible to remove the heavy mineral contaminants by spiral separation with similar efficiency to WHIMS but much lower capital cost both initially and for incremental capacity increases.

3.3.2 Process Details: Option C.

The flowsheet used here is as for Option A except for the use of spirals as a substitute for WHIMS.

3.3.2.1 Spiral Separation

Due to the lower separation efficiency of simple gravity separators it is not possible to carry out the separation in one stage and a more complex circuit with circulating loads must be used.

The circuit used here is a conventional Rougher-Cleaner-Scavenger type. In this the feed is presented to a bank of "rougher" spirals which perform an initial separation. Light minerals from the rougher contain significant amounts of impurities so they are passed to "cleaner" spirals, which remove the majority of the remaining heavy minerals. Light minerals then pass out as product to the following stages of the plant. Heavy mineral concentrate from the cleaner is recirculated to the rougher in this circuit but depending on grade may be passed to the scavenger spirals.

Heavy mineral rejects from the rougher spirals still contain a lot of product material so they are passed to "scavenger" spirals which produce a reject heavy mineral concentrate that goes to tail, and a light mineral stream which is recirculated to the rougher.

There are several possible variants of this circuit configuration and the one shown may not be the best. However changes can be made relatively easily should they be required during production. The circuit as shown is expected to achieve about 90% removal of heavy minerals in a 2% of product reject stream but this must be confirmed by pilot plant tests.

The degree of upgrading available from a spiral circuit such as the one shown may not be sufficient to justify their use as the sole upgrading unit. In this case there may still be an application for a simplified spiral circuit designed to reduce the load on the WHIMS, enabling the use of a smaller and cheaper magnetic separator.

It is essential that the most efficient spiral types are used for all stages in any flowsheet, this means that the spirals will almost certainly be new as there is little likelihood of finding suitable second hand units.

3.3.3 Conclusions: Option C.

- Spiral separation using recently developments in spiral technology is potentially a replacement for WHIMS particularly if significant proportions of the heavy mineral contaminants are non-magnetic.
- Capital cost of a spiral circuit to remove approximately 90% of heavy mineral contaminants is expected to be below $100,000.
- Operating costs of spiral circuits is quite low being mainly associated with pumping.
- Customer preferences may not allow use of spirals alone, many Japanese buyers stipulate that WHIMS must be used.
- In any case the degree of upgrading using spirals may not be sufficient to achieve the required product purity but they may still be used in a WHIMS circuit to give higher product grade or throughput.

4 Conclusions

- A viable plant can be built using readily available and proven technology to produce silica flour in the size range of –250+32 micron at 25,000 tonnes per annum. This plant would use screens for primary sizing and Wet High Intensity Magnetic Separation for removal of heavy minerals. Acid treatment in conjunction with attritioning to be employed for removal of surface coatings on the mineral grains.
- Purity of the final product is still uncertain pending further work on upgrading methods but less than 50ppm Fe2O3 would appear to be attainable.
- Milling has not been considered for the initial plant design and first years of operation. Product yield could be maximised at first by mining of the higher-grade areas. Addition of a milling circuit at a later stage is not expected to be difficult.
- Capital cost of establishment of the plant and mine could be held below $2,000,000 using predominantly new equipment. This assumes that a large proportion of the planning and project management is carried out by the principal, and with a very high standard of supervision and cost control.
- Significant areas of high capital cost are the magnetic separation and drying operations. Drying, bagging and product handling will probably account for by far the highest proportion of capital and operating costs for any area.
- Operating cost per tonne of product at the mine gate is expected to be below $50.00. Costs of transport from the mine gate to a suitable port have not been closely examined and investigation of this important aspect will be required before a realistic FOB price could be predicted.
- Other viable configurations of plant have been considered using hydraulic classifiers and spirals in place of screens and WHIMS, and these could be built at significantly lower capital cost. Ultimately however customer requirements and preferences will decide the plant configuration and capital and operating cost.
- Relatively small changes in product specifications and customer requirements could cause very large increases in capital and operating costs so all conclusions presented here are to be treated with caution until reliable market research results are available.

5 Further Work

Although it appears at this stage that the project has a good chance of success there is considerable further investigation to be done into both commercial and technical aspects before the decision to proceed to a feasibility study is made.

Commercially the existence of a market and the price for the anticipated production must be confirmed. Also the potential for sales of by-products and side streams may have an impact on project viability and should be pursued.

Technically there are two avenues to pursue: confirmation of the practicality of achieving the product grade the market requires, and reduction of capital and operating cost of production.

The following recommendations are made:

- Reduction of Impurity Content: There is uncertainty as to the attainable and practical product grades that can be achieved. More work needs to be done on optimising the acid leaching, attritioning and other surface cleaning methods including ultrasonics. Upgrading of currently unsuitable ores will improve reserves and mine life and better methods may lead to lower operating costs and fewer potential environmental problems.
- Spiral Tests: Mineral Technologies have a comprehensive test facility on the Gold Coast and will carry out testwork at a reasonable cost on separation using their own designs of spiral and other equipment, including dry magnetic separators and WHIMS. A suitable sample should be sent to them, about 250 kg is required. Spirals may not be a substitute for WHIMS but could be needed in any circuit to remove non-magnetic heavy minerals.
- Hydraulic Classification: More data should be gathered on this potentially useful and well-proven method of sizing. The manufacturer contacted to date has not been co-operative but there are several others including Eriez magnetics who are interested. A trial unit is available from Eriez for use either at customer premises or any commercial laboratory. Use of hydraulic classification could greatly reduce reliance on screens with consequent improvement in operational flexibility and reduction in operating costs.
- Market Research: When a practically attainable product specification has been established based on bench and pilot scale testwork a small parcel of product material should be produced for customer samples. Great care must be taken that this is truly representative of a realistic product and that potential customers are not given unreal expectations.

Appendix A

Details for Treatment Option A

This circuit uses screens for primary sizing and Wet High Intensity Magnetic Separation (WHIMS) for removal of heavy minerals.

- **Capital Cost Estimate**
- **Operating Cost Estimate**
- **Operation Summary**
- **Flowsheet**

Pine Hill, Maydena Silica Sand Mine

Option A — **Derrick Screens, Cyclones,WHIMS.** — **Approx 25,000 tpa Silica Flour**

Capital Cost Estimate

Area	Item	Supplier	Item Cost		Subtotals	
Mining						
	Mining equipment	Contractor	per tonne or BCM			
	Primary Screen	Contractor	per tonne			
	Open up mining area		$	15,000		
	Initial Stockpile		$	10,000		
	Subtotal Mining				**$**	**25,000**
Feed						
	Loader	Hire or lease	per hour			
	Ramp, Feed Hopper	Contractor	$	5,000		
	Hopper, Feed		$	10,000		
	Conveyor, Feed		$	12,000		
	Drive, Feed Conveyor		$	8,000		
	Belt Weightometer, Feed		$	5,000		
	Feed Box, Head Feed		$	3,000		
	Subtotal Feed				**$**	**43,000**
Sizing						
	Screen, Trash	Schenck	$	8,500		
	Hopper 1, Trash Screen Underflow		$	3,500		
	Pump 1, Sizing Screen Feed	Warman 3/2	$	8,000		
	Pump 5, Sump Pump	Warman	$	8,000		
	Screen, Sizing	Derrick Corp	$	100,000		
	Hopper 2, Sizing Screen Underflow		$	4,500		
	Pump 2, Deslime Cyclone Feed	Warman	$	8,000		
	Cyclone 1, Deslime	Krebs Engineers	$	3,000		
	Subtotal Sizing				**$**	**143,500**

Pine Hill, Maydena Silica Sand Mine

Option A	Derrick Screens, Cyclones,WHIMS.	Approx 25,000 tpa Silica Flour				
Cleaning						
	Attritioner	Warman	$	100,000		
	Hopper 3, Attritioner Discharge		$	3,500		
	Pump 3, WHIMS Feed Dewater Cyclone Feed	Warman	$	5,000		
	Cyclone 2, WHIMS Feed Dewater	Krebs Engineers	$	3,500		
	WHIMS	Readings	$	250,000		
	Acid Storage		$	8,000		
	Acid Dosing Pumps&Pipework		$	5,000		
	Subtotal Cleaning				**$**	**375,000**
Drying and Bagging						
	Hopper 4, WHIMS Nonmags		$	3,500		
	Pump 4, Product Dewater Cyclone Feed	Warman	$	5,000		
	Pump 6, Sump Pump	Warman	$	8,000		
	Cyclone 3, Product Dewater	Krebs Engineers	$	3,000		
	Bin, Belt Filter Feed Surge		$	5,000		
	Filter, Product Dewater	Delkor	$	80,000		
	Dryer, Final Product		$	180,000		
	Dust Control System		$	50,000		
	Elevator, Dryer Discharge	Ansac	$	10,000		
	Bin, Final Product Storage		$	8,000		
	Bagging Machine, Final Product		$	12,000		
	Drying Bagging and Storage Shed		$	50,000		
	Subtotal Drying and Bagging				**$**	**414,500**
Water Supply						
	Bore, Raw Water Supply		$	12,000		
	Pump,Submersible, Raw Water Supply		$	4,000		
	Pond, Process Water		$	25,000		
	Pump, Process Water	KSB Ajax	$	3,800		
	Hopper, Recirculation Water Distribution		$	5,000		
	Subtotal Water Supply				**$**	**49,800**

Pine Hill, Maydena Silica Sand Mine

Option A	**Derrick Screens, Cyclones,WHIMS.**	**Approx 25,000 tpa Silica Flour**				
Tailings Disposal						
	Thickener, Tailings	Supaflo	$	120,000		
	Flocculant Dosing System (if required)	Nalco	hire or lease			
	Hopper Lime Storage		$	6,000		
	Feeder, Lime		$	3,000		
	Pump, Thickener Underflow		$	8,000		
	Pipeline, Tailings Disposal		$	5,000		
	Pond, Tailings Disposal		$	30,000		
	Subtotal Tailings Disposal				**$**	**172,000**
Structural						
	Steelwork		$	75,000		
	Portable building		$	12,000		
	Construction Labour		$	30,000		
	Subtotal Structural				**$**	**117,000**
Civils						
	Footings, Concrete Work		$	30,000		
	Construction Labour		$	15,000		
	Roads&Drainage		$	75,000		
	Subtotal Civils				**$**	**120,000**
Electric Supply						
	Electricity, Supply Upgrade		$	50,000		
	Stepdown Transformer		$	10,000		
	Metering		$	6,000		
	Wiring and MCC		$	45,000		
	Subtotal Electric Supply				**$**	**111,000**
Compressed Air						
	Compressor and Storage		$	10,000		
	Reticulation		$	3,000		
	Subtotal Compressed Air				**$**	**13,000**

Pine Hill, Maydena Silica Sand Mine

Option A	**Derrick Screens, Cyclones,WHIMS.**	**Approx 25,000 tpa Silica Flour**			
Control					
	PLC Programming	$	8,000		
	Citect Software	$	5,000		
	Computers and Wiring	$	8,000		
	Subtotal Control			**$**	**21,000**
Design					
	Engineering Design & Drafting Structural	$	25,000		
	Engineering Design & Drafting Civil	$	18,000		
	Grand Total	**$**	**1,647,800**		

Pine Hill, Maydena Silica Sand Mine

Option A **Derrick Screens, Cyclones,WHIMS.** **Approx 25,000 tpa Silica Flour**

Estimated Operating Cost

Fixed Costs Item	**Details**		**Cost/tonne**
Mining	ROM at Plant Stockpile	$5.50/t	$5.50
Acid	Sulphuric for Surface Cleaning	0.007t/t @ $250	$1.75
Limestone	Neutralisation of Waste Acid	0.007t/t @ $200	$1.40
Flocculating Agent	Addition to Settle Slimes	$0.006/t	$0.01
Fuel for Loader	Loader Operating 8 hours in 12	1.25l/t @ $0.60	$0.75
Fuel for Drying	Using High Efficiency Dryer	$1.50/t	$1.50
Electricity	Estimate 20kwh/t	$0.06/kwh	$1.20
Water	Royalty@$0.002/m3		$0.01
Royalties	State Mineral Royalty	$0.60/t	$0.60
Product Containers	Bulk Bags, l tonne	$18.00 ea.	$18.00
	Total Fixed Costs per tonne product		**$30.71**
Variable Costs			
Labour	Four Operators, total cost	$65,000 pa ea.	$10.40
Maintenance	Including labour	$80,000 pa	$3.20
Overheads		$100,000 pa	$4.00
	Total Variable Costs per tonne product		**$17.60**
	Total Operating Cost per tonne product		**$48.31**

Pine Hill Sand Mine Operation Summary

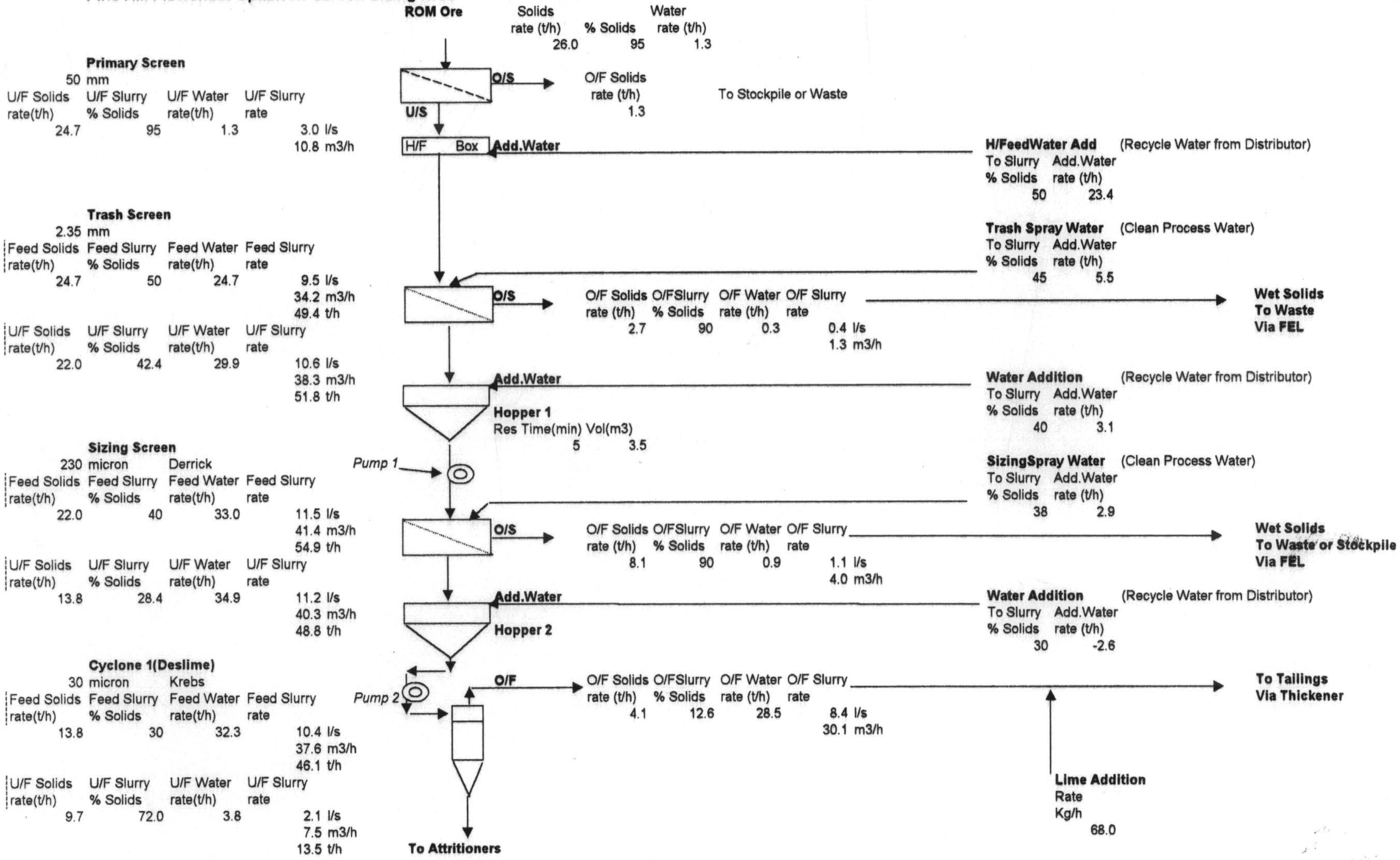
Option A Screen Sizing and WHIMS

Assumed Dry Solids SG: 2.6
Dry Product Yield: **% of Head Feed** 34.1

Stream	Units	Period			Comments
		Hourly	Annually		
			95% Utilisation 12 hr 5 day	*95% Utilisation 12 hr 9 day f/nt*	
Feed :	**tonnes (wet)**	26.0	77,276	69,548	Assuming 5% water content in ore
Product:	**tonnes (dry)**	8.9	*26,387*	*23,748*	
Acid :	**tonnes**	0.07	*202*	*182*	
Lime:	**tonnes**	0.07	*202*	*182*	
Water Without Thickener:	**m3**	26.6	79,031	71,128	Assuming 40% loss in Pond
Water With Thickener:	**m3**	11.5	34,250	30,825	

927094

Pine Hill Flowsheet Option A: Screen Sizing Area



927095

Pine Hill Flowsheet Option A: Cleaning Area

Attritioner Stage 1

Feed Solids rate(t/h)	Feed Slurry % Solids	Feed Water rate(t/h)	Feed Slurry rate
9.7	72.0	3.8	2.1 l/s 7.5 m3/h 13.5 t/h

Residence Time 16.0 min

Cyclone 2, Attritioner Discharge Deslime

30 micron Krebs

Feed Solids rate(t/h)	Feed Slurry % Solids	Feed Water rate(t/h)	Feed Slurry rate
9.7	30	22.7	7.3 l/s 26.4 m3/h 32.4 t/h

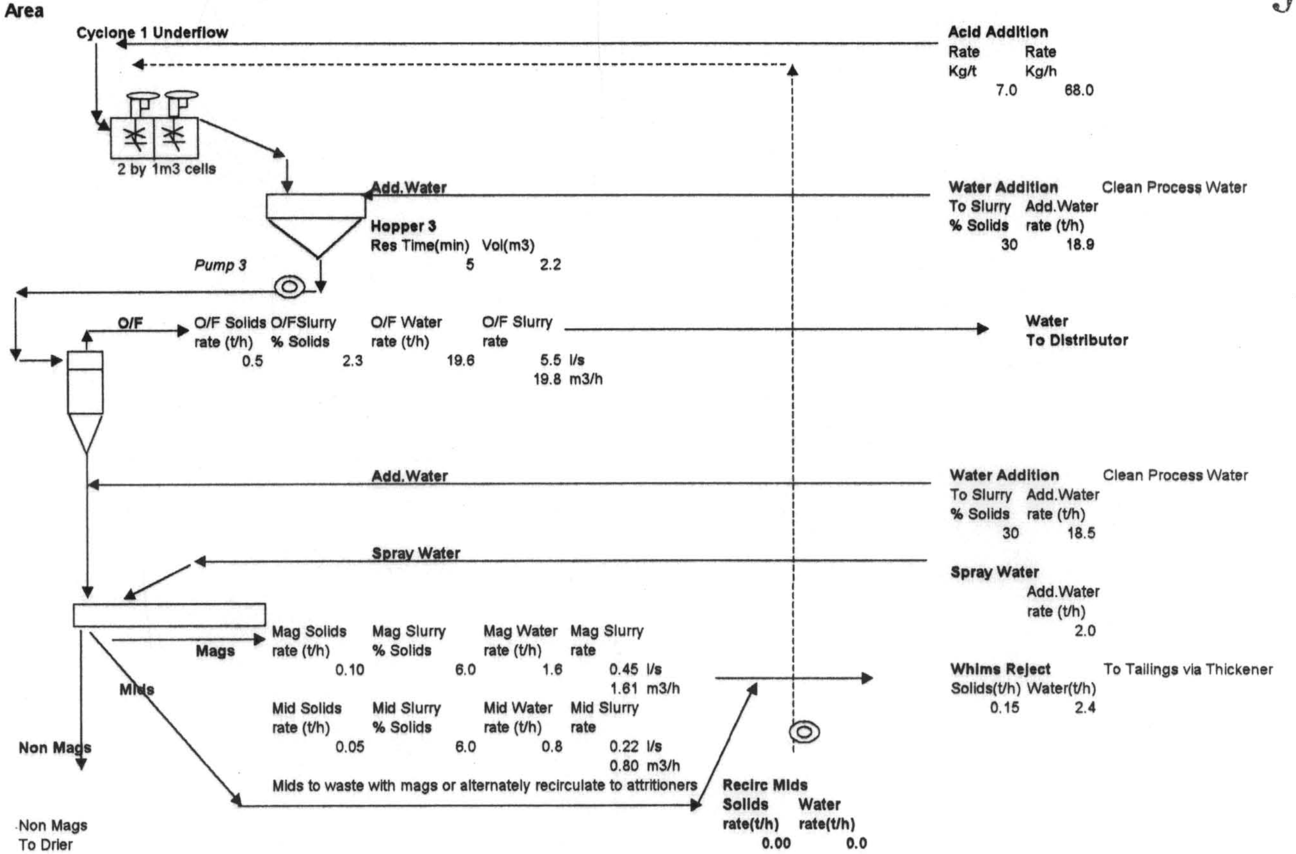
U/F Solids rate(t/h)	U/F Slurry % Solids	U/F Water rate(t/h)	U/F Slurry rate
9.2	75.0	3.1	1.8 l/s 6.6 m3/h 12.3 t/h

WHIMS

Readings 8 pole narrow gap

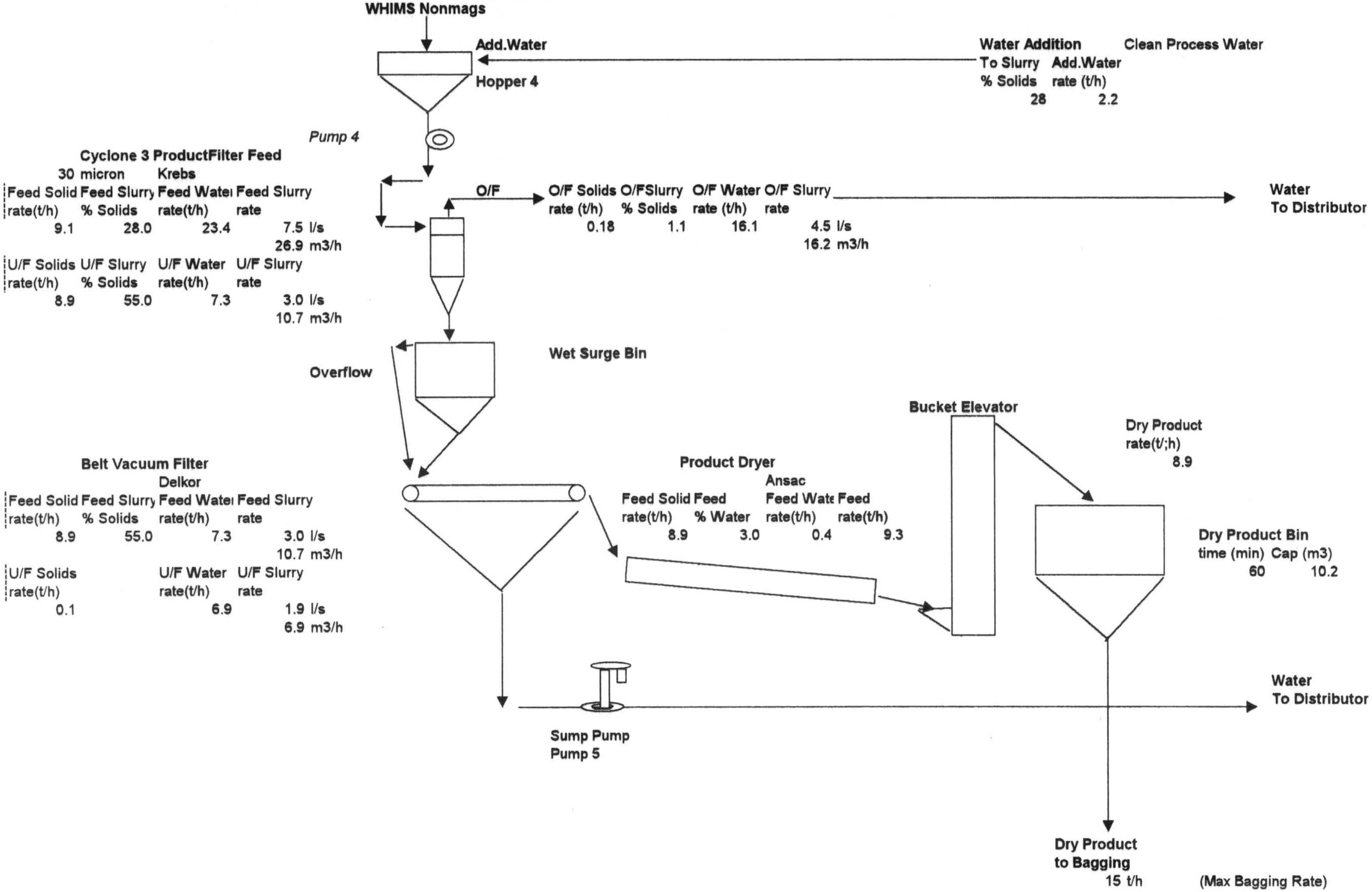
Feed Solids rate(t/h)	Feed Slurry % Solids	Feed Water rate(t/h)	Feed Slurry rate
9.2	30.0	21.6	7.0 l/s 25.1 m3/h 30.8 t/h

N/Mags rate(t/h)	N/Mags % Solids	N/Mags Water	U/F Slurry rate
9.1	30.0	21.3	6.9 l/s 24.8 m3/h 30.4 t/h



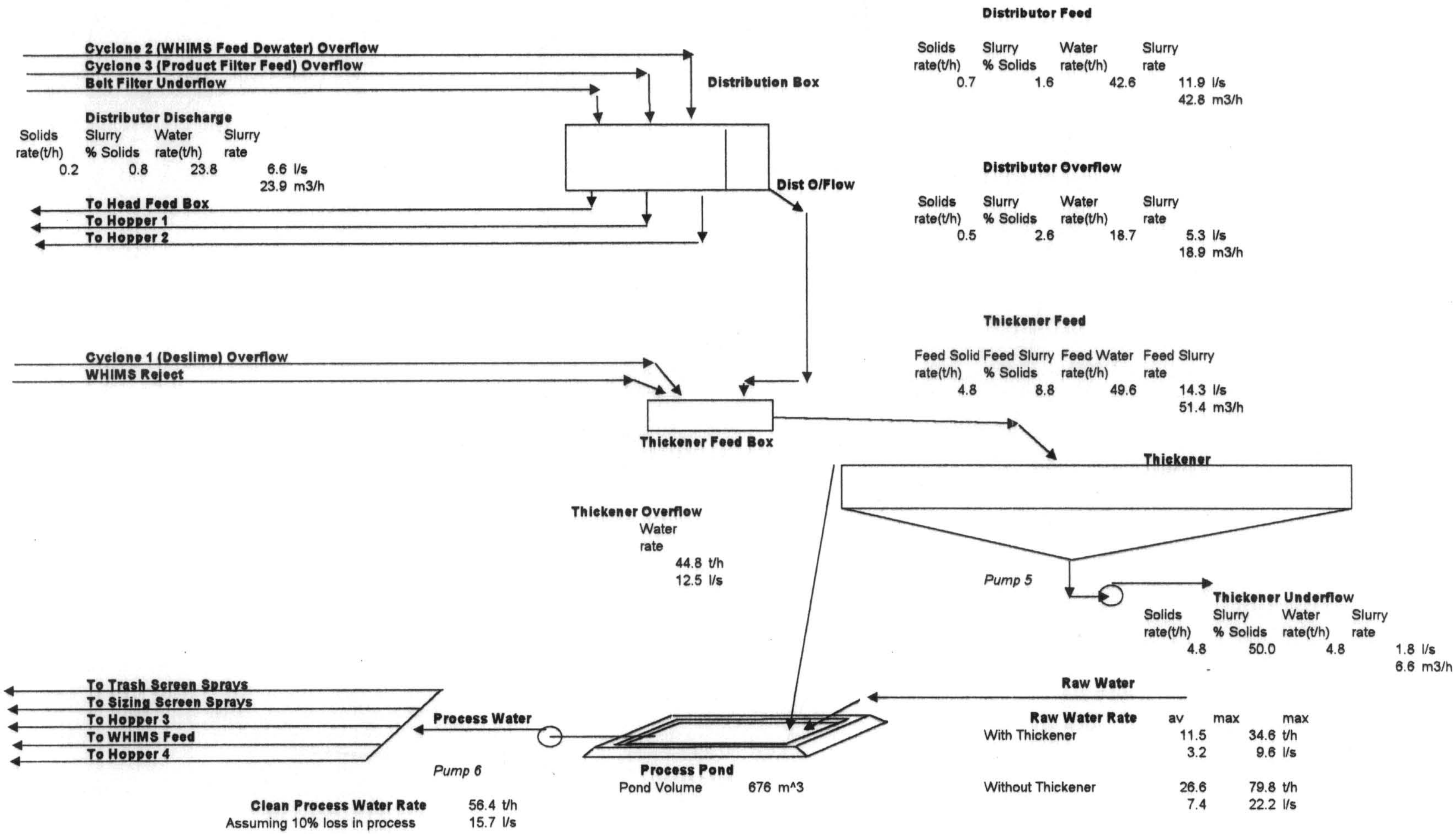
927096

Pine Hill Flowsheet Option A: Product Drying and Bagging Area



927097

Pine Hill Flowsheet Option A: Water and Waste Circuit



Appendix B

Details for Treatment Option B

This circuit is similar to Treatment Option A except for the use of a hydraulic classifier to perform the primary sizing process. Very little data for classifier performance was available so the process flows are based on a simple model that may not be accurate. Testwork must be carried out before specification of a hydraulic classifier.

- **Operation Summary**
- **Flowsheet**

927099

Pine Hill Sand Mine Operation Summary

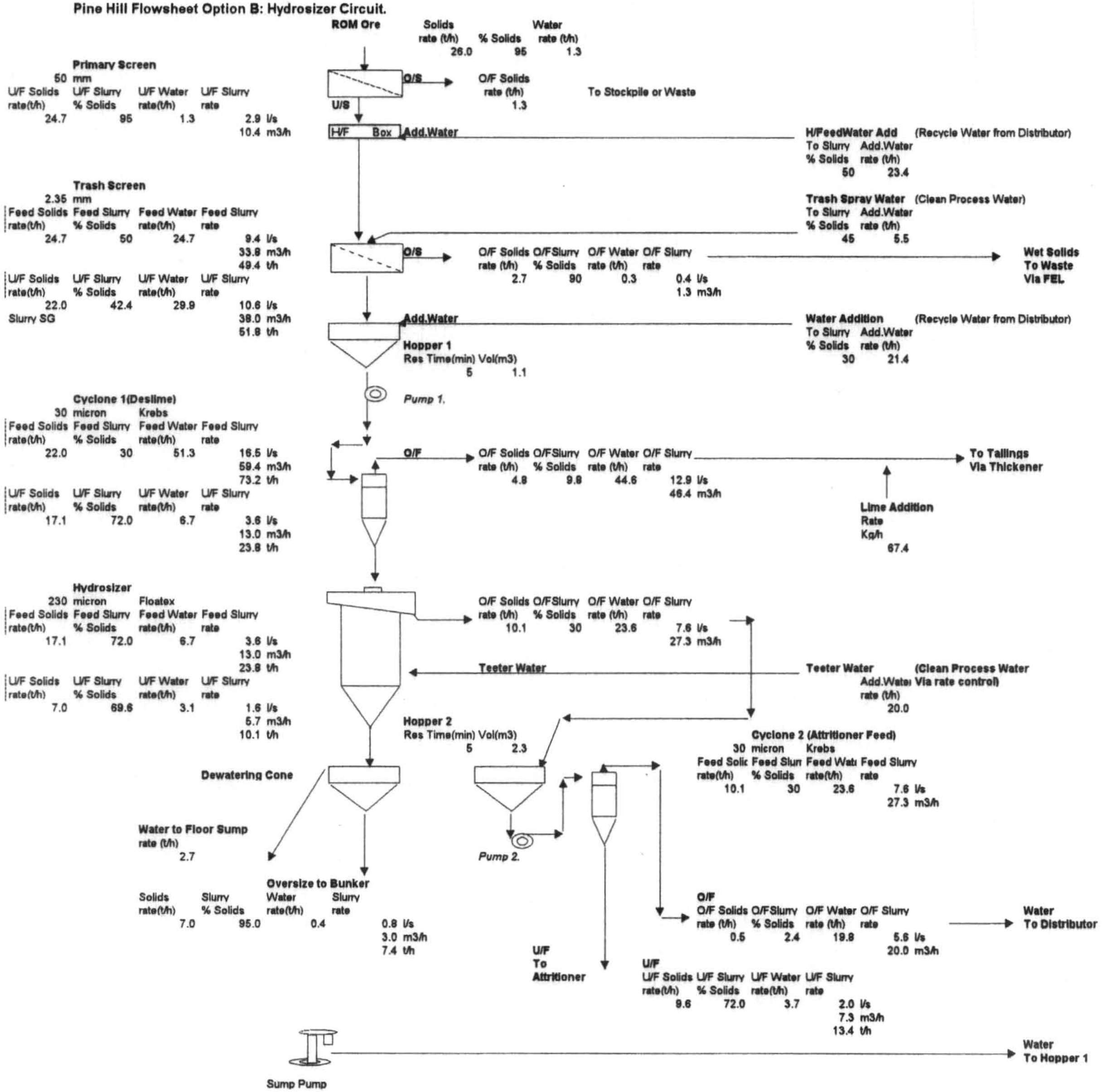
Option B Hydrosizer and WHIMS

Assumed Dry Solids SG: 2.7
Dry Product Yield: % of Head Feed 33.8

Stream	Units	Period			Comments
		Hourly	Annually		
			95% Utilisation 12 hr 5 day	*95% Utilisation 12 hr 9 day f/nt*	
Feed :	tonnes (wet)	26.0	77,276	69,548	Assuming 5% water content in ore
Product:	tonnes (dry)	8.8	*26,138*	*23,524*	
Acid :	tonnes	0.07	*200*	*180*	
Lime:	tonnes	0.07	*200*	*180*	
Water Without Thickener:	m3	33.7	100,044	90,039	Assuming 40% loss in Pond
Water With Thickener:	m3	13.5	40,099	36,090	

927100

Pine Hill Flowsheet Option B: Hydrosizer Circuit.



927101

Pine Hill Flowsheet Option B: Cleaning Area

Attritioner Stage 1

Feed Solids rate(t/h)	Feed Slurry % Solids	Feed Water rate(t/h)	Feed Slurry rate	
9.6	72.0	3.7	2.0	l/s
			7.3	m3/h

Residence Time 16.4 min

Cyclone 3, wash

30 micron Krebs

Feed Solids rate(t/h)	Feed Slurry % Solids	Feed Water rate(t/h)	Feed Slurry rate	
9.6	30	22.5	7.2	l/s
			26.0	m3/h
			32.1	t/h

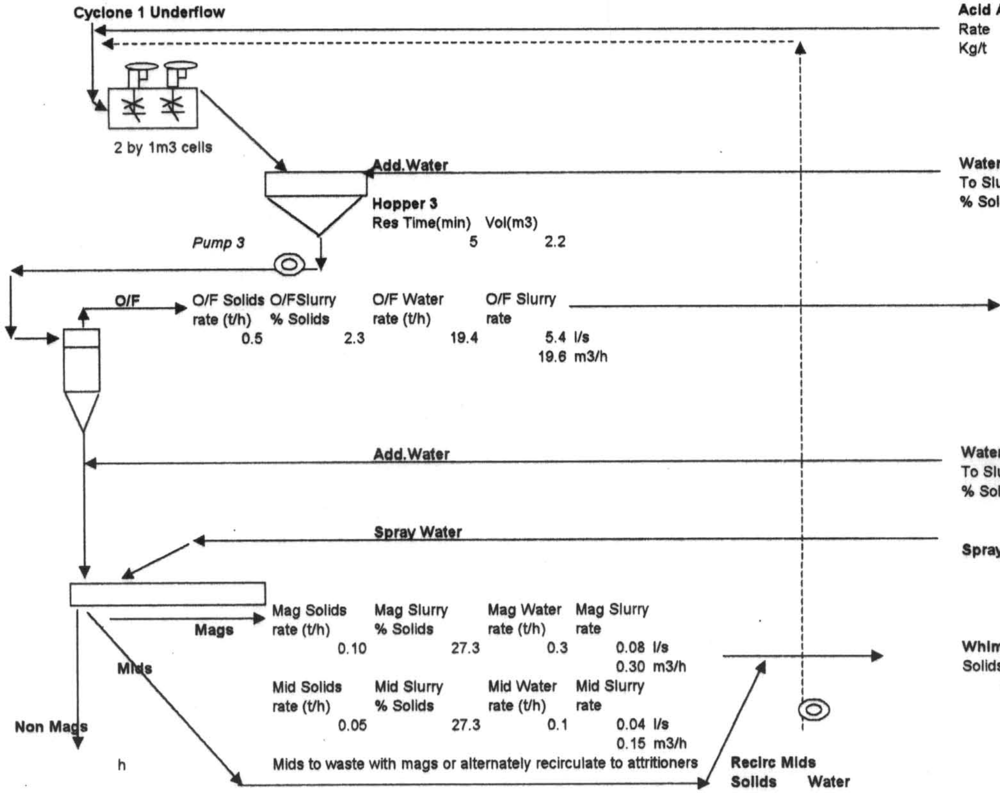
U/F Solids rate(t/h)	U/F Slurry % Solids	U/F Water rate(t/h)	U/F Slurry rate	
9.2	75.0	3.1	1.8	l/s
			6.4	m3/h
			12.2	t/h

WHIMS

Readings

Feed Solids rate(t/h)	Feed Slurry % Solids	Feed Water rate(t/h)	Feed Slurry rate	
9.2	30.0	21.4	6.9	l/s
			24.8	m3/h
			30.5	t/h

N/Mags rate(t/h)	N/Mags % Solids	N/Mags Water rate(t/h)	U/F Slurry rate	
9.0	30.0	21.1	6.8	l/s
			24.4	m3/h
			30.1	t/h



Hopper 3

Res Time(min)	Vol(m3)
5	2.2

O/F Solids rate (t/h)	O/FSlurry % Solids	O/F Water rate (t/h)	O/F Slurry rate	
0.5	2.3	19.4	5.4	l/s
			19.6	m3/h

Mag Solids rate (t/h)	Mag Slurry % Solids	Mag Water rate (t/h)	Mag Slurry rate	
0.10	27.3	0.3	0.08	l/s
			0.30	m3/h

Mid Solids rate (t/h)	Mid Slurry % Solids	Mid Water rate (t/h)	Mid Slurry rate	
0.05	27.3	0.1	0.04	l/s
			0.15	m3/h

Non Mags To Drier

Recirc Mids

Solids rate(t/h)	Water rate(t/h)
0.00	0.0

Acid Addition

Rate Kg/t	Rate Kg/h
7.0	67.4

Water Addition Clean Process Water

To Slurry % Solids	Add.Water rate (t/h)
30	18.7

Water To Waste

Water Addition Clean Process Water

To Slurry % Solids	Add.Water rate (t/h)
30	18.3

Spray Water

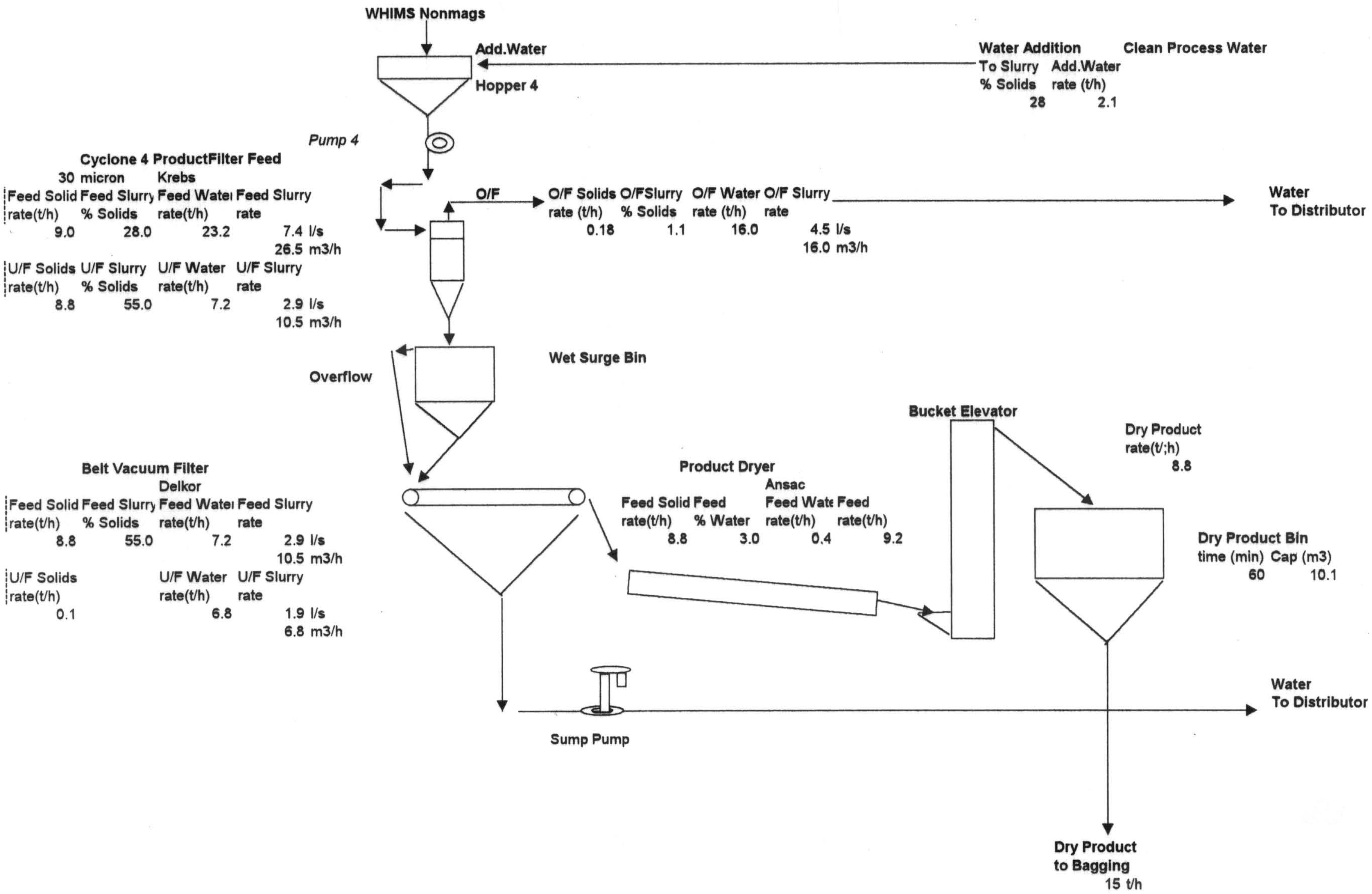
Add.Water rate (t/h)
0.1

Whims Reject To Tailings via Thickener

Solids(t/h)	Water(t/h)
0.15	0.4

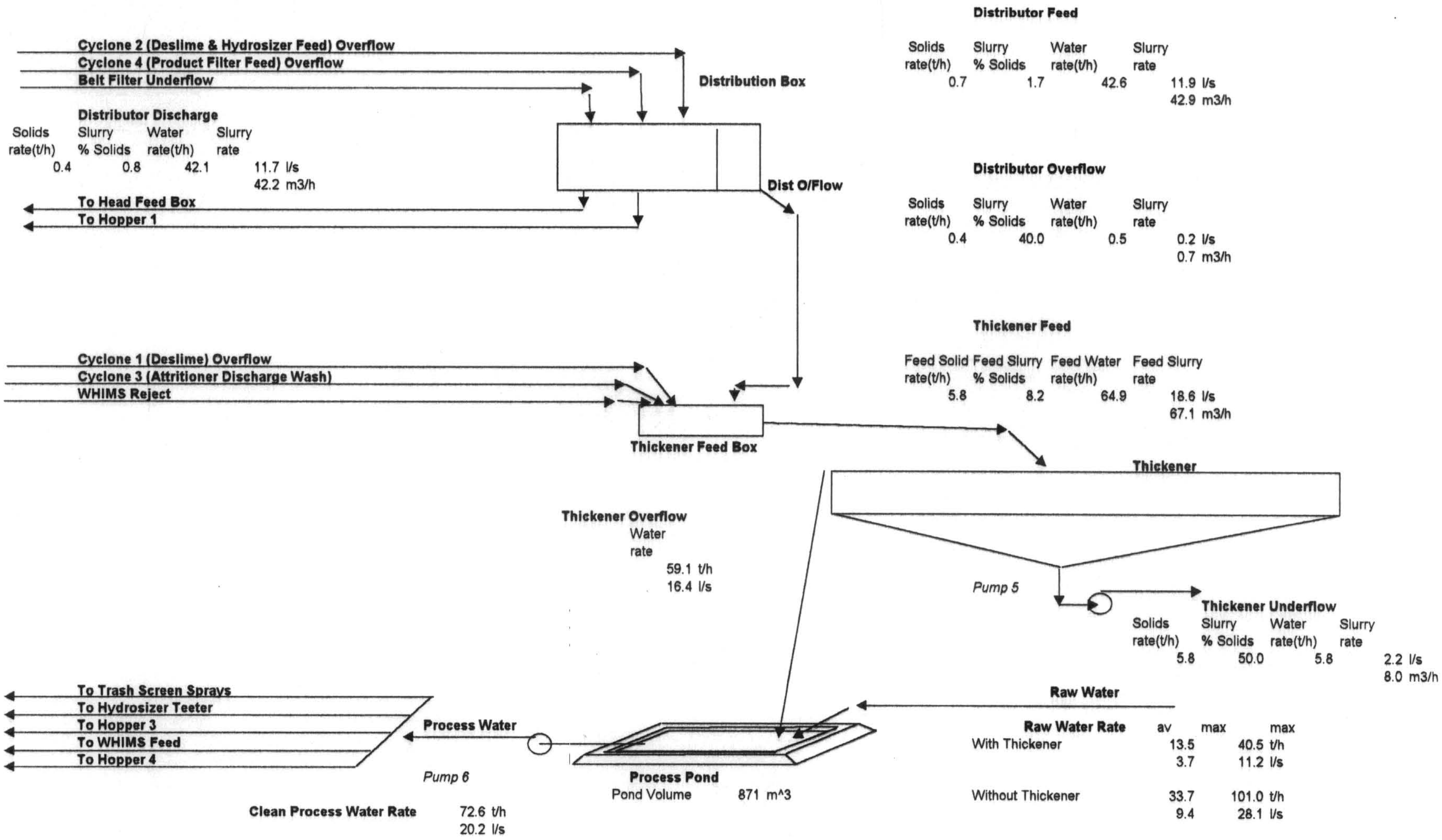
927102

Pine Hill Flowsheet Option B: Product Drying and Bagging Area



927103

Pine Hill Flowsheet Option B: Water and Waste Circuit



Appendix C

Details for Treatment Option C

This circuit shows a possible application of spirals to the removal of heavy minerals. In most other respects it is similar to Option A

- **Operation Summary**
- **Flowsheet**

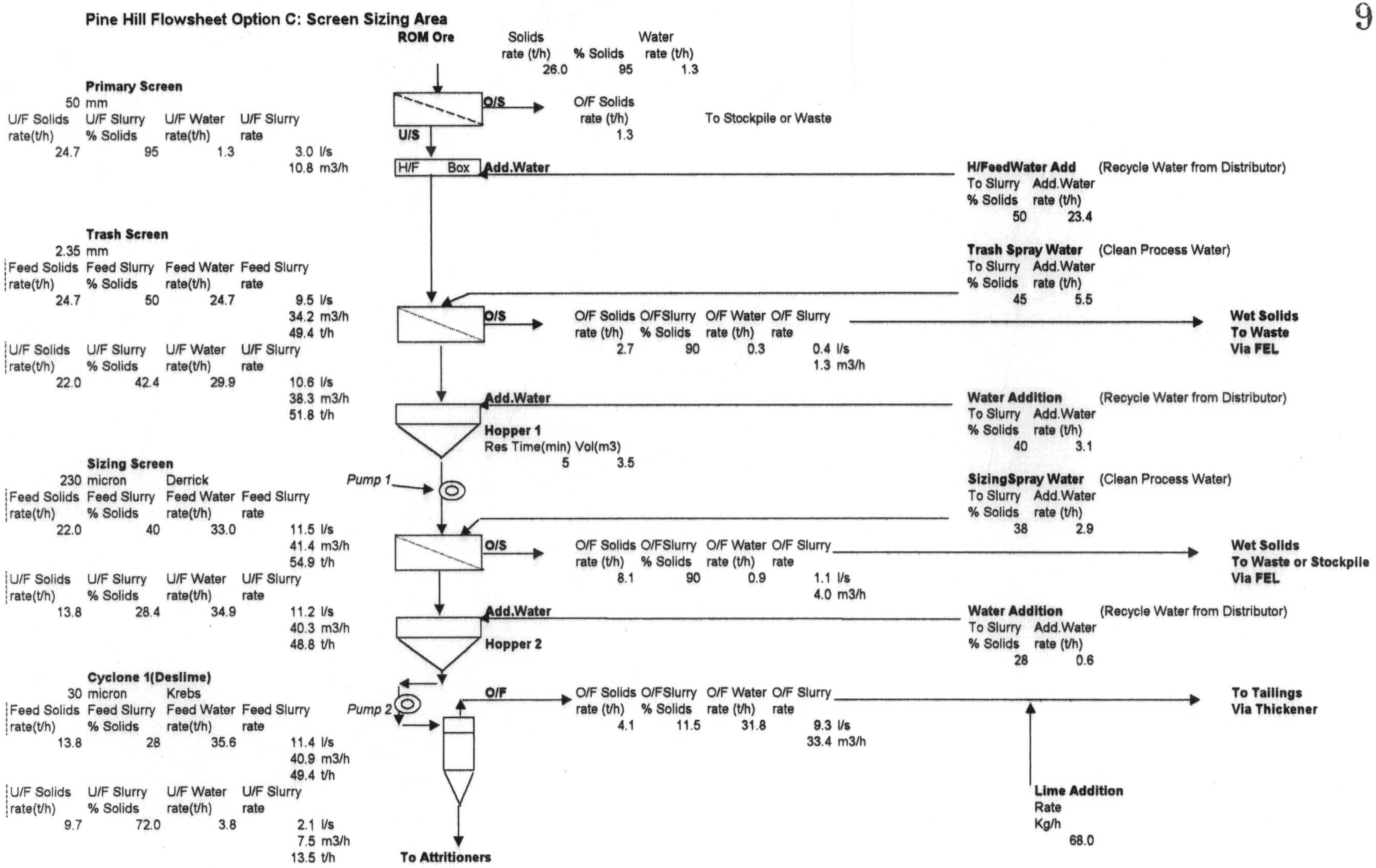
Pine Hill Sand Mine Operation Summary

Option C Screen Sizing and Spiral Separation

Assumed Dry Solids SG: 2.6
Dry Product Yield: **% of Head Feed** 33.6

Stream	Units	Period			Comments
		Hourly	Annually		
			95% Utilisation 12 hr 5 day	*95% Utilisation 12 hr 9 day f/nt*	
Feed :	**tonnes (wet)**	26.0	77,276	69,548	Assuming 5% water content in ore
Product:	**tonnes (dry)**	8.7	*25,970*	*23,373*	
Acid :	**tonnes**	0.07	*202*	*182*	
Lime:	**tonnes**	0.07	*202*	*182*	
Water Without Thickener:	**m3**	25.1	74,614	67,153	Assuming 40% loss in Pond
Water With Thickener:	**m3**	11.3	33,685	30,317	

927106


Pine Hill Flowsheet Option C: Screen Sizing Area
ROM Ore
Solids rate (t/h) 26.0
% Solids 95
Water rate (t/h) 1.3
Primary Screen
50 mm
U/F Solids rate(t/h) 24.7
U/F Slurry % Solids 95
U/F Water rate(t/h) 1.3
U/F Slurry rate 3.0 l/s 10.8 m3/h
O/S
U/S
O/F Solids rate (t/h) 1.3
To Stockpile or Waste
H/F Box
Add.Water
H/FeedWater Add (Recycle Water from Distributor)
To Slurry % Solids 50
Add.Water rate (t/h) 23.4
Trash Screen
2.35 mm
Feed Solids rate(t/h) 24.7
Feed Slurry % Solids 50
Feed Water rate(t/h) 24.7
Feed Slurry rate 9.5 l/s 34.2 m3/h 49.4 t/h
U/F Solids rate(t/h) 22.0
U/F Slurry % Solids 42.4
U/F Water rate(t/h) 29.9
U/F Slurry rate 10.6 l/s 38.3 m3/h 51.8 t/h
Trash Spray Water (Clean Process Water)
To Slurry % Solids 45
Add.Water rate (t/h) 5.5
O/S
O/F Solids rate (t/h) 2.7
O/FSlurry % Solids 90
O/F Water rate (t/h) 0.3
O/F Slurry rate 0.4 l/s 1.3 m3/h
Wet Solids To Waste Via FEL
Add.Water
Hopper 1
Res Time(min) 5
Vol(m3) 3.5
Water Addition (Recycle Water from Distributor)
To Slurry % Solids 40
Add.Water rate (t/h) 3.1
Sizing Screen
230 micron
Derrick
Pump 1
Feed Solids rate(t/h) 22.0
Feed Slurry % Solids 40
Feed Water rate(t/h) 33.0
Feed Slurry rate 11.5 l/s 41.4 m3/h 54.9 t/h
U/F Solids rate(t/h) 13.8
U/F Slurry % Solids 28.4
U/F Water rate(t/h) 34.9
U/F Slurry rate 11.2 l/s 40.3 m3/h 48.8 t/h
SizingSpray Water (Clean Process Water)
To Slurry % Solids 38
Add.Water rate (t/h) 2.9
O/S
O/F Solids rate (t/h) 8.1
O/FSlurry % Solids 90
O/F Water rate (t/h) 0.9
O/F Slurry rate 1.1 l/s 4.0 m3/h
Wet Solids To Waste or Stockpile Via FEL
Add.Water
Hopper 2
Water Addition (Recycle Water from Distributor)
To Slurry % Solids 28
Add.Water rate (t/h) 0.6
Cyclone 1(Deslime)
30 micron
Krebs
Pump 2
Feed Solids rate(t/h) 13.8
Feed Slurry % Solids 28
Feed Water rate(t/h) 35.6
Feed Slurry rate 11.4 l/s 40.9 m3/h 49.4 t/h
U/F Solids rate(t/h) 9.7
U/F Slurry % Solids 72.0
U/F Water rate(t/h) 3.8
U/F Slurry rate 2.1 l/s 7.5 m3/h 13.5 t/h
O/F
O/F Solids rate (t/h) 4.1
O/FSlurry % Solids 11.5
O/F Water rate (t/h) 31.8
O/F Slurry rate 9.3 l/s 33.4 m3/h
To Tailings Via Thickener
Lime Addition Rate Kg/h 68.0
To Attritioners

927107

Pine Hill Flowsheet Option C: Attritioning & Acid Leaching

Attritioner Stage 1

Feed Solids rate(t/h)	Feed Slurry % Solids	Feed Water rate(t/h)	Feed Slurry rate	
9.7	72.0	3.8	2.1	l/s
			7.5	m3/h
Residence Time	16.0 min		13.5	t/h

Cyclone 2, Attritioner Discharge Deslime

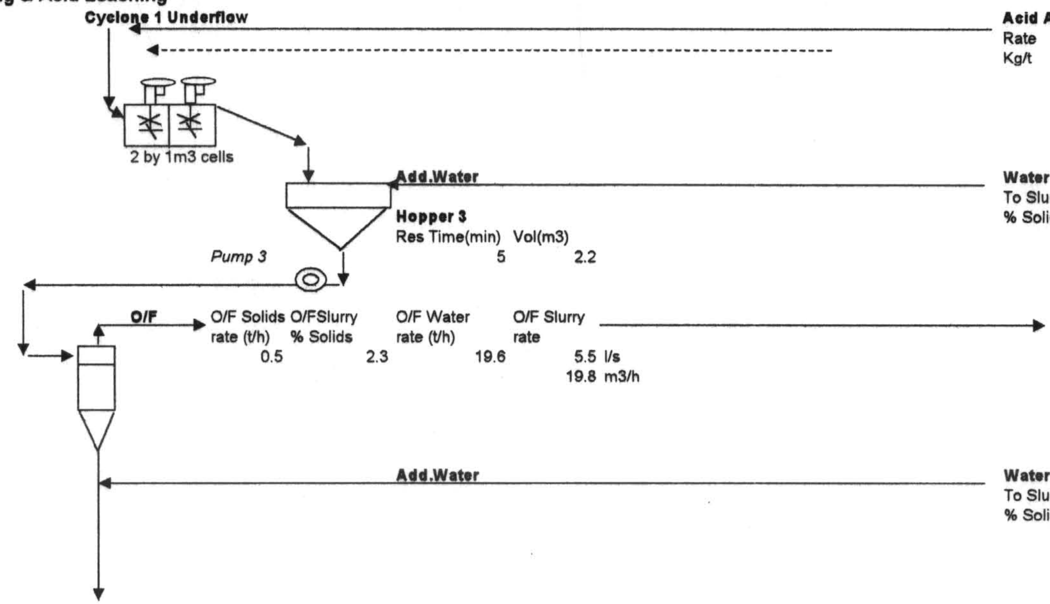
30 micron Krebs

Feed Solids rate(t/h)	Feed Slurry % Solids	Feed Water rate(t/h)	Feed Slurry rate	
9.7	30	22.7	7.3	l/s
			26.4	m3/h
			32.4	t/h

U/F Solids rate(t/h)	U/F Slurry % Solids	U/F Water rate(t/h)	U/F Slurry rate	
9.2	75.0	3.1	1.8	l/s
			6.6	m3/h
			12.3	t/h

Feed To Spiral Circuit

Feed Solids rate(t/h)	Feed Slurry % Solids	Feed Water rate(t/h)	Feed Slurry rate	
9.2	30.0	21.6	7.0	l/s
			25.1	m3/h
			30.8	t/h



Acid Addition

Rate Kg/t	Rate Kg/h
7.0	68.0

Water Addition Clean Process Water

To Slurry % Solids	Add.Water rate (t/h)
30	18.9

Water To Distributor

Water Addition Clean Process Water

To Slurry % Solids	Add.Water rate (t/h)
30	18.5

927108

Pine Hill Flowsheet Option C: Spirals

From Attritioner Discharge Deslime Cyclone

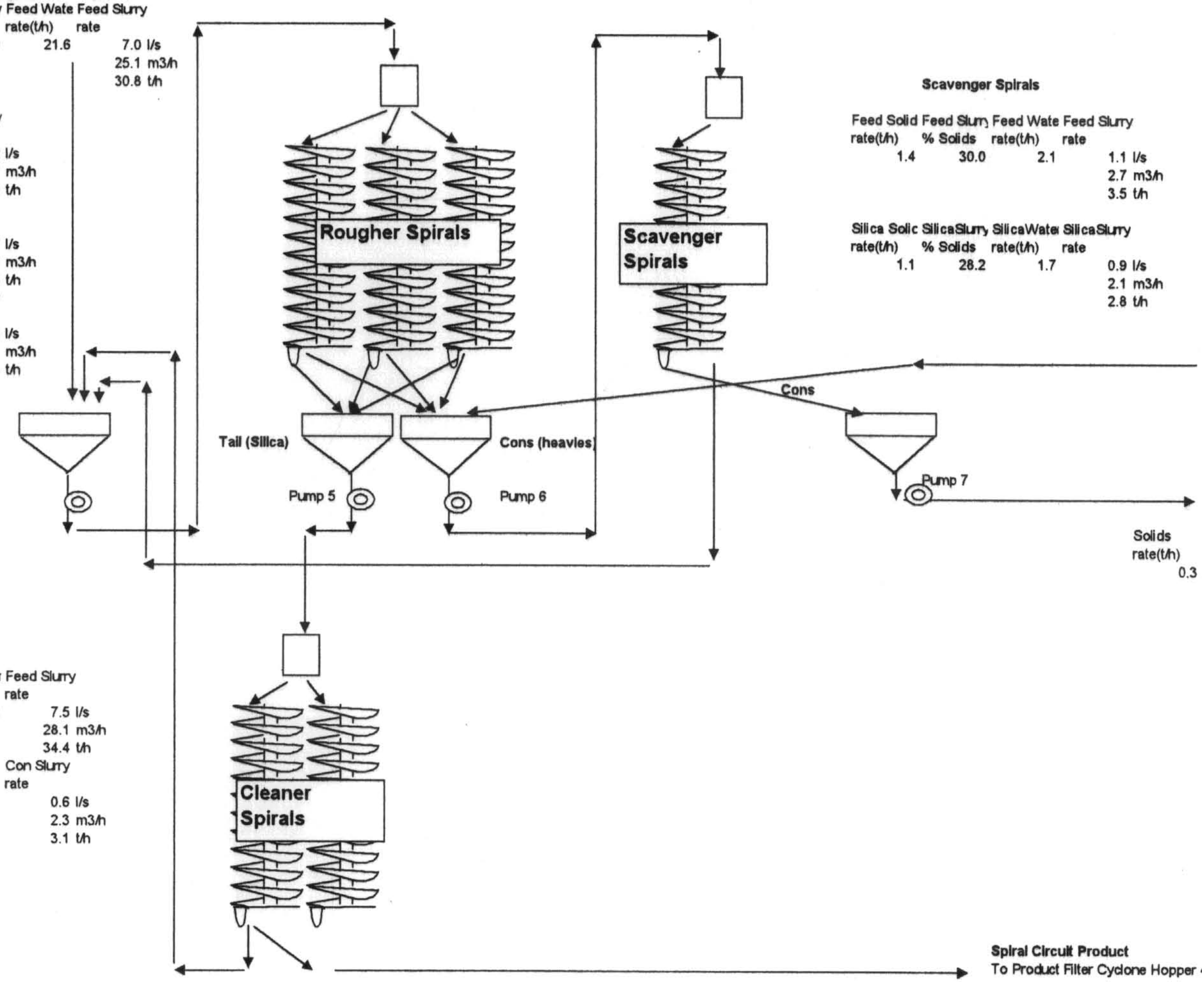
Feed Solids rate(t/h)	Feed Slurry % Solids	Feed Wate rate(t/h)	Feed Slurry rate
9.2	30.0	21.6	7.0 l/s 25.1 m3/h 30.8 t/h

Rougher Spirals

Feed Solids rate(t/h)	Feed Slurry % Solids	Feed Water rate(t/h)	Feed Slurry rate
11.6	30	26.3	8.2 l/s 30.7 m3/h 37.9 t/h

Con Solids rate(t/h)	Con Slurry % Solids	Con Water rate(t/h)	Con Slurry rate
1.4	40.0	2.1	0.7 l/s 2.7 m3/h 3.5 t/h

Silica Solids rate(t/h)	SilicaSlurry % Solids	SilicaWater rate(t/h)	SilicaSlurry rate
10.2	30.7	24.2	7.5 l/s 28.1 m3/h 34.4 t/h



Scavenger Spirals

Feed Solid rate(t/h)	Feed Slurry % Solids	Feed Wate rate(t/h)	Feed Slurry rate
1.4	30.0	2.1	1.1 l/s 2.7 m3/h 3.5 t/h

Silica Solic rate(t/h)	SilicaSlurry % Solids	SilicaWate rate(t/h)	SilicaSlurry rate
1.1	28.2	1.7	0.9 l/s 2.1 m3/h 2.8 t/h

Water Addition

Clean Process Water

To Slurry % Solids	Add.Water rate (t/h)
30	1.2

Spiral Circuit Reject

To Tails Via Thickener

Solids rate(t/h)	Slurry % Solids	Water rate(t/h)	Slurry rate
0.3	40.0	0.4	0.1 l/s 0.5 m3/h 0.7 t/h

Cleaner Spirals

Feed Solids rate(t/h)	Feed Slurry % Solids	Feed Water rate(t/h)	Feed Slurry rate
10.2	30.7	24.2	7.5 l/s 28.1 m3/h 34.4 t/h

Con Solids rate(t/h)	Con Slurry % Solids	Con Water rate(t/h)	Con Slurry rate
1.2	40.0	1.8	0.6 l/s 2.3 m3/h 3.1 t/h

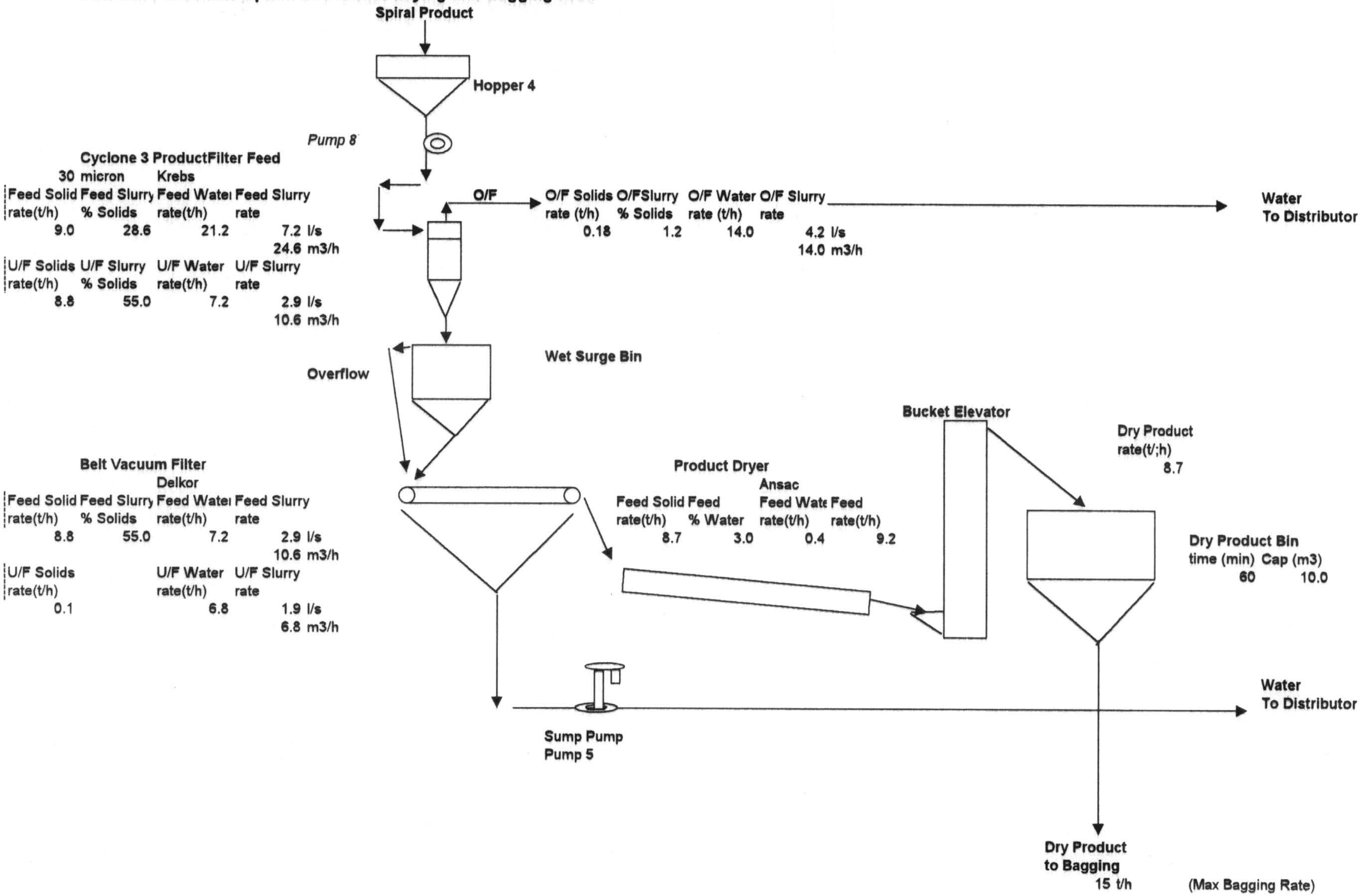
Spiral Circuit Product

To Product Filter Cyclone Hopper 4

Silica Solic rate(t/h)	SilicaSlurry % Solids	SilicaWate rate(t/h)	SilicaSlurry rate
9.0	29.8	22.3	6.8 l/s 25.8 m3/h 31.3 t/h

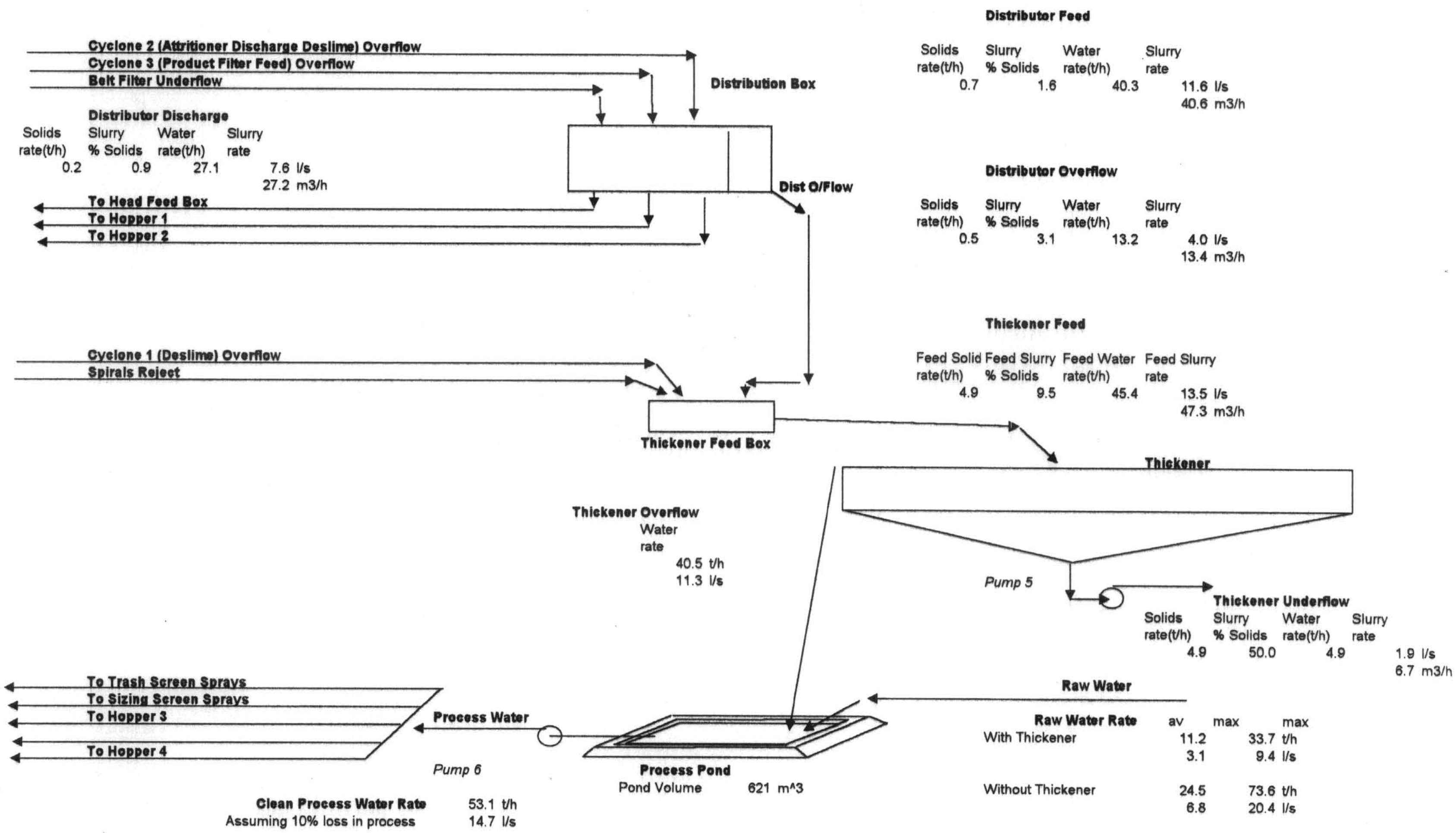
Pine Hill Flowsheet Option C: Product Drying and Bagging Area

927109



927110

Pine Hill Flowsheet Option C: Water and Waste Circuit



APPENDIX 8

ASSAY RESULTS - OHC SAMPLE

OHC

Wolfener Umweltanalytik GmbH

Prüfbericht Nr. 01113/02 vom 04.03.2002

Prüfergebnisse:

Probenbezeichnung: **Muster**

WUA - Probennummer: 02.01062.001

Siliziumdioxid	%	99,8
Aluminiumoxid	%	<0,02
Calciumoxid	%	0,01
ges. Eisen als Fe_2O_3	%	<0,01
Titanoxid	%	0,01
Phosphorpentoxid	%	<0,05

Bemerkung: **Prüfmethodik: 1.) Röntgenfluoreszenzanalyse**
2.) Säureaufschluß und ICP-OES

Bitterfeld, den 04.03.02

Nathansen

Dr. Nathansen
Laborleiter Wolfener Umweltanalytik GmbH